IMPACT OF DRYLAND FARMING TECHNOLOGY ON PRODUCTION, INCOME AND EMPLOYMENT IN RANGA REDDY DISTRICT OF ANDHRA PRADESH

BY

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CERTIFICATE

Mr. G.V. KRISHNA RAO, has satisfactorily prosecuted the course of research and that the thesis entitled **"IMPACT OF DRYLAND FARMING TECHNOLOGY ON PRODUCTION, INCOME AND EMPLOYMENT IN RANGA REDDY DISTRICT OF ANDHRA PRADESH"** is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

Date: 30-11-1991

(Dr. P.R. PARTHASARATHY)

Major Advisor

CERTIFICATE

This is to certify that the thesis entitled **"IMPACT OF DRYLAND FARMING TECHNOLOGY ON PRODUCTION, INCOME AND EMPLOYMENT IN RANGA REDDY DISTRICT OF ANDHRA PRADESH"** submitted in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN THE FACULTY OF AGRICULTURE** of the Andhra Pradesh Agricultural University, Hyderabad, is a record of bonafide research work carried out by **Mr. G.V. KRISHNA RAO,** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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(G.V. KRISHNA RAO)

DECLARATION

I, **G.V. Krishna Rao**, hereby declare that the thesis entitled **"IMPACT OF DRYLAND FARMING TECHNOLOGY ON PRODUCTION, INCOME AND EMPLOYMENT IN RANGA REDDY DISTRICT OF ANDHRA PRADESH"** submitted to Andhra Pradesh Agricultural University for the degree of **Doctor of Philosophy** is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier.

Dated: 20 -11-1991

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ABSTRACT

OBJECTIVES

1. To identify the dryland technology developed by different institutions.

2. To measure the variation in the production levels of selected crops, size-wise between adopters and non-adopters.

3. To evaluate the income inequality among the different size groups of farms of adopters and non-adopters.

4. To study the pattern of resource use and productivity among adopters and non-adopters.

5. To study the impact of dryland technology on production, farm income and employment of adopters and non-adopters.

6. To examine the consumption patterns of adopters and non-adopters.

METHODOLOGY

Maheswaram Watershed in Ranga Reddy district was purposively selected because this watershed was funded by world bank for the development of dryland farming and close proximity to the university. Six villages at the rate of one in each sub-watershed were selected. For the purpose of comparison 3 villages were selected in the area which is outside the watershed but well within the above vicinity. Finally 120 farmers in watershed area and 120 farmers in non-watershed area were selected by adopting stratified random sampling proportianate to stratum size. The information and data were collected from the respondents through interview method in specially designed pre-tested schedule. The reference period was 1988-89. To arrive at valid conclusions in additions to tabular analysis, statistical tools and techniques such as Lorenz curve, Gini concentration ratio, Mahalanobis "D^2" Cobb-Douglas type of production function were the statistical tools and techniques used.

MAIN FINDINGS

The following are the main findings which emerged from this study.

1. It was observed that the productivity was higher in adopters for all the crops raised when compared to non-adopters. The productivity of castor was 7.73 qt per hectare for adopters as against 5.01 qt for non-adopters.

2. The MVP to opportunity cost ratio's indicated high degree of resource use inefficiency on all farm size groups and for all the inputs. To increase profitability and returns on dryland farms, there is need to reduce the use of human and bullock labour and increase the expenditure on seed and fertiliser.

3. The analysis on adoption of technologies showed that the adoption of improved technologies was much in the case of paddy, an irrigated crop than on dryland crops. The important technologies were adopted for castor by almost all the farmers. None of the farmers in non-adopters group adopted the cropping system of sorghum (L) + pigeonpea with high yielding varieties.

4. Almost all the farmers used chemical fertilisers in adopters category whereas only 47 per cent of the non-adopters used chemical fertilisers.

5. The total income of adopters was Rs 18,735 per household as against Rs 16,536 in the case of non-adopters.

6. The total family expenditure per annum per household was Rs.9,726 and Rs.5,882 on adopter and non-adopter farms respectively.

The findings of the study warrants the following policy implications :

1. Since the soil and moisture conservation programmes involve large investments, the Government has to take up these programmes. *In situ* water harvesting techniques may also be popularised for adoption. Peoples participation in this programme should be ensured.

2. The State Agricultural University, the Department of Agriculture and the State Seeds Development Corporation should supply the quality seed to the farmers in time.

3. The 'input delivery system should be improved by utilising the existing institutions such as Cooperatives and Agro's Cost effective technologies and high value and low volume crops will have to be adopted by the farmers.

4. Credit will have to be provided in a big way to dryland agriculture by financing institutions.

INTRODUCTION

CHAPTER I

INTRODUCTION

Agriculture is a vital sector of our economy with nearly 75 per cent of Indian population living in rural areas and earning a livelihood from agriculture and allied activities. As such it can virtually be called the backbone of our country's economy. It is said nothing moves in Indian economy unless agriculture moves. It can also be said that agriculture cannot move unless water moves into agricultural fields. Along with irrigated lands drylands should also be given equal importance, as it constitute about 68 per cent of the total arable area of 143.8 million hectares in India. It is evident from Report on National Commission on Agriculture that out of the Nation's food basket, about 43 per cent of the food requirement in the country is met through drylands. Even with all possible efforts to bring more area under irrigation by 2000 AD, about 45 per cent of land would still be rainfed. These dry lands are conspicuous with low productivity which is due to drought spells, low fertility, aberrant weather etc. Keeping in view the growing population in India, there is every need to exploit the production potentialities from drylands by adopting new technology in order to meet the food requirement of the country.

1. RESEARCH ON DRYLAND FARMING

1.1. Earlier Research Efforts

The earliest research efforts date back to 1923 when Tamhane set up small scale plots at Majri. Kanitkar set the pace in 1926 by formulating more comprehensive research programme for improving crop production on drylands. Dryland farming research has been receiving attention of the Imperial now Indian Council of Agricultural Research) from the early 1930's and it took roots between 1933 and 1935 at Rohtak in Punjab, Solapur and Bijapur, in the former Bombay State, Raichur in erstwhile Hyderabad State and Hagari in erstwhile Madras State. The dryland research programme at these stations had a total life span of about 10 years, as the programme having been terminated in 1943[1].

As a result of these efforts a series of useful dry farming practices commonly known as the Bombay dry farming practices, the Hyderabad dry farming practices and the Madras dry farming practices were evolved.

The basic ingredients of all practices lay in soil and moisture conservation measures. However, these practices were able to increase the yields by 15 to 20 per cent only. This did not enthuse the farmers to adopt

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[1] R.P. Singh (1982). **"Dryland Research in Retrospect and Focus in the Seventies"** Published in A Decade of Dryland Agricultural Research in India 1971-80, ICAR.

them as the pay off was marginal only. The main constraint was the absence of biological material responsive to management and input.

Yet an another attempt for improving the productivity on drylands was the establishment of eight soil Conservation Research Centres in 1954. Approved soil conservation practices has been thus evolved. Factors effecting crop production on drylands came into sharper focus. Climatological analysis which was first attempted in the Deccan post-rainy season brought recognition of the fact that only the varieties that mature within a period of 100-120 days give high yields on drylands with limited moisture availability. Although new vistas of crop production on drylands were thus opened, these efforts too did not make much of a dent on crop productivity due to non-availability of suitable plant material.

In the late sixties, high yielding varieties of wheat and rice were introduced into the country. Hybrids of sorghum and pearl millet were evolved. These varieties and hybrids performed well on drylands in good rainfall years and under good management conditions. A need for comprehensive multi-disciplinary research programme thus become obvious. The Indian Council of Agricultural Research came forward by launching a comprehensive research programme on dryland agriculture. The All India Coordinated Research Project for Dryland

Agriculture (AICRPDA) was thus born in 1970 with active collaboration of the Government of Canada. The distinctive features of this project lie in its multidisciplinaryy approach in identifying and analysing constraints limiting crop yields in the semi arid and seasonally dry areas of the country and ultimatley developing a relevant location - specific technology for drylands.

The project started with 23 cooperating research centres located under different agro-climatic regions of the country. Agro-economic research was initiated at 16 centres in 1975-80. Pasture research was taken up at 5 centres in 1975-85. Operational Research Programmes were initiated at 5 centres to begin with. A Trainers' Training Centre was established at the coordinating cell at Hyderabad. With the initiation of research programmes at the 23 cooperating research centres were set up simultaneously. Currently, nine Dryland Operational Research Projects are operating at various places in different states.

Consequently Central Research Institute for Dryland Agriculture (CRIDA) came into existance with effect from April, 1985 at Hyderabad. The mandate for this institution is to find out solutions for the various problems of dry farming in the country. In developing the methods, which are simple but based on locally available resources with a low monetary input, the Indian scientists have received substantial assistance from Canadian experts for a period of 17 years, in three phases, from 1970 to 1987. The achievements covered soil and water conservation, crop production and alternative land use systems and it was proved conclusively that adopting the practices recommended would result in a significant increase in yield. The current research thrust seeks, inter alia, to identify cropping systems and management practices that will raise and stabilise productivity of drylands and workout suitable alternative land use systems that will maximise biomass production in arable and marginal lands. It also aims to develop farm implements that will be cost effective and meet the twin objectives of time liness and precision in field operations.

Similarly, International Crop Research Institute for Semi Arid Tropics (ICRISAT) has also done valuable work during last 15 years. However, it has yet to reach to the farmers of India, who are considered enough enlightened to adopt what they really find useful. It is a land mark in the history of Indian agriculture that such an effort of mutual interest is being put into action for the cause of dryland farmers.

Transfer of Technology

Transfer of technology activities have been a part of dryland project since its inception. The network of cooperating centres in AICRPDA facilitated transfer of technology across the country. Right from the early days of the project, it has been its own share of extending the transfer of technology to farmers through the active collaboration of the State Departments of Agriculture in 22 pilot development projects in the country. At headquarters, transfer of technology activities began to be formalised into specific programmes in the 1970's. The first CIDA sponsored AICRPDA Operational Research Project was started in 1976. The following year, farmers training became institutionalized with creation of Krishi Vigyan Kendra (KVK) and facilities located at the Hayatnagar Research Farm. In 1978 the Trainers Training Centre (TTC) offered its first course to extension personnel involved in farmer training. In 1979 a specific transfer of technology programme called Lab to Land (LL) was added. The watershed development programme was started at 47 centres under different agro-climatic conditions by ICAR throgh CRIDA and CSWCRTI in 1983.

1.3 The Lab to Land Programme

The Lab to Land programme was launched as yet another major step to contribute in transfer of technology. The scientists of CRIDA are actively involved in the adoption of selected farm holdings for testing on appropriate improved dryland technology including popularisation of improved farm machinery.

The Lab to Land programme of the Krishi Vigyan Kendra at Hyderabad has been implemented in nine villages of Ranga Reddy district and nine villages of Medak district in Andhra Pradesh covering 1,600 farm families till date.

1.4 Operational Research Programme

The Operational Research Programme on dryland agriculture began with a Project at Indore in 1974 with collaboration and was augmented with the addition of 4 more CIDA sponsored ORP's in 1976. The Operational Research Project has been engaged in testing of proven technology on farmer's fields so as to identify the constraints in the adoption of technology and to obtain the feed back for research workers to redesign and needing technology suiting to farmers conditions. Efforts for extending the research results to the actual users are being attempted under this programme. At present 9 ORP centres on dryland agriculture are functioning and the work is being carried out on different aspects of dryland agriculture at the centres viz., Hyderabad, Bangalore, Ranchi, Hoshiarpur, Anantapur, Solapur, Indore, Arjia and Hissar.

1.5 Krishi Vigyan Kendra

At the Krishi Vigyan Kendra, dryland farmers and farm women are given needbased and skilloriented vocational training in the latest techniques in improved crop production practices. Follow-up measures for providing on the spot guidance and imparting necessary skills to the farmers also forms an integral part of the training programmes of the Krishi Vigyan Kendra. 476 training programmes were conducted on Crop Production, Soil and Water Conservation, Animal Husbandry, Farm Machinery and Implements, Horticulture and Home Science in which so far 10,990 participants were trained.

1.6 Watershed Programme

In 1983, the Central Research Institute for Dryland Agriculture, Hyderabad, Andhra Pradesh was entrusted with the responsibility of giving technical backstop to 31 of the 47 ICAR Model Watersheds. The Model Watersheds are spread over 31 districts in 13 States viz., Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Madhya Pradesh, Maharastra, Orissa, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. These watersheds are distributed in different agro-climatic zones with varying topography and soil types. This provides appropriate conditions for evaluating the performance of dryland technology. The main thrust of the watershed programme is conservation and development of two basic resources, namely land and water through appropriate technologies and management practices and also optimum utilisation of these resources for overall improvement in productivity of watershed besides crop management.

The World Bank funded Watershed Project has initiated in Ranga Reddy District in coordination with Andhra Pradesh Agricultural University, CRIDA and Directorate of Agriculture in 1983-84. These institutions laid adaptive research trials, demonstrations etc., not only to verify the research findings but also to demonstrate the superiority and profitability of dryland technologies to the farmers and to motivate and facilitate the adoption of technologies at the field level.

1.7 PROBLEM SETTING

Dryland agriculture is characterised by low land use intensity, uncertain weather conditions, adoption of traditional and age old practices, non adoption of improved technologies, low capital investments, high risk situation etc. Consequently the production and productivity in dryland farming are not only low but unstable. As a result of this a lot of dryland farmers who form a significantly large proportion of cultivators, has remained far from satisfactory living. The employment and income of the people depending on dryland farming are at very low level. Hence in order to improve the economic conditions of the dryland farmers, several programmes have been launched. One of the most important programme is the transfer of dryland technology at field level. It has been estimated from the various researches conducted that it would be possible to increase the dryland production by three times with the existing level of technology. The transfer of dryland technology at field level has been taking place, specially during the last two decades. However, the adoption and spread of technology has not been to the desired extent. It is therefore necessary to correctly estimate the extent of adoption and the reasons for non adoption of technology and also the impact on production, income and employment in the dryland farming regions. However, not many evaluation studies were conducted to assess the impact of dryland technology on income and employment. Therefore the present study was contemplated.

1.8 OBJECTIVES

The overall objective of the study is to evaluate the impact of dryland farming technology on production, income and employment.

The Specific Objectives of the study are:

1. to Identify the dryland technology developed by different institutions,

2. to measure the variation in the production levels of selected crops, size-wise between adopters and non-adopters,

3. to evaluate the income inequality among the different size groups of farms of adopters and non-adopters.

4. to study the pattern of resource use and productivity among adopters and non-adopters,

5. to study the impact of dryland technology on production, farm income and employment of adopters and non adopters, and

6. to examine the consumption patterns of adopters and non-adopters.

1.9 Scope of the Study

The study attempts to assess the impact of dryland farming technology by comparing adopters with non adopters. The impact of study encompassess the cropping pattern, cost structure, production and productivity. The study also attempts to evaluate the impact of technology on income and employment on adopters compared with non adopters. The resource use efficiency was also studied among different categories of farmers in both adopter and non adopter groups.

The results of the study would help the researchers, policymakers and administrators in evolving various developmental programmes based on technology transfer and other aspects of dryland farming practices.

1.10 Limitations of the Study

As to that of all similar studies this investigation also suffers from certain limitations.

One of the important limitations of the study is that data pertains to a single agriculture year 1988-89. What one gets from this data is a cross sectional picture at one point of time. Therefore, the generalisation has to be made cautiously.

Secondly, the data were collected through survey method by interviewing farmers. Therefore, the objectivity of the data is limited to the extent the farmers were able to recollect from their memory as they do not maintain any records.

Finally, the dry farming technology is location specific and time specified. Hence caution is to be exercised in implementing the suggestions to areas other than those under study.

1.11 Organisation of the Thesis

Chapter I deals with **Introduction** encompassing identification of the problem; formulation of objectives, scope of the study, limitations of the study. In Chapter II, **Review of Literature** is presented. The **Material and Methods** used in the study are discussed in Chapter III. **Agro-Economic features of the study area** are presented in Chapter IV. Chapter V is covered with the **Results and Discussions** of the study with a view to drawing specific inferences for policy. **Summary, conclusions** and **suggestions** are provided in Chapter VI.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The review of literature is presented under the following parts:

PART - I DRY LAND TECHNOLOGY AND ITS COMPONENTS

PART - II RESOURCE USE EFFICIENCY/RESOURCE PRODUCTIVITY AND SCALE RETURNS

PART - III IMPACT ON INCOME, EMPLOYMENT AND PRODUCTIVITY

PART - I DRY LAND TECHNOLOGY AND ITS COMPONENTS

The Indian Council of Agricultural Research (1938) conducted cost studies in the principal sugarcane and cotton growing regions of the country by using cost accounting method.

The National Sample Survey (NSS) (1960) during 1951-52 and 1952-53 conducted cost studies of paddy, wheat, jowar, bajra, barley, ragi, maize, gram, millets, cotton, jute, minor cereals, pulses, sugarcane, oil-seeds, potato, spices and tobacco in its 5th, 6th, 7th rounds and covered the entire country, except Jammu and Kashmir and the Andaman and Nicobar Islands. The NSS adopted survey method in the enquiry.

The Indian Council of Agricultural Research (1953) in collaboration with the Indian Central Cotton

Committee and the Indian Central Oilseeds Committee, conducted a pilot study during 1952-54 on cost of production of cotton and rotation of crops (Jowar and groundnut) in Akola district. This study provided guidance for planning large scale surveys to determine cost of production of different crops. The procedures adopted in these studies were not uniform and also were not generally accepted.

The Directorate of Economics and Statistics (1954-57 to 1962-65), Ministry of Food and Agriculture, Government of India, conducted cost studies through Farm Management Studies. Some of the earlier studies were conducted by survey method while the latter were conducted by cost accounting method. The data were useful for providing guidelines for formulating agricultural policy and for extension work.

Deshpande (1960) reported that the yield of cotton was mainly dependant on manures and seeds. Human labour and bullock labour accounted for 26 per cent variation in yield, whereas 9 per cent variation was due to the size of holding. The variations were due to combination of manures, seed, bullock and human labour.

Governemnt of Andhra Pradesh (1963) conducted a study on production of rice, iowar, ragi, sugarcane and groundnut covering 540 holdings in 3 districts.

George *et al.* (1970) studied the net returns from dry farming under existing practices and suggested a plan of improved practices in some villages of Hissar district. The suggested plan showed increases in income by 221, 148 and 194 per cent on small, medium and large farms, respectively. The success of new technology calls for effective extension service and suitable institutions to provide credit for meeting the increased capital requirements. The Linear Programming Technique was used for the analysis.

Shukla (1970) worked out the optimum crop combination for a sample of rainfed farms in Jabalpur district, under traditional and advanced technologies. The potential increase in income through optimal crop combination with existing resources and techniques was around 10 per cent. While the increase through optimal crop mix improved technology was of the order of 42 per cent. The optimal crop combination, however, involves specilisation in wheat and paddy to maximise income. This assumes certainity conditions and ignores the present practice of crop diversification as an insurance against an uncertain weather.

Mighaniss and Singh (1971) have reported that crops like local bajra, pulse, gram and barley could withstand drought conditions and had more stable yields in unirrigated areas in Ferozpur district. Kahlon and Sandhu (1971) expressed that the use of fertilizers was insignificant on dry farms of Pubjab. Parthasarathy (1972) stated that the cost of cultivation of rice as a whole varied from Rs 472 to 576, with an overall average of Rs 498 per acre in West Godavari district. The gross return per acre on an average was found to be Rs 1956 while the net returns per acre varied from Rs 479 to 591 with an average of Rs 567. The cost benefit ratio showed a direct relationship with farm size.

During 1971-72, a comprehensive scheme for studying the cost of cultivation of principal crops in different States was sponsored by the Government of India. This provided data for fixing prices for important crops and for working out the cost of production indices from time to time.

Parthasarathy (1974) reported that human labour, manures and fertilizers, cattle labour and seed were the most important cost items and these costs together accounted for 55 to 66 per cent of total cost per acre of sugarcane production in Andhra Pradesh.

Subramanyam (1975) in his study on "Adoption of new technology on small farms, the role of credit and its requirements stated that; (i) the provision of credit for small farms in most cases resulted in the introduction of paddy into optimum crop plans (ii) provision of credit helped in increasing the area of high yielding varieties of paddy on the farms where it was already grown and (iii) credit requirements differ between different agro-climatic zones due to difference in the cropping pattern and capital use.

Pawar and Patil (1977) analysed size efficiency relationship of small and large farms in dry farming area of Ahmednagar district in Maharastra. They observed that small scale farming is efficient as large scale farming in dry farming areas. The use of different resources, cost of production, gross returns and net returns depend on the scale of farming. Even the marginal value productivities of different resources did not show substantial difference on the two types of farms under the existing technologies.

Patel (1978) observed that the rental value of land accounted for the largest share of total cost and human labour constituted a little less than one fifth of the total cost for all sizes of farms in Anantapur district.

Rastogi (1979) reported that investment on seed, manures, fertilizers and plant protection measures was generally very low. At Anantapur, the cash investment for setaria was nearly 7 per cent of working cost and varied between 32 and 58 per cent for groundnut. He further stated that plant protection measures were not used for most crops and wherever adopted, were inadequate. Under farmers' management as reflected by the cultivation practices followed the level of inputs used and the yields of all crops were extremely low.

Reddy and Chowdry (1979) found that the rental value of owned land constituted a lion's share of 37.07 per cent and 21.94 per cent of the total cost in the case of Jowar and groundnut respectively in Cuddapah district. Reddy (1980) stated that the plant protection was a neglected input and has no significant difference in cost 'C' among different sizes of farms in drought prone areas of Mahaboobnagar district. Suryanarayana (1980) reported that the cost of cultivation for local jowar per hectare was about Rs 1053 in kharif season. He observed that fixed cost of cultivation per hectare of jowar was more than the operational cost of cultivation in Prakasam and Mahaboobnagar districts.

Reddy and Rastogi (1983) concluded that the economic conditions of farmers in dryland tract were poor inspite of so many projects/schemes implemented to uplift the rural folk. The efforts are yet to be made to make farming from subsistance level to commercial level in our country through improved perfect dryland technology, generating employment for human and bullock labour and developing dairying to ameliorate the conditions of rural farmers.

Reddy (1987) analysed the economics and adoption levels of improved dryland technology in the case of local sorghum in Andhra Pradesh. The total per hectare working cost involved in the production of local variety and hybrid variety of sorghum were Rs 1290 and Rs 1993, respectively. The corresponding figures for yield levels were 2.69 quintals and 4.71 quintals. The proportion of material costs, human labour and bullock labour in the case of local variety of sorghum were 11, 57 and 32 per cent of the total cost, respectively. The corresponding figures for the hybrid variety of sorghum were 14, 51 and 35 per cent of the total cost of production. In both the varieties, the labour formed the major component of total cost. The gross returns and benefit cost ratio (BCR) in the case of local variety and hybrid variety were Rs 596 and Rs 686 respectively.

Mruthyunjaya (1989) reported that the cost of production ranged from Rs 1101 in mungbean to Rs 1529/ha in guar due to the application of fertilisers and higher outlay on plant protection. The unit of production is the lowest in pearlmillet bajara (Rs 760/t) and the highest in sesamum (Rs 2090/t). A better variety (BJ 104) of pearl millet and widely tested production practices offered a yield of about 1.5 t/ha, and helped reduce the unit cost of production. Despite their low yield potential, pulse and oilseed crops, like mung bean and sesamum, had a higher net income than pearl millet on account of their higher unit value and their B-C ratios were nearly twice as high as that of pearl millet.

2. RESOURCE USE EFFICIENCY, RESOURCE PRODUCTIVITY AND SCALE RETURNS

Much importance was paid to the quantitative and statistical methods. Many attempts were made to establish economically important relationship between input and output to derive a production function - A mathematical model (Khan, 1961). The credit for defining the algebraic nature of production function went to Mitecherilich in 1909. The productivities of different inputs can be derived from the production function which indicates the efficiency of individual resources; when used in varying quantities and proportions.

An infinite number of functional forms are possible in productivity studies such as Cobb-Douglas, power function, Spillman function, Quadratic forms etc.

Cobb and Douglas (1928) developed in the industrial field an exponential type of production function in the form of $y = ab^x$.

This equation can be changed into linear form by using logarithms and is represented as $\log y = \text{Log } a + x \log b$.

This type of production function is widely used in the field of agriculture because of its greater flexibility and applicability.

Heady (1954) fitted two production functions, one for crop enterprise and another for livestock to measure the marginal value.

Suryanarayana (1958) has pointed out that diminishing returns to scale were prevailing with respect to land, labour and capital services on the Telangana farms.

Agrawal and Foreman (1959) measured farm resource productivity in Meerut and Muzaffarnagar district in western Uttar Pradesh based on the Cobb Douglas function for 1955-56. The estimates of marginal value productivities of different resources at geometric mean level of inputs were: gross cropped area Rs 34.55 per acre, human and bullock labour Rs 0.5 per rupee spent; seed, manure and irrigation charges Rs 1.80 per rupee spent and farm implements Rs 4.43 per rupee spent.

Bradford and Johnson (1962) fitted a production function of Cobb Douglas type to survey data of 30 farmers in Marshal County, Kentucky, USA. They expressed gross income as a function of land, labour, machinery, investment, forage production investment and other expenses (all current expenditure except that of hired labour, taxes, insurance and maintenance of bulding and machinery investment). The forage and livestock investment were complimentary and were combined.

Hanumantha Rao (1963) studied costs and returns for farm business as a whole and also fitted production function to the data. He observed that on an average, land is being cultivated more intensively among small farms through greater application of labour input, although labour still have positive returns and that among larger farms, when production elasticity of land is very low, there is relatively greater scope for increasing output through a more intensive cultivation of land by applying increasing labour input.

Reddy (1967) fitted production function for data collected in the year 1957-58 in West Godavari district and calculated the regression coefficients required to obtain a ratio of MVP/MFC of 1.0 for each of the variables viz., land, human labour, capital other than land and production expenses. The coefficient from the regression analysis was then tested for statistically significant difference from the one required to obtain a ratio of 1.0. It was found that all the ratios, except land for rice zone and production expenses for the district, were not significantly different from 1.0 indicating that the hypothesis of production efficiency in South Indian Agriculture could not be rejected during that year.

Saini (1969) studied the efficiency with which farmers in the States of Uttar Pradesh and Punjab used their resources to achieve the objective of maximizing net returns in crop production from the Farm Management Data of a sample of farms for 1955-56 and 1956-57. The analysis showed that farmers were quite rational in terms of their response to economic opportunities and made adjustments in resource use. He estimated different regression coefficients for small, medium and large farm size groups. But the coefficients of separate equations in respect of small, medium and large farms were not statistically different from those in the pooled equations. Thus farm size may not be a good criterion for detailed economic analysis. The farm productivity may be more significantly influenced by some factors other than farm size.

The studies included those of Sankhyan and Sirohi (1971), Srivastava and Nagadevar (1972), Kumar (1975), Dhawan and Bansie (1977), Singh (1978), Ghosh (1980). Most of these studies found that the Cobb-Douglas type of production function gave the benefit to the Indian data and did not reject the hypothesis that Indian farmers by using traditional technology maximised profit through rational allocation of resources.

Singh and Kahlon (1973) compared marginal value productivities of differnt resources used on farms at varying levels of technology. They concluded that the marginal value productivities of almost all the resource categories were higher on the farms with higher level of technology, thereby indicating their efficacies in using resources to optimum levels.

Singh *et al.* (1975) fitted Cobb-Douglas production function in backward agriculture to workout the elasticity of input to which in turn were used to calculate their marginal value products for average farms. The results of the study supported the hypothesis of constant returns to scale for both small and large farms in the selected regions.

Patel and Patel (1976) made an attempt to fit Cobb-Douglas type of production function for dry and irrigated wheat and computed the marginal physical productivities and marginal net returns per additional unit of inputs by using in the production function. The function showed increasing returns to scale in the irrigated area and diminishing returns under unirrigated conditions.

Suryanarayana (1980) fitted Cobb-Douglas type of production function for jowar farmers in Kurnool district along with Prakasam and Mahboobnagar district. The function showed that the MVP to opportunity cost ratios indicated inefficient use of resources to *kharif* HYV jowar. The MVP of seed was very high when compared to its factor cost. For local *kharif* varieties, the production elasticity was significantly different from zero only for human labour.

Reddy (1980) in his study on resource use and productivity on farms in drought prone and non drought prone areas of Mahboobnagar district, Andhra Pradesh, concluded that the regression coefficients of various inputs at aggregate farm level, indicated that the gross returns would increase significantly on all farms and drought prone farms by increasing the use of land, irrigation, improved seed and plant protection chemicals. Whereas in non drought prone farms the increase in the use of irrigation, improved seed and plant protection chemicals would add significantly for higher income.

Sharma and Tiwari (1985) studied the economic rationale of resource use on different categories of farms and suggested the ways and means for their efficient utilisation in Solan, Uttar Pradesh. The economic efficiency of fertilizers and manures was more than unity and significant in both big and small farms. They also concluded that the productivity could be substantially increased by increasing the resources.

RESOURCE PRODUCTIVITY

Schultz (1964) opined that "there is at best little opportunity for growth from traditional agriculture because farmers have exhausted the profitable production possibilities of state of the arts at their disposal". This was mostly true before the introduction of high yielding technology in the developing countries. In his opinion the key to transforming a traditional agricultural sector into a production source of economic growth is investment on modern high pay off inputs which should be made available to farmers in poor countries. Economic growth from the agricultural sector of a poor country depends predominantly upon the availability to use such inputs successfully.

Giri _et_ _al_. (1966) revealed that land was one of the major sources of crop output growth in India during the period 1951-52 to 1962-63 which accounted for about three fourth to four fifth of the total growth. Further, they identified that the remaining part of the growth was contributed equally by increase in the application of fertilizers, improved techniques and technological developments.

Minhas and Srinivasan (1968) observed that though yield responses to fertiliser are normally less in unirrigated fields than in the irrigated, still it is profitable to use fertilisers in the former. They also opined that the optimal strategies is not to concentrate the use of this scarce input only on high yielding varieties or irrigated areas but also to distribute the available supply widely over new and existing varieties, irrigated and unirrigated areas so as to maximise the output.

Falcon (1970) studied the second generation problems of green revolution in South and South East Asia. He found that the high response varieties and concomitant rapid growth in fertilizer use have produced yields per acre about double those possible with most of the other local strains. The study revealed that all new varieties receive controlled irrigations. In the absence of this, fertiliser yields a low returns and lack of new seeds and fertilisers limit the rapid increase in crop production.

Sharma and Joshi (1973) found that during 1968-69 to 1970-71, the contribution of HYV into the production in Maharastra increase from 17 to 23 per cent for rice, 34 to 66 per cent for bajra, 27 to 59 per cent for hybrid jowar and 34 to 57 per cent for wheat. Increase in yield due to application of fertilizer, irrigation and plant protection was observed to be of the order of 5.7 quintals per hectare for all crops.

Rao et al. (1985) while studying the technological changes and efficiency gains in dryland agriculture in Bangalore district employed the multiplicative production function form (Cobb-Douglas version) by performing the statistical test to assess the returns to scale. Since the sum of output elasticities did not differ from unity at any reasonable level of significance in all the three cases, constant returns to scale had been deduced as a convenient emperical result to validate hectare analysis. They further partitioned the per hectare differential output into components of technology and input using coefficients of the production function.

Returns to Sale

Dantwala (1959) reported the most extensive use of scarce resources tookplace, particularly in the case of land, on sample farms of Uttar Pradesh. The study revealed a diminishing trend with an increase in the size of farm.

Auer (1961) estimated the productivity of resources on farm and indicated the existance of a surplus of farm labour, a mis-allocation of capital and the prevalence of increasing returns to scale. He attributed increasing returns to scale in his study to more efficient use of farm machinery on the larger farm units than on the smaller ones.

Reddy (1961) reported the sum of elasticities of output to scale from the Cobb-Douglas function to be very near to unity (-1.0335) and an insignificant 't' value at 5 per cent level for farms of West Godavari district. He proved that the production was linear homogeneous function and hence concluded that constant returns to scale existed.

Brees and Colyer (1962) reported constant returns to scale for cash grain farms in Northern Missouri. Fertilizer use per acre did not vary sufficiently for this variable to exert any significant influence on gross income in the equation. The regression coefficient of 0.88353 for land resources, however, was much higher than that for any other regression coefficient computed in the study. This indicated that tillable acres were, by far, the most important resource for cash grain farms and that the fertilizer use was probably reflected in the land coefficient.

Griliches (1963) fitted Cobb-Douglas function for 68 regions of the U.S. to express value of farm production per commercial farm as a function of livestock expenses, other current expenses, value of machinery, land, buildings and labour in terms of man years. The sum of coefficient was significantly greater than one, thereby indicating substantial economies of scale. The coefficients for labour and machinery were the highest, being 0.449 and 0.359, respectively.

Khusro (1964) reported the regression fits carried out with gross output, farm business income and net profit per acre as three alternative dependent variables and farm size as the independent variable, there being seven replications corresponding to seven States. He used averaged out farm accounting data collected in Farm Management studied, from 1954-55 through 1956-57. All the regression lines fitted to the data of gross output per acre and average were downward sloping, the sign of the regression coefficient being invariably negative. It was "this consistently recurring phenomenon of declining slopes in all the seven

States without exception, that lends itself to the generalization that in Indian farming gross output per acre declined with an increase in farm size".

Krishna Raj (1964) found that the sums of elasticities of land and labour were 0.87, 0.97 and0.95 for 1954-55, 1955-56 and 1956-57, respectively for the Punjab Farms. The sums for the last two years of the study were not significantly different from unity. The estimates of the scale returns for these years suggested that the constant returns to scale of land and labour inputs over a considerable range was not an implausible assumption about agriculture in the two Punjab districts since those years.

Rao (1967) analysed the resource productivities and returns to scale by fitting Cobb-Douglas type of production function to cross sectional data covering 345 families of Hyderabad State and observed that the marginal value productivity of land declined with an increase in farm size and reverse tendency prevailed with regard to marginal productivity of labour which showed increasing trend with the increase in farm size.

Saini (1969) estimated the sums of the regression coefficients of the Cobb-Douglas production function fitted to the Farm Management survey data for Uttar Pradesh and Punjab farms for 1955-56 and 1956-57 and these were not significantly different from unity. This indicated constant returns to scale in all these cases.

Mehta (1971) estimated the marginal value productivities of different resources and returns to scale for different categories of farms in Punjab. He reported the constant returns to scale on these farms.

Singh (1975) reported that the returns to scale were constant in backward agriculture. He stated that the inefficient use of factors of production by the farmer was mainly responsible for the economic backwardness of the region and the size of farm was an important factor to influence the input productivity at the farm level.

Solik Ram and Lal Gupta (1978) compared the productivity of various resources in case of paddy on the farms of adopters and non-adopters in Varanasi district. The sum of elasticities of production for adopters and non-adopters was 0.989 and 0.929, respectively. These were not significantly different from unity and indicated constant returns to scale.

Saini (1980) reported that returns to scale are indicated by divergence of the sum of regression coefficients of all inputs from unity rather than coefficient of single input.

Suryanarayana (1980) reported that there was inefficient use of resources on all farms and for rice, maize and jowar crops in Andhra Pradesh. The production function analysis of these crops in all the selected districts indicated significant constant returns to scale.

3. IMPACT ON THE INCOME, EMPLOYMENT AND PRODUCTIVITY

Most of the farmers cultivating on dryland farms are unaware of the yield increasing technology and its adoption. Research and extension support needs to be intensified in dryland farming areas. The development of dryland agriculture by yield increasing techniques has now been well recognised for achieving the plan objectives of redressing regional imbalances, alleviating poverty and increasing the production of all those crops which are in short supply. Hence an attempt has been made to review the various studies and highlight the same in various aspects.

Savele (1966) concluded that the technological changes involving large investment of capital was not accepted readily and early in dryland areas by a large percentage of farmers.

Shetty (1966) pointed out that the variation in the adoption of an innovation could be explained by the difference in size of holding, tenurial status, profitability of innovation and the farmers liquidity.

Prasad (1970) reported that low yields, low income and low standard of living of farmers was mainly due to the non-availability of crucial inputs such as irrigation; inefficient use of other resources and raising of crops mainly for food and not for fodder requirements. His study also revealed that the yields of dry crops were very low ranging from Rs 15 per acre to Rs 300 per acre.

An upward trend to both money and real wages in Punjab due to adoption of new technology was observed by Soni (1970). Desai et al. (1970) studied the impact of high yielding varieties of groundnut, bajra, wheat, jowar and cotton on per hectare employment of different kinds of labour. They found that employment of casual labour was much more in case of high yielding variety groundnut, bajra and cotton. In the case of wheat, the total wage bill for improved variety was found to be lower than the local variety.

Swaminathan (1971) emphasised that for securing farmer's participation to make dryland agriculture successful, variables involved have to be properly studied and understood. Replacement of desi plough with a hard iron plough and the introduction of deep ploughing for high protein fodder like bajra and other high quality fodder crops were suggested.

Sham and Rathore (1971) examined the impact of improved agricultural technology in the [illegible] region of Rajasthan State and found that the farm business income as well as family labour income was more than double on the adopter farms compared to the non-adopter farms. Net profit on the adopter farms was Rs 1,179.8 per farm and Rs 327.7 per acre and it was Rs 191.7 and 61.8 only per farm and per acre on the non-adopter farms. The input-output ratio was significantly higher on the adopter farm compared to the non-adopter ones. It was 1 : 1.47 and 1 : 1.3, respectively.

George and Choukidar (1972) observed that the adoption of high yielding varieties was related to the size of holding, education and social status of the farmer. Age showed a negative relationship and lack of knowledge was one of the most important factors affecting the adoption of technology

Wills (1972) concluded that, based on empirical estimates of the impact of new technology on employment and income at local level, that the adoption of new seeds, fertilizer and irrigation increases employment and wages, it also increases the disparity between incomes of farmers and agricultural labour. The disparity will increase further if labour saving machinery is introduced. However, the new technology will reduce the disparity between incomes of large and small farmers if credit and fertiliser are distributed according to area operated.

Grewal and Kahlon (1973) have studied the farm size and productivity relationship. They have observed that because of recent technological breakthrough in agriculture, the importance of the traditional inputs in the input-mix was on the decline and non-conventional inputs such as fertiliser, pesticides and machine power have become important. This seems to have altered the traditional farm size productivity relationship. Large farms have greater access to indivisible technological inputs such as tractors and allied farm machinery.

Choudhari (1974) stated that the area under kharif crops in India, has raised substantially during the past four years from 32 per cent of the gross cropped area to 54 per cent in addition to the ten-fold increase in the double cropped area as a result of adoption of the improved soil water crop and livestock management technology in the Indo-U.K. project. The crop yields were increased by 30 to 500 per cent. The technology has been labour and bullock intensive.

Rajshekar (1975) assessed analytically the nature of farm business of small and large farms in one of the dry farming regions of Maharastra State. They observed from the study that use of different resources, cost of production, gross returns, as well as net returns, depended on farm size. A substantial change in the present profitability level could be brought about through creation of irrigation resources, use of modern inputs and adoption of modern technology.

Saini (1976) presented the empirical evidence of the growing inequalities in farm incomes by analysing the farm level data collected under the scheme for studies in economics of farm management at two points of time i.e., 1955-57 and 1967-69. It is evident that the income gap between the small and large farms has widened and big farmers have gained considerably from the new technology ushered in by the green revolution.

Bisalaiah (1977) decompsed the growth in per acre wheat output in Punjab into its sources and observed that technical change contributed 15 per cent of the increased output. Increased use of labour, fertilizer and capital per acre under Mexican wheat has contributed about 25.5 per cent of increased output.

Havangi (1978) studied the impact of dryland farming and observed that the adoption of suitable land management and development techniques for dryland in Bangalore region is possible to get reasonably good yields in most of the areas receiving 500 mm or above. Hence he suggested that the land development in drylands should receive top priority both in proven practices as well as in research on large farms.

Kunal (1978) using the output decomposition model (Bisalaiah) estimated that there was 72 per cent growth in jowar output per farm in Dharwad with the introduction of new technology of this total change in output per farm, about 33 per cent was found to have been contributed by technical change, research and extension are the two important major activities for effecting technical change in farm economy. Of the total change in output per farm, about 12 per cent is indicated to have been contributed by differences in land holding size, given the output elasticity of land under new technology. About 23 per cent difference in output under new technology is contributed by capital input. Since the fertilizer component of capital input forms the greater proportion of the total value of capital, the contribution made by fertiliser to total change in output may be considered as substantially high.

Rastogi (1979) concluded that though the new dry farming technology developed at research centres has been found quite viable and feasible and though it was said to be neutral to scale. It has not yet gained popularity with the farmers in the arid and semi-arid regions of the country.

Rao and Rastogi (1980) in a study at Hyderabad district observed that the adoption of new technology was not high in dry farming tracts due to shortage of capital. Recent technological advances have substantially increased the yield potential of drylands, provided the requisite inputs are available.

Rao and Rastogi (1980) in their study conducted in Hyderabad district observed that persistance with the adoption of technology was not high in dry farming tracts due to shortage of capital. Recent technological advances have substantially increased the yield potential of drylands, provided the requisite inputs are available.

Rajasekhar (1983) in a study in the operational research project, showed that low monetary inputs like introduction of cultural practices have given encouraging results. He further stated that the early tillage practice for sorghum and use of high yielding varieties of finger millet resulted in 40 per cent extra yield.

Reddy et al. (1985) reported that over the past one decade and a half, the primary emphasis was given on the generation of dryland technologies. These include better management of soil, rain water and cropping system to optimise crop production. Additionally increased yields were achieved through the use of improved seed, application of fertilizer and better management. Apart from these, the challenges of weather abbrations were met by providing alternate crop strategy.

Jodha (1986) concluded that owing to the small size of holding on one hand and ecological limitations of dryland agriculture on the other the latter even with strong support of new technologies, may not prove a total answer to the problem of low income of those who depend on dryland farming and thus the need for non-farm activities as a part of rural development cannot be overstated.

Singh (1987) stated that the dryland soils pose serious problems of management and consequently sustained productivity. Most of the dry land soils are degraded or are in process of degradation. He also pointed out that the fodder was a priority number two, first being food, followed by fuel wood among the basic needs of the dryland areas. Because of the scarcity of fodder in dryland areas, many of the farmers cannot even own a pair of bullocks.

Reddy (1987) identified main reasons for non-adoption/partial adoption of technology which were (i) fear of risk due to failure of monsoon which lead to crop failure or low yields, (ii) lack of conviction of improved technology (iii) lack of finance to invest on improved technology.

Rao (1987) reported that the adoption levels of dryland technologies are quite low. Even the Seventh Five Year Plan has set a modest target of 25 per cent areas saturation with improved technologies by March, 1992. No hard data are available about the levels of adoption of dryland technologies by the farmers across the country. He concluded that the rate of adoption of improved varieties exceeded 70 per cent for cluster bean, 30 per cent for pearl millet and 35 per cent for maize. But the rate of adoption in case of sorghum was about 10 per cent.

Suligavi (1988) examined the impact of technological change in rainfed cotton in Dharwad district employing the output decomposition model based on the coefficients derived from the Cobb-Douglas production function. The output decomposition analysis revealed that there was an increase of 115 per cent more output per farm with the introduction of new technology. The contribution of technical change to the total change in output was 62 per cent. The inputs attributing to output changes were seed + fertiliser, plant protection chemicals, capital and labour were in the order of 19 per cent, 3 per cent and 13 per cent, respectively. Thus the total inputs brought about 53 per cent increase in the total output. The results indicated that the technical change was a major source of output growth in agricultural sector of developing economies. Research and extension are the two main activities for effecting technological change in the farm economy.

Technological change and income distribution

Kuzhents (1955) suggested that the income becomes more evenly distributed during the later stages of economic growth where there is a general increase in income levels and the income in agricultural sector is more equally distributed than in the non-agricultural sector. Similar view was taken by the committee on distribution of income and levels of living appointed by the planning commission, Government of India in 1964, which reported that "the degree of inequality in income distribution is not higher in India than in some other developed or underdeveloped countries and the distribution of income in urban sector is more unequal than in rural sector".

Khaund (1970) studied the changing pattern of income distribution in tribal village of Tripura using Lorenz curve technique, has demonstrated that changing cultural practices bring about changes in the livelihood pattern and consequent changes in the allocation of resources in the economy which in turn cause the income distribution pattern to change.

Chinnamani et. al. (1970) reported that modern dry farming technology (in Hyderabad district, Andhra Pradesh) such as adoption of soil conservation measures, graded bunding, contour bunding, timely sowing, use of improved and short duration varieties with proper and adequate seed rate, application of fertilizer under rainfed conditions and use of plant protection measures has provided the farmer an income which was 200 per cent more than what he and other farmers around the village get by adopting local conventional methods.

While estimating the income raising potential on rainfed farms Shukla (1971) found that the net gains by advanced technology of the order of 32 per cent in the dryland farms in Jabalpur district of Madhya Pradesh.

Crisostoma et al. (1971) examined the potential for labour absorption under the new technology and concluded that the new rice technology has increased labour use per hectare and that multiple cropping in Taiwan offered a potential for labour absorption.

Pandey (1972) compared the adopters and non-adopters of high yielding varieties and fertilizers in Varamati district and found that adopters used much higher levels of labour input than non-adopters. In his study, he found that the adopters used 50 per cent more family labour and 200 per cent more hired labour than the non-adopters.

Hansen and Schwartz (1977) studied the income distribution programme benefits for a sample of participants in sacrements country using Gini coefficients, they could conclude that the fraction of benefits received lower income farmers was quite large compared with their share to total income and were sufficient to cause a significant positive shift in farm income distribution.

Rao and Kahlon (1978) using Gini concentration ratios and Lorenz curves inferred that greater benefits from the green revolution accrued to the large holdings through all size groups recorded increases in farm incomes in Hissar district.

Singh et al. (1981) attempted to study income and employment effects of new dryland tecnology in Haryana. It was observed that per farm net income was increased on small, medium and large farms at intermediate and improved levels of technologies. The increase in net farm income at the intermediate technology level over the existing one was the highest, being 38 per cent on small holdings, followed by 23 per cent on medium holdings. At the improved level of technology, the net increase in income over the existing level of technology was 88 per cent, 44 and 11 per cent on small, medium and large holdings in order.

The results of the study conducted by Sidhu and Grewal (1981) have indicated that a significant change has taken place in the Punjab economy with respect to employment structure since the introduction of new agricultural technology. As revealed by the census data, the proportion of agricultural workers to total workers in the State decreased to 59.15 per cent in 1981 from 62.68 per cent in 1971. The analysis of field survey also brought out similar results whereby the share of agricultural workers in the sample villages witnessed a decrease from about 71 per cent in 1966-67 to about 65 per cent in 1980-81. However, the dependence on hired labour has increased significantly over time which is revealed by the fact that the proportion of agricultural labourers to total agricultural workers has increased from 32.10 per cent in 1971 to 38.60 per cent in 1981 according to census data and from 32.79 per cent in 1966-67 to 37.13 per cent in 1980-81 according to the field survey.

Singh et al. (1981) decomposed total change in employment due to adoption of new dryland technology in Haryana State. They observed that in Hissar zone, the contribution of technology and capital component to the employment change was positive in all the size groups. The interaction effect of capital and technology was positive and it contributed more towards increasing the employment than a single component (capital or technology) in both the zones.

Bisaliah (1982) studied the effects of new agricultural technology on functional income distribution with the help of cross section input-output data of the sample of wheat farms in Ferozpur district of Punjab. The estimates of Cobb-Douglas production function analysis revealed that the parameters governing the production relations under old technology are different from those of new technology. The dummy variable technique has suggested capital as the main variable in causing structural break in wheat.

Patel and Gangwar (1983) opined that capital has a significant role to play in changing the existing cropping pattern on all sizes of farms. Profits on all size of farms can be increased considerably by making the required capital available to the farmers. Since capital is a scarce resource particularly for the small farmers, therefore, there is a maximum increase in profit on these sizes of farms, when the capital requirements are met fully. Technology also has been found to increase the net income on small farms followed by medium and large farms. Similarly, employment of human and bullock labour increased on all farm plans excepting in the plan involving improved technology with restricted capital. The improved technology generated more employment on all sizes of farms when capital constraint was relaxed. Hence, it can be concluded that technology and capital both have vital roles to play in increasing the farm earnings and employment on all sizes of farms.

Hebbar and Bisalaiah (1984) indicated with respect to employment, land holding size relatinship are conclusive in the case of dryland crop production situation, but not that conclusive in the case of overall crop production situation. Small farms under dryland crop production are favoured from the point of view of employment expansion because of the identified inverse relationship between labour use and holding size. But under overall crop production situation, the regression coefficient for the size of holding in the per hectare employment function is not statistically significant. However, the negative sign of this coefficient indicated the tendency for decreased labour employment per hectare with an increase in holding size.

The study of Reddy (1985) revealed that the income is derived from crop production, dairy, agricultural wages, profession/service and non-agricultural wages. The variation in income among different sources is noticed from location to location and from region to region.

The expenditure on equipment in the arid region and that on labour in the semi-arid and sub-humid regions are more. On an average basis, the total income exceeded total expenditure per household. The income of the farmers can be improved through better cropping pattern/agronomic practices and diversified farming activities to derive higher cash income in drylands.

Gupta et al. (1986) carried out a study on the impact of improved technology on employment of wheat farmers under dry farming conditions. It was reported that the adoption of improved technology generated employment opportunities and there was 45 per cent additional requirement of labour as compared to the traditional technology. The improved technology of wheat required more labour per hectare as compared to the traditional method.

SUMMARY OF REVIEW

The review of literature highlighted that the dryland improved technologies were superior and profitable when compared with traditional practices. The gross returns, net returns, cost benefit ratios were higher in case of improved technologies as compared to traditional farming. The cost studies conducted through farm management studies by Directorate of Economics and Statistics provided the guidelines for calculating the cost of cultivation. Some studies indicated that the small scale farming is as efficient as large scale farming in dryland areas. Most of the cost studies conducted earlier did not take imputed value of family labour. In the present study, this was also included

A thorough examination of literature available on resource productivity, scale returns and resource use efficiency revealed that Cobb-Douglas production function is more suitable for assessing the resource productivity and resource use efficiency on dryland farms. Most of these studies did not discuss about the presence of multi colliniarity in the function. Hence a step down procedure was used to overcome this problem in the present study.

Despite some small ommissions in the literature reviewed, the review of these studies helped to develop the methodology for conducting the present study.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The study is conducted to evaluate the impact of dryland farming technology on production, income and employment.

The sample design, tools of analysis, methods of estimation and concepts used in this study are outlined in this chapter.

3.1 SELECTION OF THE AREA AND ITS PURPOSE

The world bank funded Maheshwaram Pilot Project located in Ranga Reddy district of Andhra Pradesh was setup to develop dryland farming on integrated manner on watershed basis.

To study the impact of dryland farming technology, Maheshwaram region of Ranga Reddy district was purposively selected. The programme is being carried out in this watershed area by the Department of Agriculture with the technical guidance of Andhra Pradesh Agricultural University and CRIDA.

The watershed project was started by the Government of Andhra Pradesh during the year 1984-85 and development works on dryland has commenced since then. Hence the necessity to evaluate such studies on adoption of technology was felt so as to know the real impact on production income and employment [illegible]

The Maheshwaram Project extends over an area of 25,331 hectares comprising of 16,390 hectares of arable land and 8556 hectares of non-arable land extending over 23 villages in Ranga Reddy district (4 villages from Ibrahimpatnam, 1 from Kandukur and 18 villages from Maheshwaram Mandal). The watershed drains into Pulandari Vagu which is a small tributory of Musi River which again a tributory of Krishna River[1].

3.2 SAMPLING DESIGN AND SAMPLING PROCEDURE

Two stage stratified random sampling procedure was adopted for the selection of respondents.

3.2.1 Selection of the district

Ranga Reddy district which represented the hard core of dryland areas was purposively selected for the study because such watershed development programme was initiated first in the district in Andhra Pradesh.

3.2.2 Selection of Watershed

This watershed was specifically chosen since the financial assistance of the World Bank has been provided for its development. The Andhra Pradesh Agricultural University which is located in Ranga Reddy district has been providing technical guidance in the

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1 JDA State Government, Action Plan Report (1988-89) of Pilot Project for watershed development in rainfed areas, Maheshwaram watershed, Ranga Reddy district, Andhra Pradesh.

implementation of the programme. Further the changes in agricultural activities were being effected mainly through transfer of technology developed for dryland agriculture with special emphasis on soil conservation and water harvesting besides agro-forestry systems etc. Hence Maheswaram watershed has been chosen for the study purposively based on its merits and utility.

3.2.3 Selection of Villages

a) Watershed (Adopters) Villages

The Maheswaram watershed is divided into 6 sub-watersheds. From each sub-water shed one village was selected based on the highest area under dryland cultivation and the extent of adoption of dryland technology. These villages are typical representing entire the watershed development area. The selected villages were Maheswaram, Mankhal, Ravi Ral, Mangalpalli, Banglur and Tummalur.

b) Selection of Non-watershed area (Non-adopters)

For the purpose of comparison 3 villages were selected in the area which is outside the watershed but well within the close vicinity. Though these villages are situated adjacent to the watershed area, the adoption of technology was also minimum. These three villages were selected by adopting simple random procedure. The three selected villages were 1. Lemoor, 2. China Gollapalli and Peda Gollapalli and 3. Kurmalguda.

3.2.4 Selection of Cultivators

a) Adopters :

The farmers who well expressed to new technology and / watershed based technology. These farmers derived benefits from watershed programme. It has been decided that a minimum of 120 farmers from the watershed villages be selected for the study. A list of all the farmers in all the selected villages of the watershed was prepared and ranking was made in ascending order according to size of holdings. The farmers were selected by adopting random sampling technique with proportianate to stratum size. The farmers were selected from different size groups based on the operational holdings. These groups were small (< 2 ha), medium (2 to 4 ha), large (above 4 ha) farmers. A total of 120 farmers were selected from all the villages. The frequency distribution of selected cultivators is presented in Table 3.1.

Table 3.1 Selection of Adopters

S.No.	Size group	No.of farmers in the selected Watershed villages	No.of farmers in the sample
1.	Small	620	67
2.	Medium	279	30
3.	Large	207	23
	Total Overall	1106	120

b) **Non-adopters**

These farmers are not exposed to new technology and or watershed based technology . Even they did not derive benifits directly or indirectly from watershed programme. The same number of farmers i.e., 120 were selected from non-watershed area by adopting the random sampling technique with stratified proportionate to stratum size. The frequency distribution of the selected farmers (non-adopters) is presented in Table 3.2

Table 3.2 Selection of Non-Adopters

S.No.	Size group	No.of farmers in the selected Non-Watershed area	No.of farmers in the sample
1.	Small	470	64
2.	Medium	280	38
3.	Large	104	18
	Total Overall	854	120

The table 3.3 clearly indicates the detailed distribution of sampled farmers among selected technology adopted and non-adopted villages.

Table 3.3 Distribution of sample farmers among selected villages

Name of the village	Number of sample farms			Total
	0-2 ha	2-4 ha	4 ha-above	
I Watershed area (Technology adopted)				
1. Maheswaram	15	7	4	26
2. Mankhal	8	8	4	20
3. Raviral	12	4	9	25
4. Mangalpalli	5	2	1	8
5. Banguloor	9	5	4	18
6. Tummaloor	18	4	1	23
	67	30	23	120
II Non-watershed area (Technology non-adopted)				
1. Lemoor	29	20	6	55
2. Chinnagollapalli/ Peddgollapalli	18	11	7	36
3. Kurmalguda	17	7	5	29
Total overall	64	38	18	120

3.3 COLLECTION OF DATA

The survey method was used for collection of the data from sampled farms. A suitable questionnaire was developed incorporating all the items on which information required. The entire questionnaire was pre-tested in the field with a separate sample of farmers. Based on the pre-testing, necessary modifications were made in the final questionnaire. Data on different aspects such as operational holdings, land use pattern, cropping pattern, irrigation, farm assets, family size, literacy levels were required to get a glimpse of the background information of the farmers to understand the socio-economic characteristics.

Data relating to physical inputs such as human labour, both family and hired labour, inventory of land, implements and machinery, operating capital such as seed, manure and fertilizer, plant protection chemicals, cost of maintenance of cattle, details of family expenditure, etc. were required to assess the income accruing and the employment levels of farms. The details of input prices including wage rates for hired labour, price of seed, manures, fertilizers, insecticides and fungicides are required to compute the operational costs of the farms.

Prices of output including the harvest prices of the crop products and by-products are essential for computing the gross farm income.

The respondents were individually contacted in person with the assistance of Village Development Officers and Assistant Agricultural Officers. All the required data were collected through interview method from each farmer for the agricultural year of 1988-89.

3.4 TOOLS OF ANALYSIS

Conventional as well as functional analyses were used to arrive at valid conclusions. Tabular analysis has been used mainly to find out the impact of technology by comparing adopters situations with non-adopters.

3.4.1 Lorenz Curve

To examine the income inequalities of the farmers belonging to adopted and non-adopted groups, Lorenz curve was drawn and Gini concentration ratio was calculated.

3.4.2 Gini Concentration Ratio

The Gini Ratio, which was developed by Gini in 1913, has been computed directly from the Lorenz curve to know the near inequality. Although the Lorenz curve is for graphical representation of the income inequality, it does not give a precise value that can be used for comparison. The Gini ratio, on the other hand, has the convenient property of using for comparison in a precise way

The Gini ratio is defined as "the proportion of the area under the diagonal that lies between the diagonal and Lorenz curve".

The Gini Ratio is computed using the formula

$$G.C.R. = 1 - \sum_{j=1}^{n} P_j \left[Q_j + Q_{(j-1)} \right]$$

Where P_j = Proportion of adult persons in the j^{th} house hold

Q_j = Cumulative proportion of per capita income in j^{th} household.

$Q_{(j-1)}$ = Cumulative proportion of per capita income in $(j-1)^{th}$ house hold

3.5 MAHALANOBIS D^2

To distinguish between the two situations i.e., watershed and non-watershed, Mahalanobis D^2 was obtained and was tested for significance as follows:

$$D^2 = [\bar{X}^{(1)} - \bar{X}^{(2)}]' \; S^{-1} \; (\bar{X}^{(1)} - \bar{X}^{(2)})$$

Where,

$\bar{X}^{(1)}$ and $\bar{X}^{(2)}$ are the sample Mean vectors of the variables under the two situations

S = Pooled sample variance - covariance - matrix of the variables.

$$F = \frac{N_1 N_2}{N_1 + N_2} \cdot \frac{(N_1 + N_2 - K - 1)}{(N_1 + N_2 - 2)K} \cdot D^2$$

Where,

K = No. of variables

N_1 = No. of observations under watershed

N_2 = No. of observations under non-watershed

3.5.1 Functional Analysis

Functional analysis has been used to estimate the resource productivity on adopter and non-adopter farms. Among the various functions available after a preliminary exercise of scatter diagrams, it was decided to select the Cobb-Douglas form of Production Function. Further this Production Function has got various advantages over others - most important being that these co-efficients of different independent variables directly indicate production elasticities.

The empirical evidence from the previous studies also suggested that the Cobb-Douglas function was the most appropriate one for studies of this nature.

The function can be specified as follows :

$$Y = a.x_1^{b1} \ldots\ldots\ldots x_k^{bk}.u$$

Where,

Y = dependent variable (output)

x_i = i^{th} input for i = 1,2,......K

u = Random Error and

(a,bi) for i = 1,....,k are the parameters.

In the present study, Cobb-Douglas production function was fitted to each of the size groups as well as for the overall group in respect of the adopters and non-adopters.

For this purpose the production function was fitted to the data on 7 input variables and the income. It can be specified as

$$Y = ax_1^{b1} .... x_7^{b7} .u$$

Where

Y = Income (Rupees) output

x1 = Land

x2 = Human labour (Rs)

x3 = Cattle labour (Rs)

x4 = Seed (Rs)

x5 = Manure (Rs)

x6 = Fertilizer (Rs)

x7 = Plant protection measures (Rs)

u = Random error

a = Constant and

(b_1, ... b_7) are the elasticities of the inputs

The above function reduces to a linear multiple regression model by logarithmic transformation

i.e., $\log y = \log a + b^1 \log x^1 + ... + b^7 \log 7 + e$

The above equation was fitted with the help of Least Squares method$_1$.

The common problem faced in fitting production fucntion is that the independent variables are often linearly correlated. This creates the multicollinearity problem in estimation. To minimise its effect the stepdown regression procedure was followed.

The overall fit of regression equation was ascertained on the basis of the coefficient of multiple determination R^2 and the significance of the coefficients of the variables in the functional relationship. R^2 is obtained from the following formula

$$R^2 = \frac{\text{Reg.S.S}}{\text{Total S.S}}$$

where Reg.S.S = $b1 \sum t_1 z + b2 \sum t_2 z + \ldots,$

$t_i = (\log X_{ij} - \overline{\log X_i})$; $i = 1, \ldots, k$; $j = 1, \ldots, n$.

$z = (\log y - \overline{\log y})$

Total S.S = $\sum z^2$, k = number of independent variables, n = Total number of observations

R^2 which lies between 0 and 1, indicates the percentage variation in the depndent variable explained by the independent varraibles in the euqation. The coefficients of the variables in the final equation were tested as follows.

Null Hypothesis : $b_i = 0$

Then $t_i = \dfrac{|b_i|}{SE(b_i)}$

Where, SE $(b_i) = \sqrt{EMS\ (c_{ii})}$, c_{ii} are the diagonal elements of the invers matrix of the variance covariance matrix.

Conclusion: If the calculated t_i values are $\geq$ the corresponding "t" value at (n - k - 1) df. then we reject the null hypothesis and conclude that the b_i's are significantly different from zero.

Draper NR and Smith H (1981). Applied Regression analysis. Publishers John Wiley sons, Newyork.

3.5.1 Factors and Scale Returns

The coefficients of different input variables provide the measure of factor returns, if the production elasticity is significant and less than one it indicates diminishing factor returns. If it is more than one it signifies increasing factor returns. If it is equal to one it indicates constant factor returns.

The sum of all other individual production elasticities gives the scale returns. If this is equal to one significantly, indicates significant constant returns. If it is more than one, it significantly indicates increasing scale returns. If it is less than one, it indicates diminishing scale returns.

The estimates of b_i in the regression equation provide information regarding the returns to scale. To test the hypothesis of returns to scale, the following formula has been used.

Null Hypothesis: $\sum b_i = 1$

then $$t_i = \frac{\left| \sum b_i - 1 \right|}{SE\ (\sum b_i)}$$

Where SE ($\sum b_i$)

$$= \sqrt{S\ (C_{11} + C_{22} + \ldots + C_{77} + 2C_{12} + 2C_{13} + \ldots + 2C_{76})}$$

S = Mean sum of squares due to Error in the AV Table, C_{11}, $C_{22} \ldots C_{12}$, C_{13} are the elements of inverse matrix of variance and covariance of the variables.

Conclusion: The calculated 't' value is then compared with and the the corresponding table of null hypothesis is rejected wherever 't' (Cal) $\geq$ 't' (Table). Thus, if $\sum b_i$ is not significantly differnt from 1 indicates constant returns to scale. However, if $\sum bi < 1$ or $\sum bi > 1$ then the returns are respectively diminishing, and increasing.

3.6 CONCEPTS AND DEFINITIONS

The concepts and definitions used in this study are presented below.

3.6.1 Man day

It is the work turned out by a male adult in a duration of 8 hours.

3.6.2 Cattle pair day

It is the work done by a pair of cattle in a duration of 8 hours.

3.6.3 Fixed Capital

The value of land, farm buildings, wells, machinery and equipment are included under fixed capital.

3.6.4 Working Capital

The value of work cattle, implements and other dead stock are included under this.

3.6.5 Fixed Costs

Under fixed costs, rental value of the owned land, depreciation, land revenue, interest on fixed capital (non-landed assets) were considered.

3.6.6 Variable Costs

Costs incurred on seed, manures, human labour, bullock labour, machine labour, fertilizers, plant protection chemicals, irrigation and interest on working expenses are included under variable costs.

3.6.7 Total Costs

Fixed costs and variable costs together constituted the total costs.

3.6.8 Cost A_1

This was estimated by taking the expenses actually incurred by the owner cultivator. These are cost of seed, cost of manures and fertilizers, hired, human labour, cattle labour (both owned and hired) interest on working capital, depreciation, plant protection materials, irrigation charges and land revenue.

Cost A_2 pertains to tenant farmers.

3.6.9 Cost B

This was estimated by adding the rental value of owned land and interest on fixed capital to Cost A_1/A_2 as the case may be.

3.6.10 Cost C

This is the commercial cost of production and obtained by adding the imputed value of family labour to Cost B.

3.6.11 Productivity

Yield in quintals per hectare for a crop is taken as its productivity.

3.6.12 Cropping Intensity

It is the ratio of gross cropped area to net cropped area and was expressed as a percentage. This was obtained by

$$\text{Cropping Intensity} = \frac{\text{Gross cropped area}}{\text{Net cropped area}} \times 100$$

3.6.13 Farm Returns

Differnt measures of farm returns viz., gross returns, net returns, farm business income, farm family income and farm investment income were adopted. These measures are defined hereunder.

3.6.14 Gross returns

This pertains to the total value of crops produced on the farm.

3.6.15 Net Returns

These were worked out on the basis of cost C and prime cost. These are the excess of gross returns over the respective cost concepts.

3.6.16 Farm business income

This was obtained by deducting cost A_1/A_2 from gross income. This is the return to the farmer for himself and his family labour and investment on owned land and owned fixed capital.

Farm business income = Gross income - Cost A_1 or A_2.

3.6.17 Farm family labour income

This was obtained by deducting cost B from gross income. This is the measure of returns from cultivation to family labour.

Farm labour income = Gross income - Cost B.

3.6.18 Farm investment income

This was obtained by adding to the net income the imputed value of owned land and interest on fixed capital.

Farm investment income = (Gross income - Cost C)
+ ((Cost B - Cost A)

3.7 PROCEDURE ADOPTED IN COMPUTING COSTS

3.7.1 Seed

The price of the farm grown seed has been charged at the prices prevailed in the village. For the purchased seed, the amount spent towards the purchase of the same has been taken including the transport charges.

3.7.2 Bullock labour

The cost of owned bullock labour per work day was calculated at the hire rates prevailing in the village for a bullock pair day and included in the cost of cultivation, based on the number of pair days contributed for each crop. In case of hired pair, the actual amount paid towards hire charges has been taken.

3.7.3 Human labour

The charges for human labour consists of wages that are paid for family labour, and casual labour.

The value of family labour has been imputed at the current average wages paid to the permanent labour in the locality. The wages of hired labour include the cash and perquisites and the wages in kind were converted into cash.

3.7.3.1 Man working days: Man work day usually refers to the work turned out by a man in a day of eight hours. All the work days of child and women labour were converted into man work days in proportion to the wages paid to them. In the case of family labour it was evaluated at the prevailing wage rates for hired labour. Permanent hired labour was mainly employed in the study area for maintenance of cattle and other odd jobs. Hence, the amount paid to permanent workers is not included in the wage bill. In farms where permanent workers sometime participate in crop production activity, the evaluation was done at prevailing wage rate as is done in the case of family labour.

3.7.4 Manures and Fertilizers

In the case of purchased farmyard manure, the entire amount was charged. In the case of produced manure it was imputed at the prevailing market rates in the locality. The actual costs of different fertilizers and transport charges were included in the total cost of concerned crops.

3.7.5 Plant protection material

They were computed at the purchase price. The transportation charges were also included for the purchased pesticides from nearby town.

3.7.6 Interest on working expenses

This was charged at 12 per cent per annum. Since the amount spent on working expenses was not incurred at a single point of time but spread over the entire production period, the interest was charged on total working expenses for half of the crop period.

3.7.7 Interest on fixed capital

The interest was calculated at 10 per cent on the fixed capital excluding land value.

3.7.8 Irrigation charges

The expenses actually in lifting the water from wells i.e. fuel and electricity charges were considered in the case of lift irrigation. In the case of flow irrigation the cess paid was taken as the cost of irrigation.

3.7.9 Land Revenue

The actual amount paid was charged in the case of land revenue.

3.7.10 Rental value of owned land

One-sixth of the gross value of produce was taken to impute the rental value of owned land as practiced in the village.

3.7.11 Depreciation

Depreciation of farm assets like cattle shed, storage and implements shed, electric motor shed was worked out at two per cent for pucca and five per cent for kutcha structures. Depreciation on implements was worked out ten per cent of the cost.

3.7.12 Input - Output Ratio

This is the ratio of the gross returns and total cost/prime cost.

$$\text{Input output ratio} = \frac{\text{Gross income}}{\text{Total cost}}$$

3.7.13 Benefit Cost Ratio

This is the ratio of the net returns and the total cost and estimated as

$$\text{Benefit Cost Ratio} = \frac{\text{Net returns}}{\text{Total Cost of Cultivation}}$$

The methodology, as described above, was used in conducting the study in the Maheswaram watershed area vis-a-vis an area adjoining the watershed in Ranga Reddy district. The Agro-economic features of the study area are presented in the ensuing chapter.

AGRO-ECONOMIC FEATURES

CHAPTER IV

AGRO-ECONOMIC FEATURES OF THE STUDY AREA

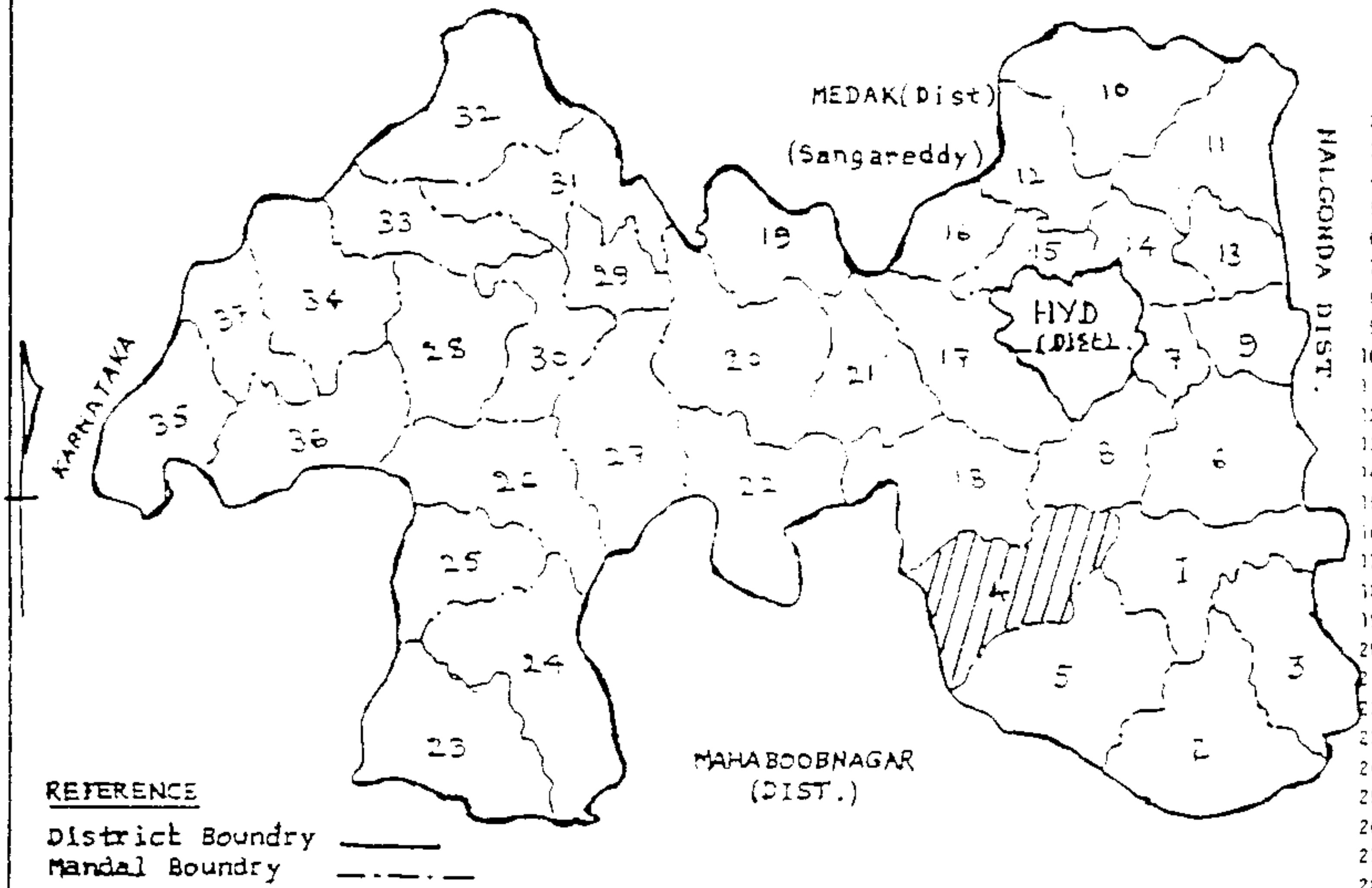
In this chapter an attempt has been made to present the agro-economic characteristics of the study area. To have a comprehensive idea of the study area and to serve as a back drop for the study, the presentation is made under sub-headings, such as, soils, climate, seasonal conditions, land use pattern, irrigation, implements and machinery, livestock, distribution pattern of land holdings, area, productivity and production of important crops etc.

4.1 THE DISTRICT IN BRIEF

4.1.1 Location

Ranga Reddy district is located at the heart of Dakshinapatha or the Deccan Plateau of the Indian sub-continent and lies between 16°0' 90' and 18°0'20' north latitude and 77°0'30' and 79°0'30' East longitude, bounded on the North by Medak district, on the East by Nalgonda district, on the South by Mahaboobnagar district and on the West by Gulbarga district of Karnataka State. It covers an area of 7493 square kilometers. The road leading to Srisailam passes through the study area and it is about 32 kms south of Hyderabad. This district is primarily the rural hinter

Fig-1 MANDALS IN RANGA REDDY DISTRICT



MANDALS

1. Ibranimpatnam
2. Yacharam
3. Manchal
4. Maheswaram
5. Kandkur
6. Hayatnagar
7. Uppal
8. Saroornagar
9. Ghatkesar
10. Medchal
11. Shamirpet
12. Qutbullapur
13. Keesara
14. Malkajigiri
15. Balanagar
16. Serilingampally
17. Rajendranagar
18. Shamshabad
19. Shankarpally
20. Chevella
21. Moinabad
22. Shabad
23. Gandeed
24. Kulakacherla
25. Doma
26. Pargi
27. Pudur
28. Dharoor
29. Nawabpet
30. Vikarabad
31. Mominpet
32. Marpally
33. Bantwaram
34. Peddemul
35. Basheerabad
36. Yalal
37. Tandur

land for Hyderabad city, feeding the powerful commercial centre with various raw materials; agricultural produce and finished products.

Table 4.1 Occupational distribution of Population in Ranga Reddy district

S.No.	Particulars	1981 Census	P.C.to total
1.	Total population	15.82 lakhs	100.00
2.	Females	8.09 lakhs	51.14
3.	Males	7.73 lakhs	48.86
4.	Females/1000 males	956 Nos.	--
5.	Rural population	12.05 lakhs	76.17
6.	Urban population	3.77 lakhs	23.83
7.	Literates	3.16 lakhs	19.98
8.	Workers	7.27 lakhs	45.95
9.	Non-workers	8.55 lakhs	54.05
10.	Cultivators	2.26 lakhs	14.29
11.	Agricultural Labourers	1.99 lakhs	12.58
12.	Density of population	211/sq km	--

Source: The Chief Planning Officer, Ranga Reddy District

4.1.2 Administrative Divisions

The Ranga Reddy district has been divided into 982 inhabited and 73 uninhabited villages and is covered by 649 Grampanchayats. There are 3 Revenue divisions viz., Hyderabad East, Hyderabad West and Vikarabad. Two divisions are headed by the Revenue Divisional Officers while the 3rd viz., Vikarabad is headed by a Sub-Collector. There are 16 towns in the district of which 14 are Panchayats and 2 Municipalities. There are about 37 Mandals in the district.

The district was formed on 15th August 1978 by carving out from the Hyderabad district excluding the twin cities of Hyderabad and Secunderabad. Still all the district offices are located and functioning in Hyderabad City only.

4.2 DEMOGRAPHIC TRENDS

According to 1981 Census, the district has a population of 15.82 lakhs. About 76.17 per cent of total population is living in rural areas. The remaining population lives in urban aglomeration. The occupational distribution of population of the district is presented in Table 4.1. The density of population in the district was estimated as 211 persons per square kilometer. The male population constituted 51 per cent as against 49 per cent of females. Thus the sex ratio worked out to 956 females for every 1000 males.

The proportion of workers and non-workers in the district has worked out to 45.95 and 54.05 per cent respectively. The cultivators and agricultural labourers constituted about 14.29 per cent and 12.58 per cent in the total population respectively.

4.3 CLIMATE AND RAINFALL

4.3.1 Climate

In Andhra Pradesh climate presents a transition from tropical to sub-tropical climate. In coastal belt, humid to sub-humid climate conditions prevail, while the rest of the State including the Ranga Reddy district, the climate is semi-arid to arid. It is observed that from about mid-February, both day and night temperatures begin to increase steadily making May the hottest month with mean daily maximum temperature of 39.6°C (103.3°F).

The particulars of the temperature in the district are presented in Table 4.2.

With the onset of the South West monsoon into the district during early June, there is appreciable drop in temperature and the weather becomes more plesant. By the beginning of the November, the decrease in both the day and night temperatures is rapid. December is the coldest month with mean daily maximum temperature at 28.8°C (83.8°F) and minimum temperature at 13.4°C (56.5°F). In this season the night temperature sometimes drops down to about 7°C (44.6°F).

Wide variations are observed in maximum and minimum temperatures during different years and months. Maximum temperature has varied from 38.5°C in the year 1987 to 43.2°C in 1986. Similarly, minimum temperature

Table 4.2 Maximum and minimum temperatures in the district (°C)

Month	Normal		1983		1984		1985		1986		1987	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Jan	28.6	14.6	29.4	14.8	29.2	17.5	29.8	16.5	30.0	14.6	28.5	16.8
Feb	31.2	16.7	33.1	19.1	30.3	18.8	32.9	17.7	34.2	18.3	30.9	16.8
March	34.8	20.0	37.0	22.1	35.2	20.2	36.5	20.2	36.2	19.3	34.5	20.8
April	36.9	23.7	38.9	24.3	37.9	24.5	38.3	21.8	37.2	23.3	39.2	24.2
May	38.3	26.2	39.7	26.6	41.4	28.1	42.5	26.0	43.2	28.9	38.5	25.2
June	34.1	24.1	36.7	28.1	34.6	24.3	35.3	20.3	38.3	22.4	36.4	24.1
July	29.8	22.3	32.0	23.1	30.1	22.0	29.0	23.3	26.4	22.83	31.1	22.5
Aug	29.5	22.1	29.5	22.4	30.8	22.0	31.2	21.2	24.3	21.2	30.5	22.5
Sept	28.7	21.1	28.1	22.1	31.3	22.4	31.2	23.2	26.3	21.0	22.9	23.2
Oct	30.0	19.3	29.5	20.5	30.9	20.6	20.8	19.5	24.0	23.2	30.8	21.7
Nov	28.7	16.0	28.4	15.7	28.7	15.7	14.4	16.9	20.9	13.8	28.2	19.2
Dec	28.8	13.4	228.9	15.5	229.8	15.5	14.4	16.3	19.8	17.6	27.6	16.3

Source: Director of Agriculture, Andhra Pradesh.

has ranged from 14.6°C in 1986 to 16.5°C in 1985. However, the normal maximum and normal minimum temperatures are registered at 38.9°C in the month of May and 13.4°C in the month of December respectively. The normal maximum and normal minimum temperature between the months ranged from 28.6°C in January to 38.9°C in May and from 13.4°C in December to 26.2°C in May respectively.

4.3.2 Rainfall

The district receives an average rainfall of 1147.4 mm as against 1198.0 mm for the State as a whole. The rainfall in the district in general increases from the South towards the North and varies from 1042.5 mm at Chevella to 864.0 mm at Ibrahimpatnam. The rainfall during the months of South-West monsoon (June to September) constitutes about 80 per cent of the total rainfall. The season-wise average rainfall is presented in Table 4.3.

It is observed that, rainfall pattern exhibited wide deviation from normal rainfall over a period of time. The South-West monsoon normally active in the month of September and received 194.9 mm of maximum rainfall in the reference year 1989-90. Out of the total rainfall of 747.5 mm received during the year 1989-90 about 86 per cent i.e., 64?.1 mm rains received during South-West monsoon itself. It also gives a clear

Table 4.3 Season wise rainfall in Ranga Reddy district (mm)

Month	Normal	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90
<u>South-West monsoon</u>									
June	107.5	164.8	84.2	80.6	50.3	112.9	118.4	106.1	109.9
July	166.7	167.7	218.5	150.8	113.4	112.9	161.7	180.0	182.7
Aug	141.8	66.1	303.7	140.8	96.3	186.5	160.2	149.1	160.1
Sept	185.3	170.4	346.5	160.2	60.8	71.2	68.3	188.8	194.9
Total	601.3	568.8	952.9	532.4	320.8	483.1	508.6	624.0	647.1
<u>North-East monsoon</u>									
Oct	61.5	70.8	149.6	28.8	20.6	10.3	99.5	62.3	70.4
Nov	20.8	17.8	1.4	3.8	-	13.5	198.2	20.1	18.1
Dec	4.3	--	--	3.3	-	11.7	5.2	4.2	4.5
Total	86.6	98.6	151.0	35.9	20.6	35.5	302.9	86.6	93.0
<u>Winter period</u>									
Jan	3.0	--	2.0	1.0	-	7.5	--	2.9	2.4
Feb	6.4	--	7.1	--		-	14.7	5.6	5.0
Total	9.4	--	9.1	1.0		7.5	14.7	8.5	7.4
Overall Total	697.3	667.4	1113.0	569.3	341.4	526.1	826.2	719.1	747.5

Source: Chief Planning Officer, Ranga Reddy district.

picture that the rainfall is deviating very much from the normal rainfall and registered below normal (697.3 mm) in most of the years. The rainfall received from the year 1987-88 onwards was more than the normal rainfall with a maximum of 1113 mm during the year 1983-84. The rainfall was extremely low in the year 1985-86 with only 320.8 mm from the South-West monsoon; 20.6 mm from the North-East monsoon and completely 'nil' in the winter period.

4.4 SOIL TYPES

Soil is the basic resource of agricultural production which varies in its fertility from district to district and within the district. Red soils predominate in the district followed by black soils. The Mandals viz., Medchal, Shamirpet, Qutubullapur, Keesara, Hayatnagar, Saroornagar, Uppal, Ghatkesar, Rajendranagar, Pargi, Doma, Samshabad, Serilingampally, Malakajgiri, Balanagar, Kulkacherla and Ganded where the red chalka soils are predominant in more than 50 per cent of the villages.

However, alfisol and vertisol occupies more than 60 per cent and less than 40 per cent of the total cropped area respectively. Thus, this district covers both mono cropping and double cropping areas in dryland farming region of Ranga Reddy district.

Dubba soils are largely found in Ibrahimpatam, Manchal, Yacharam, Maheswaram and Kandukur Mandals besides Red chalka soils. The black soils are predominent in Chevella, Shahbad, Shankerpally, Moinabad, Vikarapad, Nawabpet Dharoor, Poodur, Tandur, Peddemul, Yalal, Bhashirabad, Narpally, Mominpet and Bantaram mandals.

4.5 LAND USE PATTERN

The particulars of land utilisation in Ranga Reddy district of Andhra Pradesh are presented in Table 4.4. It is seen that the geographical area of the district is 7.5 lakh hectares. The net area sown and area sown more than once constituted about 39.3 per cent and 2.6 per cent respectively. While the current fallows constituted 15.3 per cent, the area under forest accounted for 9.7 per cent of the total geographical area.

Barren and unculturable land, permanent pastures and other grazing lands, miscellaneous tree crops and groves not included in net sown area and culturable waste put together accounted for 25.8 per cent whereas land put to non-agricultural uses constituted about 10 per cent in total geographical area. The cropping intensity was very low (107%) revealing the non-availability of irrigation to take up second crop.

Table 4.4 Land utilisation particulars in Ranga Reddy district 1988-89

S.No.	Item	Area in Hectares	Percentage to geographical area
1.	Forest	73,032	9.7
2.	Barren and unculturable land	46,681	6.2
3.	Land put to Non-agricultural uses	74,920	9.9
4.	Permanent pastures and other grazing lands	53,382	7.1
5.	Miscellaneous tree crops and groves not included in net area sown	8,827	1.2
6.	Culturable waste	27,974	3.7
7.	Other fallow lands	57,202	7.6
8.	Current fallows	1,15,230	15.3
9.	Net area sown	2,95,999	39.3
10.	Area sown more than once	19,363	2.6
11.	Total cropped area	3,15,362	41.9
12.	Total Geographical area	7,53,247	100
13.	Cropping Intensity(%)		107

Source: Chief Planning Officer, Ranga Reddy District.

4.6 IRRIGATION

Source-wise area irrigated is given in Table 4.5. It revealed an erratic distribution of rainfall which leads to instability of yields. Therefore, supplementary irrigation seems to be necessary to ensure stability of agricultural yields. It is a well accepted fact that irrigation is an indispensible input of the new agricultural technology. The new high yielding varieties require higher levels of plant nutrients and also increased levels of irrigation. Despite two good rivers traversing through the district, there are no irrigation projects even of minor nature. River Moosi runs through the district untapped for irrigation until it feeds Himayatsagar and Osmansagar tanks mainly for drinking water purposes. Therefore many a farmers go for rainfed cultivation only.

4.5 Source-wise area irrigated in Ranga Reddy district, 1988-89

(Area in hectares)

S.No.	Source	Average of preceeding five years	Area Irrigated during		
			P.C.	1988-89	P.C.
1.	Canals	3,105	5.08	3,718	4.7
2.	Tanks	11,094	18.15	12,208	16.0
3.	Wells	43,466	71.11	50,798	65.0
4.	Tube wells	906	1.48	5,838	7.0
5.	Other sources	2,556	4.18	5,720	7.3
6.	Gross Irrigated area	61,127	100	78,282	100
7.	Net Area Irrigated	43,428	--	58,143	--
8.	Percentage of gross irrigated area to total cropped area	--	-	24.82	--
9.	Percentage of net area irrigated to total cropped area	--	--	--	18.44
10.	Percentage of net area irrigated to net sown area	--	-	-	19.64

Source: Chief Planning Officer, Ranga Reddy District, Andhra Pradesh.

About 78,282 hectares of land was irrigated in Ranga Reddy district in the year 1988-89. It is seen that wells formed the major sources of irrigation in the district accounting for 65 per cent of gross area irrigated followed by tanks with 16 per cent. An estimated number of about 28,000 wells with pumpsets exist at present in the district. The percentage of gross irrigated area to total cropped area was 24.82. The intensity of irrigation worked out to 134.64 per cent which shows that substantial area has been brought under area sown more than once.

Table 4.6 Area of Principal Crops Irrigated in Ranga Reddy district (1988-89)

(Hectares)

S.No.	Name of the Crop	1988-89	P.C.	Preceding average of 5 years	P.C.
1.	Paddy	46,346	70.09	35,503	71.04
2.	Sorghum	187	0.28	360	0.72
3.	Wheat	1,850	2.80	3,115	6.23
4.	Pearl Millet	64	0.10	24	0.05
5.	Finger Millet	45	0.07	30	0.06
6.	Maize	498	0.75	476	0.95
7.	Chillies	1,120	1.69	927	1.85
8.	Groundnut	5,522	8.35	2,734	5.47
9.	Vegetables	10,496	15.87	6,812	13.63
	Total ...	66,128	100	49,986	100

Source: Bureau of Economics & Statistics, Government of Andhra Pradesh.

Crop-wise area under irrigation in Ranga Reddy district for the year 1988-89 is presented in Table 4.6.

Among the irrigated crops paddy accounted for about 71 per cent of the total area under irrigation followed by vegetables with 16 per cent and groundnut with 8 per cent. When compared with the average area of preceding five years there was a substantial increase in the area under paddy, vegetables and groundnut by the year 1988-89. The particulars of distribution pattern of land holdings in Ranga Reddy district are presented in Table 4.7. It is observed from the Table that there existed a high degree of skewness. It is seen that at one extreme end 61 per cent of small holdings accounted for only 19 per cent of total area while at the other extreme end just 18.6 per cent of large holdings accounted for as high as 60 per cent of the area.

4.7 LAND HOLDING DISTRIBUTION

Table 4.7 Distribution of land holdings by size group in Ranga Reddy district (1986-87)

S.No.	Size group	Total No.of House holds	P.C.to total	Holdings Area	P.C. to total
1	Small (< 2 ha)	11,71,360	61.48	1,00,636	19.43
2	Medium (2 to 4 ha)	37,950	19.92	1,06,702	20.59
3	Large (Above 4 ha)	35,439	18.60	3,10,793	59.98
All Groups Overall		1,90,525	100	5,18,151	100

Source: Chief Planning Officer, Ranga Reddy District, A.P.

Now-a-days modern agriculture has become capital intensive. The capacity of making investment depends on the size of farm. Large farms can mobilise not only its own resources but can also procure better services from agricultural institutions.

Failure of vast majority of farmers to obtain the benefits of new technology and slow growth in agricultural sector are often attributed to the nature of land holdings. Further, the size of holdings also influences the cropping pattern in this district.

4.8 CROPPING PATTERN

The variation in the fertility of the soil and climate factors account for the changes in the cropping pattern of the eastern and western regions in the district. While white sandy loam occurs in the eastern region; (Hayatnagar and Ibrahimpatnam) black cotton soils predominate in the western region (Chevella, Pargi, Vikarabad, Marpally and Tandur). The cropping pattern of the district is presented in Table 4.8. The principal crops of the district are sorghum, paddy, finger millet, castor and pulses. Out of the total cropped area of 3,15,055 hectares food crops accounted for about 79.04 per cent and the non-food crops formed the other 20.96 per cent.

Table 4.8 Area under important crops in Ranga Reddy district (1988-89)

S.No.	Particulars of crops	Area in Hectares			Percent to total cropped area
		kharif	rabi	Total	
1.	Paddy	27,999	20,476	48,475	15.39
2.	Sorghum	76,932	22,499	99,431	31.56
3.	Wheat	--	1,850	1,850	0.59
4.	Perl millet	2,152	64	2,216	0.70
5.	Finger millet	7,905	45	7,950	2.52
6.	Maize	4,277	418	4,695	1.49
7.	Total Major Millets	91,266	23,026	1,14,292	36.28
8.	Total Pulses	49,098	3,604	52,702	16.73
9.	Total food-grains	1,71,000	49,000	2,20,000	69.83
10.	Vegetables	--	--	14,205	4.51
11.	Chillies	2,516	1,074	3,590	1.14
12.	Groundnut	3,927	5,398	9,325	2.96
13.	Castor	24,924	--	24,924	7.91
14.	Total food crops	--	--	24,9011	79.04
15.	Total Non-food Crops	--	--	66,044	20.96
16.	Total cropped area	--	--	3,15,055	--

Source: Bureau of Economics and Statistics, Government of Andhra Pradesh.

Crops are grown to a larger extent in *kharif* season only, as these mostly depend on rainfall. Sorghum and paddy are the main staple food crops.

Sorghum is being grown mostly as rainfed crop. Sorghum is the principal crop which occupied the largest area accounting for about 31.56 per cent in the total cropped area. Sorghum is being taken up as the inter-crop with pigeonpea in the ratio of 5 1. Few of the farmers also inter-crop sorghum with pearl millet. Next to sorghum, pulses accounted for about 16.73 per cent in the gross cropped area. Pigeonpea and greengram are the two major pulses grown in the area. Paddy was also found to be one of the important crop in the area forming 15.39 per cent in the total cropped area. Among the oilseeds castor and groundnut are the two important crops grown in this area accounting for 7.91 per cent and 2.96 per cent to the total cropped area respectively. Crops like pulses, small millet, pearlmillet, fingermillet and castor are mostly cultivated under rainfed conditions. Groundnut is cultivated both under rainfed and irrigated dry conditions. Vegetables are also grown under irrigated conditions which consisted of about 4.51 per cent in the total cropped area.

4.9 PRODUCTIVITY

The details on productivity of different crops in the district from the year 1985-86 to 1988-89 are presented in Table 4.9.

Table 4.9 Average yield levels of different crops in Ranga Reddy district

(in kg/ha)

S.No. Crop	1985-36	1986-87	1987-88	1988-89
Cereals and Millets				
1. Rice	1,361	1,693	2,055	2,133
2. Wheat	842	375	375	713
3. Sorghum	768	902	790	566
4. Pearlmillet	464	369	278	325
5. Fingermillet	643	622	952	751
6. Maize	479	752	987	1221
Pulses				
1. Pigeonpea	764	547	228	243
2. Greengram	510	268	490	536
3. Blackgram	189	291	435	238
4. Horsegram	345	394	254	242
Non-food Crops				
1. Chillies	1,458	1,259	1,075	374
2. Groundnut	664	709	799	952
3. Seasamum	275	118	138	96
4. Castor	133	57	153	145

Source: Bureau of Economics and Statistics, Hyderabad, Andhra Pradesh.

The productivity of rice which was 1361 kgs per hectare during the year 1985-36 had increased to 2133 kgs per hectare by the year 1988-89. Similarly the productivity of maize also increased from 479 kgs to 1221 kgs per hectare. These two crops among the cereals and millets had shown an increasing trend in productivity levels, whereas other crops like sorghum, pearl millet and finger millet, the productivity was erratic over the years. The productivity of pulses had also not indicated any consistant behaviour over the years. With regard to chillies and seasamum, the productivity levels were drastically decreased from the year 1985-86 to 1988-89.

4.10 AGRICULTURAL IMPLEMENTS AND MACHINERY

The particulars of agricultural implements and machinery are presented in Table 4.10.

Table 4.10 Agricultural implements and machinery of Ranga Reddy district

S.No.	Name of the implements	No.	Per 1000 house-holds	Per 1000 hectares of hold-ings
1.	Seed drills	8,672	45.51	16.74
2.	Sugarcane crushers	256	1.34	0.49
3.	Plant protection equipment	796	4.18	1.54
4.	Oil Engines	4,047	21.24	7.81
5.	Electic pumpsets	24,001	125.97	46.32
6.	Tractors	535	2.81	1.03
7.	Wooden ploughs	80,568	422.87	155.49
8.	Iron ploughs	8,351	43.83	16.12
9.	Guntakas	1,62,798	854.47	314.19
10.	Wetland puddlers	37,247	195.50	71.88

Source: 14th Quinquennial Livestock Census, 1987, Chief Planning Officer, Ranga Reddy district.

The Table 4.10 reveals that the use of agricultural implements was of traditional nature in general. All the farming families possessed wooden ploughs, guntakas and Dantis. These are utilised for preparatory cultivation as well as intercultivation. Among the implements, the number of guntakas were maximum with 854 per every 1000 households followed by wooden ploughs (423), wet land puddlers (196), and electric pumpsets (126). The modern implements such as plant protection equipment and tractors which are used in adopting modern technology were 1.54 and 1.03 per every 1000 hectare of holding. However this indicates that the technologies adopted are at low level. It is also observed that the electric pumpsets consisted of about 46 per every 1000 hectares of holding while the oil engines formed about 8 per every 1000 hectares of holdings.

4.11 LIVESTOCK POPULATION

Maintenance of livestock is a major expenditure for the agriculturists in this area. In view of dependence on owned cattle pairs and maintaining dairy animals for milk and manure, every cultivator has to incur considerable expenditure on cattle maintenance. The cropping also is so adjusted that they have crops to provide food requirements, fodder requirements and cash for purchasing their family requirements.

Apart from the production of milk and meat, the cattle in the district are used as drought power for agricultural purpose. As per the livestock census of 1987 the district has livestock population of 10.47 lakhs and poultry population of 60.97 lakhs.

The Table revealed that the total livestock which was 16.05 lakhs during 1972 had reached to 71.01 lakhs by 1987. The percentage of cattle in total livestock had declined from 25.7 per cent in 1972 to 6.97 per cent by 1987. During the same period the poultry population had increased from 35.79 per cent to 85.88 per cent. The poultry population is mostly concentrated in Hayatnagar and Rajendranagar blocks due to their proximity to the twin cities. The population of buffaloes, sheep and goat also declined.

Table 4.11 Livestock population of Ranga Reddy District

Particulars	1972	1977	1983	1987
Cattle	4,13,675 (25.78)	4,05,975 (21.08)	4,74,532 (8.42)	4,23,690 (6.97)
Buffaloes	1,45,547 (9.07)	1,44,939 (7.53)	2,05,328 (3.64)	1,95,166 (2.75)
Sheep	2,75,078 (17.14)	2,82.697 (14.68)	1,87,745 (3.33)	1,80,376 (2.54)
Goats	1,80,173 (11.23)	1,74.771 (9.07)	2,04,355 (3.63)	1,89,609 (2.67)
Poultry	5,74,399 (35.79)	9,01,211 (46.79)	45,45,762 (80.69)	60,97,160 (85.88)
Others	15,874 (0.99)	16,389 (0.85)	15,884 (0.28)	15,004 (8.59)
Total ...	16,04,746 (100.00)	19,25,982 (100.00)	56,33,606 (100.00)	71,01,005 (100.00)

Source: CPO, Ranga Reddy District (LSC, 1987).
Figures in parentheses indicate percentage to total.

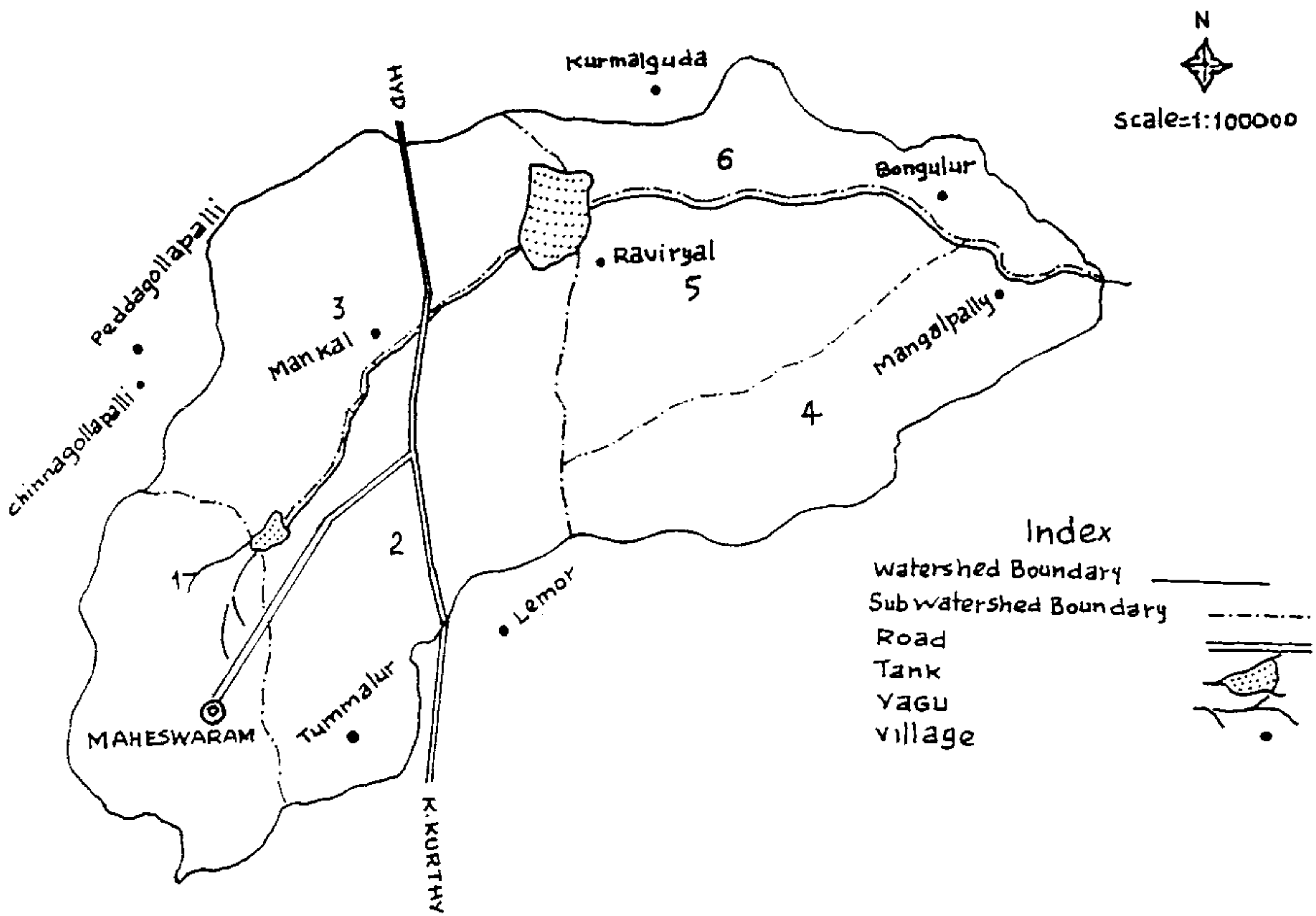
4.12 GENERAL INFORMATION ABOUT MAHESWARAM WATER SHED AREA

Based on the guidelines given by the Government of India, a pilot project was formulated for the development of water shed in rainfed areas of Maheshwaram in the Ranga Reddy district of Andhra Pradesh with a total cost of Rs.582.00 lakhs including provision for cost escalation to spread over a period of 7 years time frame. In this project, it is proposed to adopt the proven dryland development and crop management technology to ensure optimum benefits. Maheswaram water shed was one of the four World Bank aided watershed, where the technical support for development work is being provided by CRIDA.

4.12.1 Location of Project

In Andhra Pradesh, the project is located in Ranga Reddy district between 17°-15' and 17°-15' North latitude and 78°-25' to 78°-38' East longitude forms the district of Ranga Reddy on the map of Andhra Pradesh with its boundaries as Medak on the North, Mahaboobnagar in the South, Nalgonda in the East and Karnataka in the West. The population in the area is 25,267. The project extends over an area of 25,331 hectares comprising of 16,390 hectares of arable land and 8,556 hectares of non-arable land extending over 23 villages in Ranga Reddy district (4 Ibrahimpatnam, 1 Kandukur and 18 villages of Maheshwaram Mandal).

Fig - 2. SELECTED VILLAGES IN AND OUTSIDE MAHESWARAM WATERSHED AREA. RANGAREDDY DIST.



The watershed drains into pulandarivagu which is a small tributory of Musi River which itself is a tributory of Krishna River. The Maheshwaram watershed is located at about 32 km South of Hyderabad on the road leading to Srisailam. The project area is even easily accessible by road. Research Centres of APAU, ICAR, Sheep and Pasture Development Farm are all within a distance of 50 km. Training institutes like EEI, NIRD, KVK and Training Institutes of ICAR and FTC are all located within a radius of about 50 km from the project area.

4.12.2 Temperature

Average minimum and maximum temperature ranges from 14°C to 15°C in winter and 37°C to 40°C in summer though minimum temperature sometimes goes to as low as 9°C in December and January and the maximum temperature occasionally rises upto 44°C in May-June.

4.12.3 Altitude

The altitude of the project area ranges from 520 meters to 660 meters above mean sea level. The slope ranges from 1 to 3 per cent for most of the area.

4.12.4 Soils

The soils of the region are light textured and locally called as 'Chalka or Dubba'. They are red in colour, shallow to medium in depth and have multiple slopes ranging from 1 to 3 per cent. The soils are inherently poor in nitrogen and phosphorus but adequately endowed with Potash. pH of the soil is almost neutral. They are prone to sheet and gully erosion.

The main objective of the project is to introduce the improved practices of dry farming in order to improve and stabilise the agricultural production by way of soil and water conservation measures, timely land preparation and adoption of water harvesting techniques, use of high yielding varieties, timely sowing, application of fertilizers, maintenance of optimum plant population, weed control and adoption of integrated pest management practices.

4.12.5 Rainfall

The month-wise normal rainfall received in Maheshwaram Watershed area is presented in the Table 4.12.

The project area represents the typical semi-arid tract with an average rainfall of 775 mm per annum. The rainfall is mostly through South-West monsoon which is generally erratic and highly unevenly distributed with high intensities. A dry spell of 3 to 4 weeks is a regular feature from mid July to August. The South-West monsoon generally sets on 10th June and receeds by 1st week of October spanning nearly 4 months. The month-wise distribution of normal rainfall (in mm) which speaks volumes about its variability.

Table 4.12 Month-wise normal rainfall in Maheshwaram Watershed area (1988 - 1989)

Month		Normal rainfall in mm
June	...	109
July	...	161
August	...	135
September	...	171
October	...	73
November	...	32
Decmeber	...	6
January	...	8
February	...	12
March	...	13
April	...	26
May	...	29
Total	...	775 mm

Source : Joint Director of Agriculture Maheswaram Watershed Project

4.12.6 Cropping Pattern

Due to low rainfall and sandy soils crops are grown in the <u>kharif</u> season. Jowar and castor are the two important crops of the area. Jowar occupies 37 per cent and castor 35 per cnet. Jowar is inter-cropped with redgram in the ratio of 5 : 1. Local varieties of jowar, redgram and bajra are the popular crops in the area. Jowar is rotated with castor and sometime ragi is rotated with castor. Horsegram is grown as late <u>kharif</u> crop.

4.12.7 Main Components of the Project

1) **Soil Conservation measures:** The use of resources particularly fertilisers, improved seeds and plant protection chemicals will be more effective when the soil and moisture conditions are favourable. Therefore soil conservation has been given top priority in dryland farming techuology. The soil conservation has mainly got three components (1) Engineering programmes (2) Agronomic practices (3) Mechanical structures. Under Engineering measures contour bunding is the most important one. It is estimated that an amount of Rs 600 is required for contour bunding per acre. In addition to contour bunding, graded bunding is also suggested. Alternatively a vegetative barrier with khus grass plantation is also recommended. Agronomic practices include compartmental bunding, cultivation across the slope etc. Gully plugging through check dams is a very important structural measure for soil conservation.

2) **Improved Crop Management:** The improved crop management includes not only the high yielding crop varieties but also the clean cultivation through inter-culturing and weeding, proper nutrient application and integrated pest managemnet. It is observed that the High yielding straight varieties are preferred to Hybrids by the farmers. The crops should be selected according to land capability classification.

3) Reforestation and Silvipasture development in degraded forest areas: The existing forests are observed to be devoid of forests. Only shrubs are found in this degraded forests. It is therefore necessary to take up afforestation programmes in the degraded forest lands. Suitable species which would provide fodder, fuel, fruit and timber should be selected. In this degraded forest lands it would be possible to raise pastures and grasses for grazing and fodder purposes. Stylo species, cinchorous species and other leguminous species are ideally suited to these areas.

4) Farm Forestry: In dryland areas the per capita availability of land is higher than in irrigated areas. It is advantageous to grow not only the annual crops but also the tree species under the farm forestry. The tree cultivation helps to conserve the moisture, provides organic material in addition to firewood and timber etc. The important tree species are neem and acacia etc.

5) Forage Development: Since livestock is important component of agriculture, fodder development assumes importance. A small portion of the land held by the farmer may be earmarked for fodder cultivation. The important fodder species are napier, deenanath, elephanta etc. In addition to this fodder crops fodder trees like Subabul may also be raised.

6) **Social Forestry along Roads:** One of the important programmes taken by watershed development project is social forestry along roads. The important species used under this programmes are tamarind, soapnut and euacalyptus etc.

7) **Plantation of fodder and multipurpose trees on bunds:** In the farmers fields all along the bunds, the farmers are encouraged to plant multipurpose trees and also fodder trees. The multipurpose trees would serve the needs of farmers such as fuel, fodder, fruits, timber etc. Fodder trees like Subabul, acacia may also be planted all along the bunds.

8) **Horticulture:** Some of the drylands are not really suitable for crop cultivation. Such lands can be profitably used for plantation of horticultural trees. The horticultural plants will have capacity to withstand the variations in soil moisture created by abbrant and erratic weather conditions. Over the years the risk is very much minimised in horticultural crops. Further the returns from horticulture would be much higher when compared to the annual crops. Fruit species selected should have tolerance to salinity and alkalinity which are common features of drylands. The important horticultural tree species are aola, bear, gauva.chikoo, mango etc.

4.13 TRANSFER OF TECHNOLOGY

The CRIDA's Division of Transfer of Technology is extending to Maheshwaram Project through Operational Research, Training and Communication and Lab-to-Land Programmes.

4.13.1 Mandate

1. To develop suitable models in training, extension and communication for quick diffusion and adoption of dryland technology.

2. To develop need-based training programmes on various aspects of dryland technology, keeping the clientale in view.

3. To impart skills needed to optimise yields in dryland areas by training trainers and practising farmers.

4. To study constraints in transfer of dryland technology on watershed basis and provide a feed-back to research for restructuring and refining the research programme.

4.13.2 Responsibilities to implement the Maheshwaram Watershed Programme

1) Department of Agriculture has to carry out the soil and water conservation works related to crop production and soil surveys.

2) The forest department has to look after afforestation and reforestation in forest areas and will also be incharge of farm forestry and social forestry in the project area.

3) Pasture, forage development and silvi-pasture programmes on public, community and on farmers' fields will have to be looked after by Animal Husbandry Department.

4) Research and on-farm trails to be taken up by Andhra Pradesh Agricultural University and CRIDA.

5) Cooperative Department and other financing agencies will have to arrange for the credit required by the beneficiaries of the project area.

6) Monitoring and evaluation of the programmes has to be carried out by Administrative Staff College of India, Hyderabad.

7) The Joint Director of Agriculture (WSP), Hyderabad will have to coordinate the activities of the line departments and arrange to implement the programme.

4.14 LAND UTILISATION PARTICULARS OF MAHESWARAM WATERSHED AREA

The particulars of land utilisation are presented in Table 4.13.

Table 4.13 Land utilization particulars of Maheswaram watershed area of Ranga Reddy District of Andhra Pradesh (1988-89).

Particulars	Area (ha)	P.C.
Forests	4709	18.59
Revenue land	1799	7.10
Community land	2048	8.08
Well irrigation	1126	4.45
Rainfed including current follows	14720	58.11
Permanent fallowland	544	2.15
Non-agricultural lands	385	1.52
Total area under watershed	25331	100.00

Source: Joint director of Agriculture Maheswaram Watershed Govt. of A.P.

The geographical area under Maheshwaram water shed is 25,331 hectares. The area under rainfed including current fallows constitutes 58.11 per cent of the total area. The area under forest accounted for 18.59 per cent of total area. The share of well irrigation, revenue land, community land and permanent fallows formed 4.45 per cent, 7.10 per cent, 8.08 per cent, 2.15 per cent of the total area respectively.

4.15 ECONOMIC FEATURES OF SELECTED VILLAGES

4.15.1 Adopted Villages

It is seen from the Table 4.14 that all the selected villages are situated within 19 to 30 kms distance from Hyderabad and well connected by roads. All the villages are electrified. Three villages are having educational facilities upto primary school level while 3 others were having facilities upto high school. Except Maheswaram, none of the villages is having Government hospital. None of the villages is having any market yard to sell agricultural products.

With regard to banking facilities only Mankhal and Maheswaram villages are having commercial banks and cooperative banks. Under public distribution system all the villages are provided with a ration shop.

The particulars on land utilization and some basic facts of Maheswaram watershed are presented in Table 4.14 and 4.15.

4.15.2 Non-adopted Villages

The socio-economic particulars of the non-adopted villages are presented in Table 4.16. It is observed from the Table that all the selected villages are electrified and well connected by roads. All the villages are having educational facilities from elementary school to primary school and only the village

Table 4.14 Particulars of selected adopted villages

Particulars	Raviryal	Mankhal	Tummadun	Maheswaram	Mangalpalli	Bongulur
Distance from Hyderabad	20 kms	21kms	27kms	30kms	26kms	19kms
Area (sq.km)	11.30	30.83	23.02	21.17	22.86	3.5
Post office	1	1	1	1	Nil	Nil
Electrified Yes or Not	Yes	Yes	Yes	Yes	Yes	Yes
Educational Institutions	High School	High School	Middle School	High School	Primary School	Primary School
Connected by Roads or not	Connected	Connected	Connected	Connected	Connected	Connected
Govt.Hospital	Nill	Nill	Nill	1	Nill	Nill
Market yard	Nill	Nill	Nill	Nill	Nill	Nill
Communial bank	--	1	Nill	1	Nill	Nill
Co-op. bank	—	1	Nill	1	Nill	Nill
Agri.Godowns	Nill	Nill	Nill	1	Nill	Nill
Ration Shop	1	1	1	1	1	1
Population	5000	4000	2476	8000	5000	2600
Bore wells	10	6	3	20	6	4
Water tank	1	Nill	Nill	1	Nill	Nill
Open wells	Nill	Nill	Nill	65	Nill	Nill
Soils	Dubba Red Black	Dubba Sandy Red	Red Sandy	Red Sandy	Red soil 75% Black 25%	Dubba Red Black

Source: Village records.

Table 4.15 Some basic facts of Maheswaram watershed area of Ranga Reddy District of Andhra Pradesh (1988-89).

Basic facts	Particulars
1. Average rainfall	770 mm
Rainfall distribution	80 % during June to September
Soil type	Medium to deep alfisols (loamy sands to sandy loams)
Land shape (Topography)	Rolling
No.of sub-watersheds	6 Nos.
No.of villages	23 Nos.
Total population	25,267 Nos
Landless famalies	3,937 Nos
Farm families	4,200 Nos
Average farm size:	
a) Scheduled castes	1.35 ha
b) Scheduled tribes	2.16 ha
c) Other castes	4.02 ha

Source: Joint Director of Agriculture Maheswaram Watershed Govt. of A.P.

Table 4.16 Particulars of selected non-adopted villages

Particulars	Kurmalguda	Peddagollapalli	Chinegolapalli	Lemor
Distance from Hyderabad	15 kms	22 kms	21 kms	34kms
Area (sq.km)	3.69	4.01	5.10	3.4
Post office	Nill	Nill	Yes	Nill
Electrified Yes or Not	Yes	Yes	Yes	Yes
Educational Institutions	Elementary School	Primary School	Primary School	High School
Connected by Roads or not	Connected	Connected	Connected	Connected
Govt.Hospital	Nill	Nill	Nill	Nill
Market yard	Nill	Nill	Nill	Nill
Commercial bank	Nill	Nill	Nill	Nill
Co-op. bank	Nill	Nill	Nill	Nill
Agri.Godowns	Nill	Nill	Nill	Nill
Ration Shop	Yes	Yes	Yes	Yes
Population	1,500	1,324	1,186	5,000
Bore wells	4	3	2	12
Water tank	Nill	Nill	Nill	1
Open wells	Nill	Nill	Nill	Nill
Land soils	Red Black Alkoli Dubba Sandy	Red Black Alkoli Dubba Sandy	Red Black Alkoli Dubba Sandy	Dubba Red Black

Source: Village records.

Lemoor is having high school facilities. None of the selected non-adopted villages is having Government Hospitals, market yards or banking facilities in the village.

In the background of the Agro-economic Features of the study area, as described above, the results and discussion are presented in the chapter that follows.

WAGE RATES

The wage rates for different operations are presented in Table 4.17.

Table 4.17 Wages paid for different operations (Rs/day)

Sl. No.	Operations	Adoptors		Non-adoptors	
		M	F	M	F
-Farms					
1	Ploughing	15	0	15	0
2	Sowing	15	8	15	8
3.	Weeding	0	8	0	8
4.	Blade harrowing	15	0	15	0
5.	Harvesting	15	8	18	8
6.	Threshing	15	8	15	8
B-Non-farms					
1.	Wood cutting	18	0	18	0
2.	Well digging	18	10	18	10
3.	Bunding	15	8	15	8
4.	Road repairs etc.	12	12	12	12

For males in adopters and non-adopter villages the wage rate per day was Rs.15 for all the farm operations, right from ploughing to harvesting and threshing. The wage rate for female labour was Rs.8 per day. Thus a clear descrimination is shown against the female labourer. For non-farm operations the wage rate for wood cutting and well digging was Rs.13 per day for male labourer and Rs.10 for female labour. The wage rate for road repairs was Rs.12 per day either for male or female labour.

RESULTS AND DISCUSSION

CHAPTER V

RESULTS AND DISCUSSION

The data collected from secondary and primary sources were computerised, processed, analysed, and interpreted which are presented in this chapter. The findings and results are also discussed in detail in this chapter under the following sub-heads.

5.1 Technologies developed by the different institutions

5.2 Basic characteristics of selected house holds

5.3 Structure of costs and returns

5.4 Resource productivity, returns to scale and resource use efficiency

5.5 Adoption of Technologies

5.6 Income and expenditure pattern Gini Concentration Ratio Lorenz Curve

5.1 DRYLAND FARMING TECHNOLOGY DEVELOPED BY DIFFERENT INSTITUTIONS

Farmers in the dryland regions has been practising dryland agriculture generation after generation since times immemorial. However, the improved dryland technologies have been developed as a result of serious efforts made by scientists in the early thirties and subsequently in seventies in India. The research results from these research stations formed the basis for the improved dryland technology. Greater emphasis was laid on the soil and moisture conservation practices. The dryland agriculture research received an impetus with the establishment of All India Coordinated Research Project in 1970 with headquarters at Hyderabad (now known as CRIDA). Twenty three Dryland Research Centres are currently functioning under the guidance of AICRIPDA. Further, different Agricultural Universities in the country are also conducting researches on dryland agriculture. The technologies for the development of dryland farming are developed and perfected by the institutions after verifying the results in research farms and farmers' fields. The dryland technologies eminated from the different institutions are grouped under the following heads:

1. Land and water conservation.
2. Crops and cropping systems.
3. Fertilizer use in dryland agriculture.
4. Plant protection measures.
5. Inter-cultivation and weeding.
6. Agricultural implements.

5.1.1 Land and water conservation

Land and water conservation is the crucial factor in dryland agriculture. The conservation measures can be classified into three types viz., (1) mechanical or engineering construction such as contour bunds (2) vegetative barriers with khus grass plantation and (3) in situ water harvesting techniques.

5.1.1.1 Contour bunding: It is estimated that 2 to 3 tonnes of top soil is eroded annually from one hectare of the cropped land. Experiments conducted in different Research Stations revealed that contour bunding from 9 to 12 Sq ft are proved to be highly effective in arresting the run off and soil erosion. The research stations have suggested the contour bunding are/in cultivation the dryland areas and indicated that the size of the bund should be based on the slope of the land. Thus, graded bunding etc., are suggested. It is estimated that the construction of bunds would cost almost Rs 600 to Rs 800 per acre.

5.1.1.2 Khus grass plantation: Since construction of contour bunds is costlier and time consuming, research work has been initiated on alternative measures. Khus grass plantation is one such alternative measures. When khus grass is planted along the contours it acts as an effecive barrier in checking soil erosion and run-off. The total expenditure on this would be just around Rs 100/ha. Many farmers opined that this is less costly and effective by it establishes and services during summer period.

5.1.1.3 In situ water harvesting techniques

A) Deep ploughing: The experiments conducted in Anantapur Dryland Research Station indicated that by deep ploughing once in three years had helped in conserving the moisture and there by increasing the yields.

B) Dead Furrow: A furrow is opened in cropped land at a distance of 2 meters across the slope within 15 to 20 days after sowing. This is called dead furrow. The furrow is opened with big wooden plough. The experiments on adoption of furrow method at Anantapur Dryland Research Station revealed increase of yields by 58 per cent in sunflower and 62 per cent in bajra. An investment of Rs 10 on this operation yielded an additional income of Rs 200 (Chowdry 1983).

C) Compartmental Bunding: Small bunds with 15 metre length and 10 meter width are formed with a bund former in the cropped land. This practice yielded 20 per cent additional yield at the Anantapur Research Station (Annual Reports of ARS, Anantapur of various years).

D) Ridge and Furrow System: This system is developed by ICRISAT. Ridges and furrows reduce the run-off and allow sufficient time for the water to soak into the profile. The field must be thrown into ridges and furrows across the slope before sowing. Each ridge acts as obstruction to the flow of rain water which can stand in the furrow, thereby allowing more water to infiltrate into the soil profile. The results of the demonstrations laid on castor crop in Maheswaram Watershed indicated that atleast one quintal per hectare of yield could be additionally achieved (Annual Report of Maheswaram Watershed Prlject, 1989).

5.1.2 Crops and Cropping Systems - Varieties etc.

Efforts made by scientists in improving the varieties and breeding better varieties in some of the dryland crops have been successful. The yields obtained crop-wise at the CRIDA Research Farm in Ranga Reddy district are presented in Table 5.1.

Table 5.1. Crops and varieties with their particulars

Crops	Varietis/ Hybrids	Yield potential (q/ha)	Days to 50 % flowering	Duration from seed seed (days)
Sorghum	C-SH-6,	40	50	90
	C-SH-5	45	60	105
Pearl millet	BJ-104	25	35	85
Castor	Aruna,	15	60	150
	Gujarat Hybrid	18	60	150
	R-63 (Bhagya)	15	55	145
Pigeonpea	Hy-2	12	80	150
	Hy-4	12	90	150
Setaria	ISe-71	16	35	75
Ragi	PR-202	40	75	120
Horsegram	Local	10	30	75

Source : CRIDA Annual Report, 1990.

All the yields of improved varieties are far better when compared with local varieties. The high potential of yields opened new vistas in these crops. Though the potential yields seems to be very high, still they are not unrealistic. If all package of practices are adopted, then there is no reason why the farmers cannot achieve these yields. Experiments conducted in various locations over a period of time have clearly brought out the fact that the gap between these potential yields and actual yields obtained by farmers is getting reduced. This also brought out the importance of concentrating our research on cropping and farming systems.

It is seen from the Table that yield of sorghum CSH-6 and CSH-5 is 50 qt and 45 qt per hectare respectively when compared with average yield of 10 qt per hectare. The yield of the HYV was 4 to 4 1/2 times higher. The potential of pearl millet BH-104 is 25 qt per hectare. In castor 3 varieties are recommended for this watershed. Hy-2 and Hy-4 pigeonpea varieties gave an yield of 12 q per hectare.

For making the best use of available resources, research on inter cropping and sequence cropping has been in progress since long. The parity and often superiority of inter cropping over sole cropping in terms of insurance from risk, better resource-use and higher returns has been highlighted by many workers. The scope of raising successful sequence cropping is subject to soil storage and the rainfall received during the post-monsoon period. Experience has shown that even in low rainfall situations (areas receiving almost 400mm average annual rainfall) inter cropping can be taken with advantage.

5.1.2.1 System of Planting: Demonstations were conducted on farmers fields for jowar crop with wider row spacing of 45 cm and narrow row spacing 30 cm. In narrow spacing fertilizer was applied. The net returns were increased from Rs 81 to Rs 1188 per hectare with a cost benefit ratio of 1 : 2.44 (Chowdry, 1981).

5.1.2.2 Inter-cropping Systems:

The proven results from Dryland Research Stations were tested in farmers' fields at various locations in the country indicates that even the yield of base crop in inter-cropping system was higher at some centres compared to the yield in the sole crop.

It may be due to the fact that leguminous crops are cultivated along with non-leguminous crops. This helps in nitorgen fixation by leguminous crops which was utilised effectively by non-leguminous crops. The yield of sorghum (base crop) with redgram (inter-crop) increased by about 100 per cent at Hyderabad Centre. The inter-cropping system provides higher returns compared to sóle crop system. In Hyderabad region many demonstrations were conducted on farmers fields. The inter cropping systems covering Bajra + Redgram yielded the net returns amounting to Rs 1239 per hectare with cost benefit ratio of 1 : 2.48. Jowar + Redgram inter cropping systems gave net returns of Rs 248 per hectare under improved conditions as against Rs 114 under traditional practices.

5.1.3 Nutrient Management in Dryland Agriculture

Nutrient supply in inadequate amount is a key factor in any crop production programme. Supplementing plant nutrients, particularly N and P through chemical fertilizer has been found to contribute about 40 per cent increase in productivity of dryland crops (towards a sustainable dryland agricultural practices -R.P.Singh, S.K. Das, U.M. Bhaskara Rao and M. Narayana Reddy, CRIDA, 1990 p.28). The All India Coordinated Research Project for Dryland Agriculture has been conducting experiments on integrated nutrient management since 1982 at different locations. Plant nutrients are supplied through inorganic, organic and through conjective use of organic and inorganic sources. In all the cases integrated nutrient management has resulted in higher yields.

5.1.3.1 Placement of Fertiliser: The placement of fertiliser for all the crops at 2" aside and 2" below the seed was found to be very useful in increasing the yield by 8-10 per cent through increase in fertiliser use efficiency.

5.1.4 Plant Protection Measures

Various experiments conducted on the control of pests and disease convincingly proved that plant protection measures, taken in time, increased the yields of dryland crops by 30-40 per cent. Dusting was observed to be more suitable for dryland crops.

5.1.5 Inter-cultivation and Weeding

From the experiments laid out at Hayatnagar Farm on castor crop, it is reported that 2.80 quintals per hectare of yield was additionally obtained due to inter-culture and weeding (Annual Report of 1988, CRIDA, Hyderabad).

5.1.6 Implements

It is due to the efforts of the Agricultural Engineers, certain dryland implements are evolved. One of them is fertiliser-cum-seed drill, which was developed by Dr. C Sriram (1987), CRIDA has many advantages i.e., particularly it facilitates the sowing of seed and placing of fertilizer simultaneously. This would not only help in labour saving but in increasing the fertiliser use efficiency.

The study of the technologies developed by the different institutions provided insights into the adoption of technologies by different categories of farmers, whose basic characteristics are discussed in the ensuing paragraphs.

Table 5.2 Family strength and its composition per house hold

Particulars	Adoptors				Non-Adoptors			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall
Adults								
Male	1.85	1.52	2.14	1.82	2.00	1.97	2.17	2.02
Female	1.22	1.22	1.91	1.35	1.45	1.16	1.50	1.36
Total	3.07	2.74	4.05	3.17	3.45	3.13	3.67	3.38
Children								
Male	0.99	1.32	0.95	1.07	0.50	0.89	0.83	0.68
Female	1.00	1.10	0.55	0.94	0.39	0.63	0.17	0.43
Total	1.99	2.42	1.50	2.01	0.89	1.52	1.00	0.00
Total family members	5.06	5.16	5.55	5.18	4.34	4.65	4.67	4.49
Converted adults equivalents	3.82	3.71	4.19	3.86	3.61	3.66	3.87	3.66
Total number of workers	2.60	2.48	3.09	2.66	2.27	2.08	2.00	2.17

5.1.7 Family strength and composition

The particulars on the family composition per house hold are presented in Table 5.2. The average size of family for the sample as a whole was 5.18 and 4.49 in adopters and non-adopters families respectively. In terms of adult equivalent it was 3.86 and 3.60 for adopters and non-adopters respectively. The average number of workers per house hold was 2.66 and 2.17 for adopters and non-adopters respectively.

5.2 BASIC CHARACTERISTICS OF THE SELECTED HOUSEHOLDS

The economic strength of the farmer is largely determined by certain important characteristics such as size of holding, percentage of irrigated area to the total cultivated area, cropping intensity etc. These characteristics affect the economic behaviour of the farmers and reflects in the potential for the development. An attempt is made to study the important characteristics of the household which includes the asset composition.

5.2.1 Farm Assets

As indicated in the methodology chapter, the farm assets consist of land, livestock and implements and machinery. No machinery worth the name has been owned by any of the selected farmers except electric motors.

5.2.2. Farm Implements: It was observed from Table 5.3 that the farmers in the category of adopters by and large did not possess any improved implements. The only farm machinery owned by farmers was electric motors. It was observed that only one farmer had an iron plough and none of the farmers had seed drill, sprayers and dusters.

Table 5.3. Farm implements (number) and value in rupees/(house hold)

Adopters

Sl.	Particulars	Small		Medium		Large		Overall	
		Number	Value (Rs)	Number	Value (Rs)	Number	Value (Rs)	Number	Value (Rs)
1	Plough (Wodden)	0.69	72	0.9	123	1.86	196	0.96	108
2	Plough (Iron)	0.02	1	0	0	0	0	0.01	0.01
3	Guntaka	0.55	49	0.55	59	1.27	116	0.68	64
4	Gorru	0.24	18	0.19	10	0.14	9	0.21	15
5	Dante	0.51	34	0.55	38	1.32	100	0.67	47
6	Jambu	0.34	30	0.26	34	0.86	83	0.42	41
7	Sickle	3.82	40	4.26	42	5.91	56	4.31	44
8	Kurpi	3.81	19	3.94	20	5.77	30	4.2	21
9	Crowbar	0.96	36	0.97	68	1.54	105	1.07	57
10	Spade	1.06	47	1.16	48	1.73	68	1.21	50
11	Axe	1.06	38	1.19	48	1.54	63	1.18	45
12	Bullock cart	0.12	254	0.16	306	0.27	545	0.16	321
13	Electric motor	0.15	799	0.23	1303	0.73	4336	0.28	1578
14	Seed drill	-	-	-	-	-	-	-	-
15	Other	-	-	-	-	-	-	-	-
	Total		1437		2099		5707		2392

The important implements possessed by the farmers were wooden plough, guntaka, gorru, dhanti, jambo, bullock cart and the simple tools like sickle, kurpi, crowbar, spade and axe. The total value of implements worked out to Rs 2,392 per house hold in overall situation. The value of implements was Rs 1,437, Rs 2,099 and Rs 5,707 in the case of small, medium and large farms respectivley of adopters. Electric motor was the only costly item in the implements.

In the case of non-adopters the value of implements possessed by households was Rs 1,593, Rs 4,024 and Rs 6,516 in case of small, medium and large farmers, respectivley and in the overall situation the same was Rs 3,102 (Table 5.4). Most of the implements possessed by the farmers were of only traditional implements. The share of implements in the value of the total asset composition appears to be very low.

5.2.3 Value of Assets

The analysis (Table 5.5) indicated that for the sample as a whole the per farm assets value including land was relatively higher on non-adopter farm households as compared to that of adopter farm households. The same was also true with respect to different farm size groups. On an average the value of farm assets including land per hectare ranged from Rs 25,811 to Rs 39,251 with an overall [illegible]

Table 5.4. Farm implements (number) and value in ruppes/(house hold)

Non Adopters

Sl.	Particulars	Small		Medium		Large		Overall	
		Number	Value (Rs)	Number	Value (Rs)	Number	Value (Rs)	Number	Value (Rs)
1	Plough (Wodden)	0.95	78	1.10	93	2.22	188	1.19	99
2	Plough (Iron)	0.02	4	0.00	0	0.00	0	0.01	2
3	Guntaka	0.97	57	1.13	65	1.89	112	1.16	67
4	Gorru	0.02	1	0.00	0	0.00	0	0.01	1
5	Dante	0.67	32	0.92	42	1.67	83	0.90	43
6	Jambu	0.52	28	0.92	48	1.08	55	0.73	38
7	Sickle	2.70	24	3.79	33	6.06	49	3.55	31
8	Kurpi	3.44	14	2.24	15	5.72	23	3.40	16
9	Crowbar	0.72	41	0.97	55	1.44	78	0.91	51
10	Spade	0.80	27	1.03	34	1.39	47	0.96	32
11	Axe	0.89	10	0.83	10	1.67	14	1.01	11
12	Bullock cart	0.00	0	0.16	300	0.44	950	0.12	238
13	Electric motor	0.36	1277	0.95	3329	1.11	4917	0.65	2473
14	Seed drill	-	-	-	-	-	-	-	-
15	Other	-	-	-	-	-	-	-	-
	Total		1593		4024		6516		3102

Table 5.5 Average values of assets (per hectare) Rupees.

Sl. No.	Assets Particulars	Adopters				Non-Adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1	Land	34889	23894	24143	26837	34121	36784	33348	34600
2	Livestock	3110	1183	1388	1771	4414	2281	1225	2342
3	Implements	1252	734	944	961	1210	1464	779	1097
4	Total value with land	39251	25811	26475	29569	39745	40529	35352	38039
5	Total values with out land	4362	1917	2332	2732	5624	3745	2004	3439

the sample as a whole in the case of adopters. The same ranged from Rs 35,352 to Rs 39,745 with an overall average of Rs 38,039 for the sample non-adopters as a whole. The value of total farm assets has not indicated any relationship with farm size.

An attempt has also been made to examine the value of non land assets per hectare. It is observed from Table 5.5 that the value of non-land assets per hectare varied from Rs.1,917 on medium farms to Rs.4,362 on small farms with an overall average of Rs.2,732 for the sample as a whole for adopters. The same in the case of non-adopters it ranged from Rs.2,004 to Rs.5,624 in non-adopters with an overall average of Rs.3.439 perhectare for the whole sample. It is seen that the value of non land assets indicated an inverse relationship with farm size in non-adopters. Though such relationship has not been exhibited by adopters still this value was higher on small farms. This clearly brought out an interesting observation viz., that on both adopters as well as non-adopters, small farms are capital intensive. This might be due to the problem of indivisibilities of farm assets like livestock and implements.

The details of livestock and its value is presented in Table 5.6. In agriculture livestock plays an important role by providing draft power for farming operations and some additional income obtained through

Table 5.6 Value of Live stock (per hectare)

Adopters

Sl.	Particulars	Small Value (Rs)	Medium Value (Rs)	Large Value (Rs)	Overall Value (Rs)
1	Bullocks	1348.50 (43.2)	550.79 (46.5)	542.69 (39.2)	752.66 (42.5)
2	Milch animals	1590.38 (51.4)	517.04 (43.7)	561.56 (40.4)	813.36 (45.9)
3	Young stock	170.81 (5.4)	115.12 (9.8)	283.60 (20.5)	204.55 (11.6)
4	Sheeps & Goats	-	-	-	-
5	Others	-	-	-	-
	Total	3109.69 (100)	1182.95 (100)	1387.85 (100)	1770.57 (100)

Non Adopters

Sl.	Particulars	Small Value (Rs)	Medium Value (Rs)	Large Value (Rs)	Overall Value (Rs)
1	Bullocks	2337.65 (52.9)	1243.42 (54.5)	621.93 (50.8)	1239.40 (52.9)
2	Milch animals	1541.40 (34.9)	818.76 (35.8)	443.85 (36.3)	831.94 (35.5)
3	Young stock	535.08 (12.2)	218.32 (9.7)	158.80 (12.9)	270.16 (11.6)
4	Sheep & Goats	-	-	-	-
5	Others	-	-	-	-
	Total	4414.34 (100)	2281.00 (100)	1224.58 (100)	2341.50 (100)

Note : The figures in Parentheses indicates percentage to total va milch animals. It is observed from the Table 5.6 that the total value of livestock was Rs 1,770.57 on an average per hectare in the overall situation in the category of adopters. The large farmers comparatively possessed less number of bullocks, with that of small and medium farms. The total value of the livestock on small, medium and large farms were Rs.3109.6, Rs.1182.95 and 1387.85 respectively. The live stock possessed by small farmers appeared to be high when compared with medium and large farms. It is also observed that the availability of bullocks for farm operations was lowest on large farms.

The per hectare value of livestock was of the order of Rs 4,414.34, Rs 2,281.0 and Rs 1,224.58 and Rs 2,341.46 respectively on small, medium, large farms and for the sample as a whole for non-adopters.

An attempt was also made to examine how many farmers did not possess even basic implements and work cattle. This information is presented in Table 5.7.

It is seen from the table that 53 and 38 out of 240 total number of farmers did not possess any wooden ploughs. The situation with regard to samll farmers category the possession wooden ploughs was very poor, as 33 adopters and 38 non-adopters did not possess this implement. With regard to iron plough, 116 adopters and 101 non-adopters at the overall level did not possess

Table 5.7 Details of farmers having zero implements amd work cattle

S.No.	Group	Total No.of Farms		Zero Iron ploughs		Zero Iron ploughs		Zero Guntaka		Zero Gorru		Zero Dante		Zero Jambu		Zero Bullock Cart		Zero Elec. Motor		Zero Work Cattle	
		A	NA	A	NA	A	NA	A	NA	A	NA	A	NA	A	NA	A	NA	A	NA	A	NA
1.	Small	67	64	33	38	63	63	35	2	52	62	37	21	47	32	59	64	58	41	2	4
2.	Medium	31	38	15	--	31	38	17	--	26	38	16	5	24	3	26	31	24	4	--	3
3.	Large	22	18	5	--	22	--	6	--	19	18	7	1	10	2	16	10	8	--	2	--
4.	Overall	120	120	53	38	116	101	58	2	97	118	60	27	81	37	101	105	90	45	4	7

A : Adopters, NA : Non-adopters
Nil indicates all farms having implements and cattle.

any iron plough. The position is somewhat better with regard to Guntaka. Most of the adopters possess Guntaka, while about 50 per cent of the non-adopters did not possess the same. Gorru was another implement which was not held by many farmers. A great majority of the farmers did not possess the bullockcart. In general the posssession of implements by the samll farmers was very low. It is also seen that by and large all the farmers possess work cattle with very few exceptions.

5.2.4 Holding particulars of the selected farmers

The particulars of household, land holding and cropping pattern of the selected farmers are provided in Table 5.8. A total number of 120 households in each category i.e., the adopters category and non-adopters category are selected for the study. Among the adopters, a large number i.e., 67 households were covered under small category followed by 31 in medium category and 22 in large category. In the case of non-adopters, 64, 38 and 18 households respectively were selected under small, medium and large farm categories.

Land is the indespensable resource in agriculture. The total land owned by the selected households in case of adopters was 298.54 hectares, as against 339.28 hectares in non-adopters. The average size of holding in the case of adopters was 2.49 hectares as against 2.80 hectares in the case of non-adopters.

Table 5.8 Holding particulars of the selected farms

(Area in hectares)

Particulars	Adopters				Non-adopters			
	Small	Medium	Large	Average	Small	Medium	Large	Average
Sample size	67	31	22	120	64	38	18	120
Operational land	79.40	88.60	133.04	298.54	84.23	104.55	150.50	339.28
Net cultivated area	76.40	86.74	132.24	295.38	84.18	103.35	135.90	323.43
Gross cultivated area	78.60	88.80	137.30	305.42	84.18	103.35	137.50	324.49
Cropping intensity	102.80	102.40	104.00	103.40	100.00	100.00	101.20	100.30
Irrigated area	16.82	16.90	25.98	59.70	18.50	38.40	44.50	101.40
Percentage of irrigated area to the gross cropped area	21.40	19.00	18.90	19.50	22.00	37.20	32.40	31.20
Percentage of irrigated area to the Net cropped area	22.00	19.50	19.60	20.20	22.00	37.20	32.70	31.40
Average size of cultivated holdings	1.15	2.86	6.05	2.49	1.32	2.71	8.25	2.80

The average cultivated area per household was 1.15 hectares in case of small farmers. On an average the cultivated area per holding varied from 1.15 to 6.05 hectares with an overall average of 2.49 hectares for the sample as a whole in adopters. In case of non-adopters the average size of cultivated holding ranged from 1.32 to 8.25 hectares with an overall average of 2.80 hectares for the sample as a whole. It is also seen that there was not much difference in the cropping intensity between adopters and non-adopters despite marked differences in percentage area irrigated to gross cropped area and net cropped areas.

5.2.5 Cropping Pattern of Selected Farms

It is observed from the Table 5.9 that the castor, sorghum + redgram and paddy were the most important crops in kharif. Paddy was the most important crop taken in rabi in both the categories of farmers.

The area under castor ranged from 33 to 40 per cent of the cultivated area in case of adopters while it ranged 22 to 32 in case of non-adopters. In the case of adopters sorghum + pigeonpea was cultivated under improved conditions, while it was not the case with the non-adopters. The non-adopters cultivated sorghum + pigeonpea with local practices only and 28 per cent of the cultivated area was under this system. It was only 19 per cent of the cultivated area was used for

Table 5.9 Cropping patterns of selected farms (Area in hectares)

Particulars	Adopters				Non-Adopters			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall
Kharif (Area)	76.40	86.74	132.24	295.38	84.18	103.35	135.90	323.43
Paddy	16.11	15.12	23.09	54.32	18.50	37.80	37.90	94.20
	(21)	(17)	(17)	(18)	(22)	(37)	(28)	(29)
Sorghum+P.Pea(Local)	17.57	18.16	19.56	55.29	25.95	25.85	39.80	91.60
	(23)	(21)	(15)	(19)	(31)	(25)	(29)	(28)
Sorghum+P.Pea(Hybrid)	12.28	15.79	21.64	49.71	-	-	-	-
	(16)	(13)	(17)	(17)				
Castor(Auruna)	24.48	34.49	46.66	106.63	32.61	36.30	46.60	115.51
	(33)	(40)	(35)	(36)	(39)	(35)	(34)	(36)
Pearlmillet+P.Pea(Local)	-	-	-	-	7.10	2.40	5.60	15.12
					(5)	(2)	(4)	(5)
Others	4.96	3.18	21.29	29.63	0.00	1.00	5.00	7.00
	(7)	(4)	(16)	(10)	(0)	(1)	(5)	(2)
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Rabi (Area)	2.20	2.60	5.60	10.40	0.00	0.00	1.60	1.60
Paddy	1.80	2.60	4.80	9.20	0.00	0.00	1.60	1.60
	(82)	(100)	(86)	(88)	(0)	(0)	(100)	(100)
Others	0.40	0.00	0.80	1.20	0.00	0.00	0.00	0.00
	(18)	(0)	(14)	(12)	(0)	(0)	(0)	(0)
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: The figures in parentheses indicates percentage to total area cultivating sorghum + pigeonpea by adopters. 18 per cent of the cultivated area and 29 per cent of the cultivated area were utilised for cultivating paddy by adopters and non-adopters, respectively. There was not much variation in the percentage of area under paddy amongst the different sizes of farmers. The percentage of area under paddy was the lowest with 22 and it was maximum with 37 in the case of small and medium farmers respectively in the category of non-adopters.

5.2.6 Productivity of crops in selected farms

Productivity is measured in terms of average yield per hectare. The information on productivity of different crops size-wise for adopters and non-adopters is given in Table 5.10 It is observed that the productivity was relatively higher in adopters for all the crops raised when compared to non-adopters. For the sample as a whole the productivity of kharif paddy was 43.01 quintals for adopters as against 29.31 quintals for non-adopters. Even among the size groups also the productivity of paddy was more for adopters. The productivity of paddy varied from 40 quintals on medium farms to 45 quintals per hectare on large farms for adopters. The same ranged from 27.65 to 32.16 quintals in the case of non-adopters. The productivity of paddy in non-adopters revealed an inverse relationship with farm size.

Table 5.10 Productivity of different crops

(q/ha)

Sl. No.	Name of the crop	Adopters				Non-Adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
	Kharif								
1	Paddy	43.08	40.01	45.01	43.01	32.16	30.18	27.65	29.31
2	Sorghum (L) + P.pea	9.02 1.25	9.25+ 1.2	8.827+ 1.43	9.03+ 1.3	8.29+ 1.52	7.91+ 1.65	6.86+ 1.02	7.56+ 1.34
3	Sorghum (H) + P.pea	13.64+ 1.71	9.82+ 1.74	9.457+ 1.86	10.6+ 1.76	0.0	0.0	0.0	0.0
4	Castor (Aruna)	7.2 0.0	8.55 0.0	7.42	7.73	5.66	4.78	4.23	4.8
5	Castor (Local)	0.0	0.0	0.0	0.0	5.32	4.59	4.49	5.01
	Rabi								
	Paddy	44.17	35.17	32.5	35.27	0.0	0.0	15.00	15.00

With respect to castor the productivity has indicated an inverse relationship with farm size in non-adopters. It varied from 4.23 quintals to 5.66 quintals with an overall average of 4.8 quintals for the sample as a whole with respect to Aruna variety. The same ranged from 7.2 quintals on small farms to 8.55 quintals on medium farms with an overall average of 7.73 quintals for the sample as a whole for adopters. The productivity of local variety of castor (raised only by non-adopters) ranged from 4.49 to 5.32 quintals with an overall average of 5.01 quintals for the sample as a whole.

The productivity of sorghum (local) + pigeonpea was 9.03 + 1.30 quintals per hectare in the case of adopters, while the same was 7.56 + 1.34 quintals in case of non-adopters. The difference in productivity between the adopters and non-adopters with regards to castor (Aruna) was also substantial.

The foregone analysis clearly established the fact that the farmers who adopted the new technology achieved greater productivity from all the crops than those in the case of non-adopters.

5.3 COST STRUCTURE OF IMPORTANT CROP ENTERPRISES

One of the important objectives of the study is to assess the impact of technology on productivity and profitability. In the earlier section it was observed that productivity of various crops was relatively more on adopter farms as compared to that of non-adopters. It is of interest to know whether this higher productivity is the result of higher costs or otherwise. To find out this there is need to analyse the cost structure of different enterprises. This information is presented in Table 5.11.

It is observed from the Table that paddy (<u>kharif</u>), castor and sorghum (local), pigeon pea are the crops raised by both adopters as well as non-adopters. Hence, the analysis on the outset is restricted to these three enterprises.

5.3.1.1 Sorghum (L) + Pigeon pea

The total cost of cultivation per hectare was Rs 3800 for adopters as against Rs 2674 for non-adopters. In both, the total cost of cultivation per hectare indicated an inverse relationship with farm size. Among the farm size groups it varied from Rs 3154 to Rs 4506 on adopter farms as aginst Rs 2243 to Rs 3112 on non-adopter farms. Thus the cost of cultivation was relatively higher in adopters on all farm size groups as compared to that of non-adopters. It is also seen that the variable as well as fixed cost of cultivation per hectare related inversely with farm size and adopter farms. Only fixed costs per hectare revealed this relationship on non-adopter farms.

Table 5.11 Distribution of cultivation costs according to operational and fixed costs.

(Rs/ha)

Sl. No.	Crop/Size	Adopters			Non-adopters		
		O.C	F.C	T.C	O.C	F.C	T.C
1.	Sorghum (L) + P.pea						
	Small	3298.00	1207.61	4505.61	1761.00	1351.27	3112.27
		(73.20)	(36.80)	(100.00)	(56.58)	(43.42)	(100.00)
	Medium	2257.00	985.16	3242.16	1168.00	1212.84	2380.84
		(69.61)	(30.39)	(100.00)	(49.06)	(50.94)	(100.00)
	Large	2175.00	979.48	3154.48	1316.00	927.50	2243.50
		(68.95)	(31.05)	(100.00)	(58.66)	(41.34)	(100.00)
	Overall	2739.00	1061.43	3800.43	1499.00	1174.53	2673.53
		(72.07)	(27.93)	(100.00)	(56.07)	(43.93)	(100.00)
2.	Sorghum (H) + P.pea						
	Small	2739.00	1465.61	4204.61	-	-	-
		(65.14)	(34.86)	(100.00)			
	Medium	2351.00	1234.16	3585.16	-	-	-
		(65.58)	(34.42)	(100.00)			
	Large	2062.00	1298.48	3360.48	-	-	-
		(61.36)	(38.64)	(100.00)			
	Overall	2430.00	1326.43	3756.43	-	-	-
		(64.69)	(35.31)	(100.00)			
3.	Castor (Auruna)						
	Small	2224.00	1530.61	3754.61	1841.00	1333.27	3174.27
		(59.23)	(40.77)	(100.00)	(58.00)	(42.00)	(100.00)
	Medium	1907.00	1616.16	3523.16	1535.00	1136.84	2671.84
		(54.12)	(45.88)	(100.00)	(57.45)	(42.55)	(100.00)
	Large	1883.00	1427.48	3310.48	1811.00	971.50	2782.50
		(56.87)	(43.13)	(100.00)	(65.08)	(34.92)	(100.00)
	Overall	2051.00	1507.43	3558.43	1700.00	1162.53	2862.53
		(57.64)	(42.36)	(100.00)	(59.39)	(40.61)	(100.00)
4.	Paddy (Kharif)						
	Small	4872.00	2443.61	7315.61	4570.00	2067.27	6637.27
		(66.60)	(33.40)	(100.00)	(68.85)	(31.15)	(100.00)
	Medium	3996.00	2123.16	6119.16	4441.00	1794.84	6235.84
		(65.30)	(34.70)	(100.00)	(71.22)	(28.78)	(100.00)
	Large	4523.00	2447.48	6970.48	4369.00	1595.50	5964.50
		(64.89)	(35.11)	(100.00)	(73.26)	(26.74)	(100.00)
	Overall	4559.00	2332.43	6891.43	4478.00	1808.53	6286.53
		(66.15)	(33.85)	(100.00)	(71.[illegible])	(28.77)	(100.00)

O.C : Operational costs, FC : Fixed costs, TC : Total costs.

The proportion of variable costs to total costs was 72.1 per cent on adopter farms as against 56.1 per cent on non-adopter farms.

The foregoing analysis has clearly revealed that in general the variable cost of cultivation was relatively higher on adopter farms as compared to that of non-adopter farms. It is of interest to know whether this higher variable costs would influence productivity and in turn the net returns on adopter farms quite significant. This will be discussed latter.

5.3.1.2 Sorghum (H) + Pigeonpea

In the case of farmers of non-adopters category, no farmer raised the crop combination of sorghum (H) + pigeonpea.

In the adopters category the total cost of cultivation for the sample as a whole was Rs. 3,756 comprising Rs 2430 and Rs 1326 as operational and fixed costs respectively. The proportion of variable cost to total cost was 65 per cent. Among the farm size groups the total cost of cultivation had varied from Rs 2062 to Rs 2739 per hectare. The total cost of cultivation indicated an inverse relationship with farm size.

5.3.1.3 Castor (Aruna)

The total cost of cultivation perhectare for the whole sample was Rs.3,558 for adopters as against Rs.2,863 for non-adopters. The analysis indicated that while the total cost per hectare had an inverse relationship with farm size in adopters, no perceptible relationship was observed in non-adopters. Among the farm size groups the total cost of cultivation varied from Rs 3,310 to Rs 3,755 per hectare for adopters. The same ranged from Rs 2,672 on medium farms to Rs 3,174 on small farms. It is also seen from the analysis that the total cost of cultivation per hectare was relatively much higher on all farm size groups for adopters as compared to that of non-adopters. This higher cost on adopter farms was the result of adoption of technology.

The proportion of variable costs to total cost was 58 per cent on adopter farms as against 59 per cent on non-adopter farms. It is further observed that while variable costs per hectare indicated a inverse relationship with farm size on adopter farms, fixed costs per hectare indicated the same relationship on non-adopters.

5.3.1.4 Paddy (kharif)

For the sample as a whole the total cost of cultivation was Rs 6,891 per hectare for adopters as against Rs 6,287 for non-adopters. Among the farm size groups it ranged from Rs.6,119 on medium farms to Rs.7,316 on small farms in adopters as against Rs 5,964 to Rs 6,637 for non-adopters. It is further seen that the total cost of cultivation per hectare has indicated an inverse relationship with farm size in the case of

Table 5.12 Components of Cost of Cultivation
Crop: Sorghum(L)+Pigeonpea

(Rs/ha)

Sl. No.	Operational costs	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1.	Human labour (Including family labour)	1738 (53.00)	1144 (50.70)	1100 (50.60)	1419 (52.20)	990 (56.20)	737 (63.00)	737 (56.00)	858 (57.23)
2.	Bullock labour	735 (22.00)	435 (19.20)	392 (18.00)	570 (20.80)	408 (23.16)	280 (24.00)	419 (32.00)	367 (24.50)
3.	Farm yard Manure	229 (6.90)	208 (9.20)	193 (8.90)	215 (7.80)	277 (15.73)	85 (7.30)	34 (2.60)	170 (11.34)
4.	Seed	67 (2.00)	71 (3.10)	61 (2.80)	67 (2.40)	47 (2.70)	39 (3.30)	36 (2.60)	42 (2.80)
5.	Fertiliser	411 (12.50)	319 (14.20)	324 (14.90)	364 (13.20)	-	-	50 (3.30)	27 (1.80)
6.	Plant protection	42 (1.20)	24 (1.10)	41 (1.90)	36 (1.20)	-	-	14 (1.00)	2 (0.13)
7.	Interest on Cost	76 (2.30)	57 (2.50)	64 (2.90)	68 (2.40)	39 (2.21)	27 (2.40)	26 (2.00)	33 (2.2)
	Total Operational costs	3298 (100.00)	2257 (100.00)	2175 (100.00)	2739 (100.00)	1761 (100.00)	1163 (100.00)	1316 (100.00)	1499 (100.00)
	Fixed Costs								
1.	Land Rent	867.00 (71.80)	816.00 (82.80)	774.00 (79.00)	832.00 (78.40)	949.00 (70.26)	878.00 (72.40)	742.00 (80.00)	888.00 (75.60)
2.	Depreciation	122.61 (10.20)	73.29 (7.40)	89.77 (9.20)	93.22 (8.80)	121.06 (8.92)	147.32 (12.18)	85.3 (9.20)	114.64 (9.30)
3.	Interest on Fixed Capital	218 (18.00)	95.87 (9.70)	115.71 (11.80)	136.21 (12.80)	281.21 (20.82)	187.02 (15.42)	100.20 (10.80)	171.89 (14.60)
4.	Total Fixed Cost	1207.61 (100.00)	985.16 (100.00)	979.48 (100.00)	1061.43 (100.00)	1351.27 (100.00)	1212.34 (100.00)	927.50 (100.00)	1174.53 (100.00)
	Total Cost of Cultivation	4505.60	3242.16	3154.48	3800.43	3112.27	2380.84	2243.50	2673.53

Figures in parentheses indicates percentages to total.

non-adopters. It is also of interest to know that in both adopters and non-adopters the total cost of cultivation was highest on small farms.

Further it is observed that the total cost of cultivation was relatively higher on all farm size groups in adopters as compared to that of non-adopters. This is due to the adoptions of technology by the adopters.

The analysis of total costs into fixed and variable has indicated that for the sample as a whole 66 per cent of total costs has been accounted for by variable costs in adopters as against 71 per cent in non-adopters. It is also noted that while on adopter farms the fixed or variable costs per hectare has not indicated any perceptible relationship with farm size, both i.e., fixed and variable costs per hectare revealed an inverse relationship with farm size for non-adopters.

5.3.2 Components of Cost of Cultivation

Having discussed the cost of cultivation according to fixed and variable costs in the previous sections, an attempt has been made to present the cost of cultivation according to different components of cost items. This analysis would clearly reveal which category of farmers and which size group in a particular category is spending more in certain inputs. The analysis is presented separately for variable costs and fixed costs.

5.3.2.1 Sorghum (L) + Pigeonpea

The components of cost of cultivation of sorghum (L) + P.Pea is presented in Table 5.12. Labour constituted the major cost component in the variable cost. For the sample as a whole 52 per cent (Rs 1,419) of the total variable cost was incurred towards human labour on adopter farms as against 57 per cent (Rs 858) on non-adopter farms. The average amount spent on human labour was highest on adopter farms but the percentage contribution was highest on non-adopter farms. The amount spent on human labour ranged from Rs 1,100 per hectare on large farms to Rs 1,738 on small farms of adopters. The same on non-adopter farms it was Rs 737 per hectare on medium and large farms and Rs 990 per hectare on small farms. It is clear that among the size groups, in both the categories of adopters and non-adopters small farmers incurred the highest on human labour. Bullock labour formed the next major item of variable cost. Relatively higher expenditure was incurred on this by adopters when compared to non-adopters except in the case of large farms it was highest on non-adopter farms. For the all farms on adopters it was Rs 570 per hectare (20.8%) as against Rs 367 per hectare (24.5%) on non-adopter farms. Among the size groups the bullock labour cost on adopter farms ranged from Rs 392 per hectare on large farms to Rs 735 per hectare on small farms. With regard to non-adopters the same ranged from Rs 280 per hectare on medium farms to Rs 419 per hectare on large farms. In order of preference fertilizers formed the next important item of variable cost on adopters, while it was farmyard manure on non-adopter farms. As a whole the fertiliser cost on adopter farms constituted about 13 per cent (Rs 364 per ha) of total variable cost as against 1.8 per cent (Rs 27 per ha) on non-adopter farms. The fertiliser cost incurred was highest on small farms of adopter group with Rs 411 per hectare followed by large (Rs 324) and medium (Rs 318) farms. In the case of non-adopters none of the small and medium farmers has used any fertiliser. As indicated small farmers had used FYM to the larger extent on non-adopter farms and it formed about 15 per cent of (Rs 277 per ha) total variable cost. It was Rs 85 and Rs 34 per hectare on an average on medium and large farms, respectively. In the case of adopters on an average the cost incurred on FYM was highest on small farms Rs 229 per hectare followed by Rs 208 and Rs 193 per hectare on medium and large farms, respectively. For the farm as a whole it was Rs 215 per hectare. It is clear from the analysis that majority of the non-adopter farmers has got inclination towards using FYM rather than going for fertilisers as could be seen in the case of adopter farms.

Seed cost formed the next important cost item. With respect to adopters the cost incurred on seed varied from Rs 61 on large farms to Rs 71 on medium farms with an overall average of Rs 67 per hectare. For the whole sample. The proportion of cost incurred on this input to total variable cost ranged from 2per cent on small farms to 3.1 per cent on medium farms with an overall average of 2.4 per cent for the whole sample. In the case of non-adopters the cost incurred on seed varied from Rs 36 on large farms to Rs 47 per hectare on small farms, with an overall average of Rs 42 per hectare for the whole sample. With regard to plant protection input all categories of farmers in adopter group had used them as against only large farmers on non-adopter group farms. The cost incurred on this item on adopter farms ranged from Rs 24 (1.1%) on medium farms to Rs 42 per hectare (1.3%) on small farms with an average of Rs 36 (1.2%) for the farm as a whole. In the case of non-adopters only large farmers had used this input and it constituted one per cent of the total variable cost with Rs 14 per hectare.

Among the fixed costs in both the categories of farmers and on all farm size groups, rental value of land accounted as a major share. For the sample as a whole it was 78.4 per cent of total fixed cost on adopter farmers as against 75.6 per cent on non-adopter farms. The rental value of owned land varied from Rs 774 on large farms to Rs 867 on small farms with an overall average of Rs 832 per hectare for the whole sample on adopter farms. The same for non-adopters, it ranged from Rs 742 on large farms to Rs 949 per hectare on small farms with an overall average of Rs 888 per hectare for the sample as a whole. The rental value of land indicated an inverse relationship with farm size in both adopter and non-adopter farm situations.

5.3.2.2 Sorghum (H) + Pigeonpea

The particulars of cost of cultivation of sorghum (H) + P.Pea is presented in table 5.13. This crop combination has been taken up by only adopter farmers. As was the case in other crop situations, similarly the human labour cost constituted a major cost in total variable cost. The human labour cost ranged from Rs 649 per hectare on large farms (31.5%) to Rs 1,001 per hectare (37%) on small farms, with an overall average of Rs 869 per hectare(35.8%) for the sample as a whole. Bullock labour was the next important item which constituted 19.4 per cent of total variable cost for the sample as a whole. It ranged from 18.6 per cent on large farms to 20.3 per cent on small farms. In absolute terms the range was Rs 383 on large farms to Rs 556 per hectare on small farms. The same for the sample as a whole was Rs 471 per hectare. Fertiliser and farmyard manure almost equally occupied the cost component and contributed about 17 per cent to the overall farm situation. As the adopter farms, they gave importance to these inputs in raising the hybrid varieties of sorghum. The seed and plant protection items also formed as important inputs in this crop combination.

Table 5.13. Components of cost of cultivation

Crop : Sorghum (R) + Pigeonpea

(Rs./ha)

S.No.	Operation costsse	Adopters			
		Small	Medium	Large	Overall
1	Human Labour (Including family labour)	1001.00 (37.00)	880.00 (37.13)	649.00 (31.47)	869.00 (35.76)
2	Bullock labour	556.00 (20.30)	452.00 (19.22)	383.00 (18.57)	471.00 (19.38)
3	Farmyard Manure	473.00 (17.20)	384.00 (16.33)	356.00 (17.26)	414.00 17.03)
4	Seed	113.00 (4.20)	111.00 (4.72)	108.00 (5.23)	111.00 (4.57)
5	Fertiliser	457.00 (16.70)	411.00 (17.48)	385.00 (18.67)	424.00 17.45)
6	Plant Protection	67.00 (2.00)	49.00 (2.08)	117.00 (3.13)	73.00 (3.00)
7	Interest on cost	72.00 (2.60)	64.00 (2.74)	64.00 (3.13)	68.00 (2.81)
	Total Operation costs	2739.00 (100.00)	2351.00 (100.00)	2062.00 (100.00)	2430.00 (100.00)
Fixed Costs					
1	Land Rent	1125.00 (77.00)	1065.00 (86.30)	1093.00 (84.18)	1097.00 (82.72)
2	Depreciation	122.61 (8.37)	73.29 (5.94)	89.77 (6.91)	93.22 (7.02)
3	Interest on fixed capital	218.00 (14.63)	95.87 (7.76)	115.71 (8.91)	136.21 (10.26)
4	Total fixed cost	1465.61 (100.00)	1234.16 (100.00)	1298.48 (100.00)	1326.43 (100.00)
Total cost of cultivation		4204.61	3585.16	3360.48	3756.43

Figures in parentheses indicates percentages

For the farm as a whole seed and plant protection contributed 4.6 per cent and 3 per cent, respectively. The seed cost varied from Rs 108 per hectare on large farms to Rs 113 per hactare on small farms with an overall average of Rs 111 for the sample as a whole. The cost on plant protection input varied from Rs 49 on medium farms to Rs 117 on large farms with an overall average of Rs 73 for the whole sample.

With regards to fixed costs rental value of land constituted as a major component and formed 82.7 per cent of total fixed cost. The same ranged from 77 per cent on small farms to 86.3 per cent on medium farms. In absolute terms it ranged from Rs 1,065 per hectare on medium farms to Rs 1,125 per hectare on small farms.

5.3.2.3 Castor (Aruna)

The components of cost for Castor (Aruna) is presented in Table 5.14. Castor is one of the important dry crops in the study area. Among the total variable cost human labour formed as a major component by contributing more than 50 per cent in the variable cost. For the sample as a whole 54.7 per cent (Rs 1,122 per ha) of the total variable cost was incurred towards human labour on adopter farms as against 62.1 per cent (Rs 1,056 per ha) on non-adopter farms. With regard to size wise, the human labour ranged from 52.5 per cent (Rs 1,001 per ha) on medium farm to 55.4 per cent (Rs 1,232 per ha) on small farms in adopters category. The same in non-adopters, it ranged from 59.5 per cent (Rs 913

Table 5.14 COMPONENTS OF COST OF CULTIVATION

Crop: CASTOR (Auruna) (Rs/ha)

Sl. No.	Operation Costs	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1.	Human Labour (including family labour)	1232.00 (55.40)	1001.00 (52.49)	1056.00 (56.08)	1122.00 (54.71)	1133.00 (61.54)	913.00 (59.48)	1199.00 (66.21)	1056.00 (62.12)
2.	Bullock labour	490.00 (22.03)	497.00 (26.06)	460.00 (24.43)	485.00 (23.65)	419.00 (22.76)	406.00 (26.45)	332.00 (18.33)	390.00 (22.94)
3.	Farmyard Manure	146.00 (6.56)	59.00 (3.09)	26.00 (1.38)	91.00 (4.44)	50.00 (2.72)	44.00 (2.87)	49.00 (2.71)	47.00 (2.76)
4.	Seed	72.00 (3.23)	75.00 (3.93)	71.00 (3.77)	72.00 (3.50)	83.00 (4.51)	84.00 (5.47)	85.00 (4.69)	84.00 (4.91)
5.	Fertiliser	199.00 (8.95)	206.00 (10.8)	195.00 (10.36)	200.00 (9.75)	117.00 (6.36)	52.00 (3.39)	115.00 (6.35)	88.00 (5.07)
6.	Plant Protection	35.00 (1.57)	25.00 (1.31)	20.00 (1.06)	28.00 (1.37)	-	-	-	-
7.	Interest on Cost	50.00 (2.26)	44.00 (2.32)	55.00 (2.92)	53.00 (2.58)	39.00 (2.11)	36.00 (2.35)	31.00 (1.71)	35.00 (2.25)
	Total Operation Cost	2224.00 (100.00)	1907.00 (100.00)	1883.00 (100.00)	2051.00 (100.00)	1841.00 (100.00)	1535.00 (100.00)	1811.00 (100.00)	1700.00 (100.00)
	Fixed Costs								
1.	Land Rent	1190.00 (77.75)	1447.00 (89.53)	1222.00 (85.61)	1278.00 (84.78)	931.00 (69.83)	807.00 (70.55)	786.00 (80.90)	876.00 (75.35)
2.	Depreciation	122.61 (8.00)	73.29 (4.53)	89.77 (6.29)	93.27 (6.18)	121.06 (9.08)	147.87 (13.00)	85.30 (8.78)	114.64 (9.86)
3.	Interest on Fixed Capital	218.00 (14.25)	95.87 (5.94)	115.71 (8.10)	136.21 (9.04)	281.21 (21.09)	187.02 (16.45)	100.20 (10.32)	171.80 (14.79)
4.	Total Fixed Costs	1530.61 (100.00)	1616.16 (100.00)	1427.48 (100.00)	1507.43 (100.00)	1333.27 (100.00)	1136.84 (100.00)	971.50 (100.00)	1162.00 (100.00)
	Total Cost of Cultivation	3754.61	3523.16	3310.48	3558.43	3174.27	2671.84	2782.50	2862.53

Figures in parentheses indicates percentages per ha) on medium farms to 66.2 per cent (Rs 1,199 per ha) on large farms. Followed by human labour, bullock labour formed the next major item under variable cost. The bullock labour constituted about 23.6 per cent on overall farm situation with Rs 485 per hectare on adopter farms as against 22.9 per cent and Rs 390 per hectare on non-adopter farms. Among the size groups the cost in total variable cost it varied from 22 per cent on small farms to 26 per cent on medium farms in adopter group as against 18.3 per cent on large farms to 26.5 per cent on medium farms in non-adopter farms. Fertiliser formed the next important input in the cost component. In total variable cost it consisted of about 9.7 per cent for the sample as a whole as against 5 per cent on non-adopter farms. With regard to farm size the contribution varied from 8.9 per cent on small farm to 10.8 per cent on medium farms in adopter group of farmers, while the same on non-adopter farms it ranged from 3.4 per cent on medium farms to 6.4 per cent on small and large farm categories equally. Seed formed the next input in order of preference in the cost items. The cost of seed on adopter farms accounted more than 3 per cent on an average as against more than 4 per cent on non-adopter farm situation. With regards to the vital input for adopter farms i.e., plant protection only adopter farmers has incurred about 1.4 per cent on an average for the farm as a whole. None of the non-adopter farmers had taken up this input. The analysis clearly indicates that adopter farms has substantially used fertilisers, farmyard manure and plant protection chemicals when compared with that of non-adopter farms.

With regard to fixed cost rental value of land formed as the major component with a contribution of 84.8 per cent on an average for the sample as a whole on adopter farms as against 75.4 per cent on non-adopter farms. In absolute terms the rental value ranged from Rs 1,190 on small farms to Rs 1,447 per hectare on medium farms of adopter category. On an average it was Rs 1,278 per hectare for the sample as a whole. With regard to non-adopters the rental vaue varied from Rs 786 on large farms to Rs 931 per hectareon small farms with an overall average of Rs 876 for the sample as a whole. Comparatively the rental value of land was higher on adopter farms indicating better productivity as a result of adopting new technology.

5.3.2.4 Paddy (kharif)

The particulars the cost components of Paddy (Kharif) is presented in Table 5.15. Among the variable costs, labour formed the major cost component. For the sample as a whole 54 per cent of the total variable cost was incurred towards human labour on adopter farms as against 62 per cent on non-adopter farms. On an average an amount of Rs 2,464 per hectare was spent by adopters as against Rs 2,794 by non-adopters. Among the size groups, in both the categories the small farmers

Table 5.15 COMPONENTS OF COST OF CULTIVATION

Crop : Paddy (Kharif) Rs/ha

Sl. No.	Operation Costs	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1.	Human Labour (Including family Labour)	2574.00 (52.83)	2244.00 (56.16)	2519.00 (55.69)	2464.00 (54.05)	2827.00 (61.86)	2772.00 (62.42)	2772.00 (63.45)	2794.00 (62.39)
2.	Bullock Labour	597.00 (12.25)	551.00 (13.79)	571.00 (12.62)	578.00 (12.68)	880.00 (19.26)	862.00 (19.41)	788.00 (18.04)	852.00 (19.03)
3.	Farmyard Manure	515.00 (10.57)	274.00 (5.86)	331.00 (7.32)	393.00 (8.62)	337.00 (7.37)	276.00 (6.22)	221.00 (5.06)	286.00 (6.39)
4.	Seed	301.00 (6.18)	273.00 (6.83)	282.00 (6.25)	283.00 (6.21)	389.00 (8.51)	331.00 (7.45)	333.00 (7.62)	353.00 (7.88)
5.	Fertiliser	810.00 (16.63)	629.00 (15.74)	736.00 (16.27)	764.00 (16.76)	70.00 (1.53)	129.00 (2.90)	175.00 (4.00)	118.00 (2.64)
6.	Plant Protection	--	--	--	--	--	--	--	--
7.	Inerest on Cost	75.00 (1.54)	65.00 (1.62)	84.00 (1.86)	77.00 (1.68)	67.00 (1.47)	71.00 (1.60)	80.00 (1.83)	75.00 (1.67)
	Total Operation Costs	4872.00 (100.00)	3996.00 (100.00)	4523.00 (100.00)	4559.00 (100.00)	4570.00 (100.00)	4441.00 (100.00)	4369.00 (100.00)	4478.00 (100.00)
	Fixed Costs								
1.	Land Rent	2103.00 (86.06)	1954.00 (92.03)	2242.00 (91.60)	2103.00 (90.16)	1665.00 (80.54)	1460.00 (81.34)	1410.00 (88.37)	1522.00 (84.16)
2.	Depreciation	122.61 (5.02)	73.29 (3.45)	89.77 (3.67)	93.22 (4.00)	121.06 (5.86)	147.82 (8.24)	85.30 (5.35)	114.64 (6.34)
3.	Interest on Fixed Capital	218.00 (8.92)	95.87 (4.52)	115.71 (4.73)	136.21 (5.84)	281.21 (13.60)	187.02 (10.42)	100.20 (6.28)	171.89 (9.50)
4.	Total Fixed Costs	2443.61 (100.00)	2123.16 (100.00)	2447.48 (100.00)	2332.43 (100.00)	2067.27 (100.00)	1794.84 (100.00)	1595.50 (100.00)	1808.53 (100.00)
	Total Cost of Cultivation	7315.61	6119.16	5970.48	6891.43	6637.27	6235.84	5964.50	6286.53

Figures in parentheses indicates percentages.

incurred the highest on human labour. The labour costs varied from Rs 2,244 on medium farms to Rs 2,574 on small farms in adopters. The same ranged from Rs 2,772 on large farms to Rs 2,827 on small farms in non-adopters.

The next major item of variable cost was fertilizers. It is clearly seen that while adopters spent considerable amount of this input, the non-adopters spent a small proportion of total variable costs on this. On an average, for the sample as a whole 16.76 per cent of variable cost was incurred by adopters as against just 2.64 per cent by non-adopters. This clearly reveals the adoption pattern of new technology between adopters and non-adopters. Among the farm size groups, there was not much difference in the proportion of expenditure incurred to the total variable cost. However in absolute terms there is variations. In the case of adopters, the expenditure incurred per hectare on chemical fertilisers ranged from Rs 629 on medium farms to Rs 810 on small farms with an overall average of Rs 764 for the whole sample. With respect to non-adopters it varied from Rs 70 to Rs 175 with an overall average of Rs 118 for the whole sample. In this category the fertiliser expenditure per hectare indicated a direct relationship with farm size.

Next in order of importance is the bullock labour. Relatively higher expenditure was incurred on this by non-adopters when compared to adopters. For the sample as a whole the adopters incurred Rs 578 per hectare on bullock labour as against Rs 852 by non-adopters. This formed 12.6 per cent and 19 per cent of total variable costs respectively on adopter and non-adopter farms. While the expenditure incurred on this cost item indicated an inverse relationship with farm size in non-adopters, no specific relationship was observed on adopter farms. However even in adopters, small farmers incurred highest amount on this. Among different farm size groups, the expenditure incurred on bullock labour varied from Rs 551 on medium farms to Rs 597 on small farms in adopters. With respect to non-adopters, it ranged from Rs 788 to Rs 880 per hectare.

Both the category of farms incurred considerable amount on FYM. This clearly shows that one of the nutrient management practices viz., integrating organic manures with inorganic manures has been adopted not only by adopters but also by non-adopters. The expenditure incurred in this input ranged from Rs 274 on medium farms to Rs 515 on small farms in adopters with an overall average of Rs 393 per hectare for the sample as a whole. On this category of farms the proportion of amount spent to total variable cost varied from 5.9 per cent on medium farms to 10.6 per cent on small farms with an overall average of 8.6 per cent for the whole sample. With respect to non-adopters the expenditure incurred on FYM ranged from Rs 221 to Rs 337 per hectare with an overall average of Rs 286 for the sample as a whole. This indicated an inverse relationship with farm size. The proportion of expenditure on FYM to the total variable cost varied from 5 to 7.4 per cent with an overall average of 6.4 per cent for the whole sample.

Seed cost formed the next important cost item. With respect to adopters, the cost incurred on seed varied from Rs 273 on medium farms to Rs 301 on small farms with an overall average of Rs 283 per hectare for the whole sample. The proportion of cost incurred on this input to total variable cost ranged from 6.2 per cent on small farms to 6.8 per cent on medium farms with an overall average of 6.2 per cent for the whole sample. In the case of non-adopters the cost incurred on seed varied from Rs 331 (7.5%) on medium farms to Rs 389 per hectare (8.5%) on small farms with an overall average of Rs 353 (7.9%) for the sample as a whole.

Among the fixed costs in both the categories of farmers and on all farm size groups, rental value of land accounted for a major share. For the sample as a whole it was 90 per cent of total fixed cost on adopter farms as against 84 per cent on non-adopter farms. The rental value of owned land varied from Rs 1954 per hectare on medium farms to Rs 2242 on large farms with an overall average of Rs 2103 for the whole sample in adopters. The same for non-adopters ranged from Rs 1410 to Rs 1665 with an overall average of Rs 1522 for the sample as a whole. The rental value of owned land indicated on inverse relationship with farm size in non-adopter farms. However the rental value of owned land was relatively higher on all farm size groups in adopters. This clearly revealed that the productivity of paddy was higher on adopter farms.

5.3.3 COST CONCEPTS

Having discussed the cost of cultivation on important crops according to cost components in the previous sections, an attempt has been made to present the same according to cost concepts. The details for the selected crops are presented in Table 5.16.

5.3.3.1 Sorghum (L) + Pigeonpea

The cost of cultivation according to cost concepts clearly indicated that on adopter farms the cost of cultivation was relatively higher on all farm size groups when compared to the non-adopter farms. On an average, the cost of cultivation according to cost A1, varied from Rs 1,758 on medium farms to Rs 2,378 on small farms with an overall average of Rs 2,114 for the sample as a whole on adopter farms. The same on non-adopter farms ranged from Rs 848 on large farms to Rs 1288 on small farms with an overall average of Rs 1,101 for the sample as a whole. The cost A1 had indicated an inverse relationship with farm size in the non-adopter category. The cost of cultivation according to Cost B also exhibited an inverse relationship with farm size on

Table 5.16 Cost of cultivation of crops according to cost concepts

(Rs/ha)

Sl. No.	Name of the crop & Size	Adopters Rs/ha			Non-Adopters		
		Cost A1	Cost B	Cost C	Cost A1	Cost B	Cost C
1.	Sorghum(L)+Pigeonpea						
	Small	2377.61	3462.61	4505.61	1288.06	2528.27	3112.27
	Medium	1758.29	2670.16	3242.16	946.82	2011.84	2380.84
	Large	1989.77	2879.48	3154.48	848.30	1690.50	2243.50
	Overall	2114.22	3082.43	3800.43	1100.64	2160.53	2673.53
2.	Sorghum(H)+Pigeonpea						
	Small	2260.61	3603.61	4204.61	-	-	-
	Medium	1984.29	3145.16	3585.16	-	-	-
	Large	1989.77	3198.48	3360.48	-	-	-
	Overall	2105.22	3338.43	3756.43	-	-	-
3.	Castor (Auruna)						
	Small	1607.61	3015.61	3754.61	1282.06	2494.27	3174.27
	Medium	1480.29	3023.16	3523.16	1225.82	2214.84	2671.84
	Large	1708.77	3046.48	3310.48	997.30	1883.50	2782.50
	Overall	1648.22	3062.43	3558.43	1157.64	2205.53	2862.53
4.	Paddy (Kharif)						
	Small	3964.61	6285.61	7315.61	3560.06	5506.27	6637.27
	Medium	3396.29	5446.16	6119.16	3756.82	5403.84	6235.84
	Large	4360.77	6718.48	6970.48	4177.30	5687.50	5964.50
	Overall	4040.22	6279.43	6891.43	3925.64	5619.53	6286.53

this category. The cost of cultivation according to cost B ranged from Rs 1690 per hectare to Rs 2528 with an overall average of Rs 2,161 for the sample as a whole on non-adopter farms. The same on adopter farms varied from Rs 2,670 on medium farms to Rs 3,463 on small farms with an overall average of Rs 3,082 for the whole sample.

Since the total cost of cultivation has already been discussed in the previous section, discussion on Cost C has not been presented here.

The foregoing analysis has clearly showed that on adopter farms the cost of cultivation was relatively higher whatever the cost concept. This again supports our earlier findings that these higher costs on adopter farms are due to adoption of new technology on these farms. The analysis is presented separately for variable costs and fixed costs.

5.3.3.2 Sorghum (H) + Pigeonpea

With regards to the cost of cultivation of this crop enterprise cost A1 varied from Rs.1,984.79 on medium farms to Rs.2,260.60 on small farms with an overall average of Rs.2,105.22 for the whole sample. The cost of cultivation according cost B ranged from Rs.3,145.16 on medium farms to Rs.3,603.61 on small farms. The same for the sample as whole was Rs.3,338.43. It clearly indicated that the cost of cultivation per hectare has not indicated any perceptable relationship with that of farm size. This crop enterprise i.e., sorghum (hybrid) + pigeonpea has been taken up only by adopter farmers indicating the raising of hyb rid varieties under new technology.

5.3.3.3 Castor (Aruna)

The cost of cultivation according to cost concepts in castor also revealed that adopters incurred higher cost on all farm size groups as compared to that of non-adopters. While Cost A1 and Cost B indicated an inverse relationship with farm size in non-adopters, only Cost B indicated a direct relationship with farm size in the case of adopters. Cost A1, varied from Rs 1,480 per hectare on medium farms to Rs 1,709 on large farms in adopters. It ranged from Rs 997 to Rs 1,282 in non-adopters.

Cost B ranged from Rs 3016 to Rs 3046 in adopters and from Rs 1884 to Rs 2,494 on non-adopter farms.

5.3.3.4 Paddy (*kharif*)

It is observed that cost of cultivation per hectare according to cost concepts has not indicated any perceptible relationship with farm size in adopters. On an average cost of cultivation according to cost concept A1, varied from Rs 3,396 on medium farms to Rs

4,361 on large farms with an overall average of Rs 4,040 for the sample as a whole. The same for non-adopters indicated a direct relationship with farm size. It varied from Rs 3,560 to Rs 4,177 with an overall average of Rs 3,926 for the sample as a whole.

With regard to cost B it ranged from Rs 5,446 on small farms to Rs 6,718 on large farms with an overall average of Rs 6,279 for the sample as a whole for adopters. The same in the case of non-adopters it varied from Rs 5,404 on medium farms to Rs 5,688 on large farms with an overall average of Rs 5,620 for the sample as a whole.

5.3.4 RETURNS AND INPUT-OUTPUT RATIOS

An attempt has been made in this section to estimate gross and net returns, derive input-output ratios and to assess the profitability of different enterprises grown by adopters and non-adopters. This information is presented in Table 5.17.

5.3.4.1 Sorghum (L) + Pigeonpea

The analysis revealed that in both adopters and non-adopters the gross returns per hectare for this inter-cropping system has indicated an inverse relationship with farm size. In adopters the gross returns per hectare varied from Rs 3,186 to Rs 3,528 per hectare with an overall average of Rs 3,338 for the sample as a

Table 5.17 Returns and Input-Output Ratio's on adopter and Non-adopter farm situations

Sl. No.	Crop & Farm size	Adopters				Non-Adopters			
		Total Cost (Rs/ha)	Gross Returns (Rs/ha)	Net Returns (Rs/ha)	Input-Output Ratio	Total Cost (Rs/ha)	Gross Returns (Rs/ha)	Net Returns (Rs/ha)	Input-Output Ratio
1.	**Sorghum(L)+Pigeonpea**								
	Small	**4505.61**	3528.00	-977.61	0.78	3112.77	**3533.00**	**420.73**	**1.14**
	Medium	**3242.16**	3310.00	67.84	1.02	2380.84	**3423.00**	**1042.16**	**1.43**
	Large	3154.48	3186.00	31.57	1.01	2243.50	**2698.00**	454.50	**1.20**
	Overall	3800.43	3338.00	-462.43	0.88	2673.53	3140.00	466.47	1.17
2.	Sorghum(H)+Pigeonpea								
	Small	4204.61	4500.00	295.39	1.07				
	Medium	3585.16	4258.00	672.84	1.19				
	Large	3360.48	4372.00	1011.52	1.30				
	Overall	3756.43	4386.00	629.57	1.17				
3.	Castor (Auruna)								
	Small	3754.61	[illegible]	[illegible]	[illegible]	3174.27	4176.00	1001.73	1.32
	Medium	3523.16	5788.00	2264.84	1.64	2671.84	2942.00	270.16	1.10
	Large	3310.48	4889.00	1578.52	1.48	2782.50	3120.00	337.50	1.12
	Overall	3558.43	5113.00	1554.57	1.44	2862.53	3360.00	497.47	1.17
4.	Paddy (Kharif)								
	Small	7315.61	8414.00	1098.39	1.15	6637.27	6660.00	22.73	1.00
	Medium	6119.16	7814.00	1694.39	1.28	6735.84	**5840.00**	-395.84	**0.94**
	Large	6970.48	8968.00	1997.52	1.29	5964.50	5642.00	-322.50	0.95
	Overall	6891.43	8412.00	1520.57	1.22	6286.53	6090.00	-196.53	0.97

whole. In non-adopter farms it ranged from Rs 2,698 to Rs 3,533 with an overall average of Rs 3,140 for the whole sample. When net returns are seen, only medium and large farm size groups had marginal returns with Rs 67.84 and Rs 31.52 respectively. The small farms incurred a loss of Rs 977.61 for adopter farms. With regard to non-adopters the net returns are highest in medium farms with Rs 1,042.16 followed by large (Rs 454.50) and small (Rs 420.73) farms. It was Rs 466.47 for the sample as a whole. The input output ratios were comparatively less on adopter farms as against non-adopter farms. The input output ratios for adopter farms ranged from 0.78 on small farms to 1.02 on medium farms with an overall average of 0.88 for the sample as a whole. With regards to non-adopters it ranged from 1.14 on small farms to 1.43 on medium farms with an overall avrage of 1.17 for the whole sample. The higher ratios in the case of non-adopters might be due to lower cost C when compared with adopter farms.

5.3.4.2 Sorghum (H) + Pigeonpea

This crop combination has been taken up only on adopter farms. The analysis indicated that the gross returns varied from Rs 4,372 on large farms to Rs 4,500 on small farms, with an overall average of Rs 4,386 for the whole sample. When the net returns are observed it revealed a direct relationship with farm size. With highest returns on large farms (Rs 1,011.52) followed by medium (Rs 672.84) and small (Rs 295.39) farms. For the sample as a whole it was Rs 629.57. The input output ratios were 1.30, 1.19 and 1.07 in the same order and indicated profitability in all farm situations.

5.3.4.3 Castor (Aruna)

The gross returns on this crop enterprise for adopter farms was highest i.e., Rs 5,788 on medium farms followed by Rs 4,889 on large farms and Rs 4,759 on small farms. The same was Rs 5,113 for the whole sample. With regard to non-adopter farms the gross returns was highest on small farms (Rs 4,176) followed by large (Rs 3,120) and medium (Rs 2,942) farms. On an average it was Rs 3,360 for the sample as a whole. The net returns were comparatively high on adopter farms and it ranged from Rs 1,004.39 on small farms to Rs 2,264.84 on medium farms as against variation of Rs 270.16 on medium farms to Rs 1,001.73 on small farms. The input output ratio was highest on medium farms (1.64) of adopters, while it was highest (1.31) on small farms in non-adopters. For the overall situation of adopters the input output ratio was 1.43 as against 1.17 of non-adopters. The analysis clearly indicated better returns in the case of adopters by following new technology when compared with non-adopter farm situations.

5.3.4.4 Paddy (<u>kharif</u>)

On paddy crop the gross returns varied from Rs 7,814 on medium farms to Rs 8,968 on large farms on adopter farms as against variation of Rs 5,642 on large farms to Rs 6,660 on small farms of non-adopters. On an average the gross returns were Rs 8,412 and Rs 6,090 on adopter and non-adopter farms, respectively. The net returns showed direct relationship with farm size in adopter farms, with highest returns of Rs 1,997.52 on large farms. The same was Rs 1,098.39 and Rs 1,694.39 for small and large farms respectively on adopter farms. In the case of non-adopters the net returns had indicated a marginal net profit of Rs 22.73 while medium and large farms incurred a net loss of Rs 395.84 and Rs 322.50, respectively. On an average the net loss was Rs 196.53 for the sample as a whole for non-adopters. The input output ratios for adopter farms ranged from 1.15 on small farms to 1.28 on large farms with an overall average of 1.22 for the whole sample. With regard to non-adopters the ratios were 1.0, 0.93, 0.94 and 0.96 for small, medium, large and all farms, respectively.

The higher input output ratios on adopter farms indicated adoption of technology has increased their returns over the investment. It is also evident that non-adopter farms with low input output ratio incurred net losses in medium and large size group farms.

The foregoing discussion on costs and returns for different enterprises between adopters and non-adopters has clearly broughtout the impact of technology on adopter farms as compared to that of non-adopter farms. It was observed that in the case of castor and paddy on all farm size groups the gross returns and net profits were substantially higher on adopter farms as compared to that of non-adopter farms. In turn this has ultimately resulted high input output ratios on adopter farms. Thus it could be concluded that the impact of technology on productivity, gross returns and net returns was positive and quite significant on adopter farms.

5.4 MAHALANOBIS "D^2"

It is likely that adopters and non-adopters may exhibit a differential behaivour in their inputs and output due to the two different situations (i.e., watershed and non-watershed).

To study this differential behaviour Mahalanobis D^2 was estimated for the two sets of data i.e., adopters and non-adopters.

The results are presented in Table 5.18 It can be seen in respect of each crop that there was a significant differnce between adopters and non-adopters in their input and output values. The D^2 was significant at 1 per cent level. This behaviour indicated that a separate analysis with regard to the resource productivity is to be carried out for the two situations. Hence the category-wise analysis carried out has been discussed in the following sections.

Table 5.18 MAHALANOBIS "D2"

Sl. No.		Sorghum(L)+Pigeonpea			Caster (Auruna)			Paddy (Kharif)		
		Mean		D=	Mean		D=	Mean		D=
		Adopters	Non-Adopters	A-NA	Adopters	Non-Adopters	A-NA	Adopters	Non-Adopters	A-NA
1.	Output Value	3542.69	2863.86	678.83 (1.79)	5818.37	2351.47	3466.90 (7.95)	8047.27	6686.29	1360.98 (1.74)
2.	Land (ha)	1.06	0.91	0.15 (1.70)	1.15	0.64	0.51 (6.12)	0.97	1.16	-0.19 (-1.6)
3.	Human labour	124.71	63.68	61.03 (6.60)	109.89	58.15	51.74 (7.42)	204.76	286.48	-81.72 (-3.23)
4.	Cattle labour	26.28	16.17	10.11 (5.30)	27.51	12.25	15.26 (7.78)	26.00	47.71	-21.71 (-6.28)
5.	Seed	117.03	25.06	91.97 (9.70)	92.25	56.20	36.05 (5.94)	261.00	392.77	-131.77 (-4.14)
6.	Manure	190.92	101.33	89.59 (2.19)	68.88	63.60	5.28 (0.27)	343.17	273.52	69.65 (1.45)
7.	Fertiliser	-	-	-	224.36	55.67	168.69 (8.08)	660.65	167.02	493.63 (8.77)
8.	Plant protection	-	-	-	24.15	27.30	-3.15	-	-	-
	$"D^2"$	13.61**			2.66**			9.99**		
	F Value	75.02 (With 6 and 145 DF)			10.39 (With 8 and 134 DF)			44.70 (With 7 and 128 DF)		

** Indicates significant at 0.01 level of probability

5.4.1 RESOURCE PRODUCTIVITY, RESOURCE EFFICIENCY AND RETURNS TO SCALE

An attempt is made in this section to estimate resource returns, returns to scale and resource use efficiency on adopter and non-adopter farms. Functional analysis was used to estimate the quantitative relationship between the gross income and input variables. The analysis will also help to explore the possibilities of increasing the gross income by adjusting the input levels.

Among the various available functional forms, Cobb-Douglas Production function model was selected to estimate the resource productivity after examining the scatter diagram. The production function estimated for different crops for adopter and non-adopter farms are discussed separately. In case of both these categories the "overall" production functions are also discussed.

The Cobb-Douglas Production functions are fitted by taking all the important input variables viz., human labour, cattle labour, seed, manure, fertiliser and plant protection chemicals as the independant variables and output as the dependant variable (all measured in monetary terms). It is observed that the land was the basic resource upon which the inputs used depends mostly. As a result of this, the land had almost a perfect linear relationship with the input variables. This created the problem of multi-colliniarity.

To overcome the effect of land which is the cause for inter-relationship among the input variables, the production function was fitted separately to each of the size groups of the farmers classified as small, medium and large. Since these size groups are homogeneous with regard to size (i.e. land), the independent variable "Land" was dropped from the functions. Thus, variable land though deleted still its influence can be seen since the functions are fitted for different size groups.

Since land is not considered in the analysis (the size groups which are homogeneous with regard to the land holdings) the analysis for "overall" group which is now a heterogeneous group and reflects the behaviour of all size groups could not be considered for interpretation for all the crops in respect of adopters and non-adopters.

Despite dropping the land input to minimise the problems of multicolliniarty, the zero order correlation matrix with other input variables again revealed a high degree of interrelationship. The production functions were seen by dropping land. It was observed for all crops and all size groups that the production function fitted with all input variables (excluding land) resulted in a high coefficient of multiple determination i.e., R^2. However, many partial regression coefficients were statistically not significant and in some cases there was a distortion in sign of the variables also. This behaviour clearly reflected the ill-effects of multi-colliniarity. Hence the step down regression procedure was applied for screening the independant variables for their inclusion in the production function analysis. This procedure identifies the most significant variables that directly or indirectly affect the output after removing the effects of inter-relationship among the independent variables.

The detailed discussion of the functional analysis is presented below.

5.4.1.1 Sorghum (L) + Pigeonpea (adopters)

Sorghum (L) + Pigeonpea is an important inter-cropping system recommended in dryland agriculture. The production elasticities and related statistics are presented in Table 5.19.

Small farms

The coefficient of multiple determination R^2 was 0.76. The production elasticities of the variables namely human labour and fertilisers were 0.84 and 0.72, respectively. These two coefficients of variables were positively correlated with gross value of output. These were found to be statistically significant at 1 per cent

Table 5.19 Production Elasticities and Related Statistics: Jowar + Pigeonpea (Local) (Value in Rupees) Perfarm

Sl. No.	Particulars	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1	No. of farms								
	Constant log(a)	1.3224	3.4910	8.2169	2.8831	4.0295	4.6543	4.9605	3.1788
2	Production elasticities								
	Land (ha)	-	-	-		-	-	-	-
	Human labour	0.8432**	-	-	0.5695*	0.3369*	-	-	0.4648**
		(0.2963)			(0.2668)	(0.1489)			(0.0990)
	Cattle labour	-0.6279*	-		-0.5045*	-	0.2839*	-	-
		(0.2890)			(0.2436)		(0.1138)		
	Seed	-	0.5875**	-	0.2842*	0.4161	0.4989**	0.8898**	0.4686**
			(0.1863)		(0.1320)	(0.1139)	(0.1682)	(0.0835)	(0.0970)
	Manure	-	0.1948**	-	0.0547**	-	-	-	0.0194
			(0.0227)		(0.0138)				(0.0087)
	Fertiliser	0.7271**	0.2603*	-	0.4371**	-	-	0.0352	-
		(0.1602)	(0.1272)		(0.1072)			(0.0196)	
	Plant protection	-	-	0.0985*		-	-	-0.0755**	-
				(0.0427)				(0.0244)	
3	R2	0.7609	0.8315	0.3708	0.7845	0.6624	0.5869	0.9200	0.8585
4	Return to scale	0.9423*	0.9427*	0.0984*	0.8419*	0.7530*	0.7828*	0.8496*	0.9139*
5	Geometric mean								
	Output	2160.53	3064.13	4816.97	2850.44	1844.84	2687.11	6083.89	2505.77
	Land	-	-			-	-		
	Human labour	1492.13	1579.04	2536.52	1678.60	655.44	787.84	2020.54	821.38
	Cattle labour	456.67	444.28	656.87	489.02	196.62	231.08	836.28	255.62
	Seed	73.76	114.15	182.53	102.19	26.05	30.00	70.82	29.73
	Manure	4.36	19.19	49.84	11.52	92.15	7.89	3.31	23.29
	Fertiliser	258.56	286.55	519.60	309.34	-	-	7.54	-
	Plant protection	3.98	3.66	14.45	5.09	-	-	4.24	-

** Significant at 1 per cent level of probability

* Significant at 5 per cent level of probability

level. These two variables explained the variation in the gross value of output to the extent of 76 per cent. Human labour played an important role in dryland agriculture as several cultural operations would be required to perform for sowing, inter-culturing and weeding etc. Hence the impact of human labour on output was significantly high. Further it was also found that the output was highly responsive to fertiliser application in jowar (L) + pigeonpea in inter-cropping system. The results clearly indicated that by increasing 1 per cent of human labour the gross value of output would be increased by 0.84 per cent. Similarly a 1 per cent increase in fertiliser would increase the gross output by 0.72 per cent. It was also observed that cattle labour had negatively correlated with output and it was also statistically significant at 5 per cent level. This indicated that the cattle labour was excessively used and hence it would be profitable to curtail the use of cattle labour in this inter-cropping system. One per cent increase in the use of cattle labour would result in a loss of output to the extent of 0.62 per cent.

Medium farms

The included variables viz., seed and manure explained 83 per cent variation in gross output. The regression coefficients of seed and manure were 0.58 and 0.19, respectively. These two variables were positively and significantly correlated with the output at 1 per cent level. Manure also had an impact on the output. The results clearly indicated that it would be possible to increase the gross output by 0.58 per cent and 0.19 per cent by increasing 1 per cent of seed and 1 per cent of manures respectively.

Large farms

37 per cent of the variation in output was explained by plant protection variable. It was surprising that the other important variables namely human labour, fertilisers, seed and manures did not show any impact on output in the case of large farmers, unlike in the case of small and medium farmers.

Overall

Though the impact of different variables on output was different in different size grups, all the variables included in the function showed significant impact on the gross output. The positive impact which was also statistically significant was noticed in the case of human labour, seed, manures, fertilisers and plant protection. However, the cattle labour had negative but significant impact on output. In other words the cattle labour was found to be excessively used. Hence there was need to curtail the use of cattle labour in this inter-cropping system. All the included variables explained 78 per cent of variation in the value of gross output.

Returns to scale

The sum of regression coefficient i.e. (b_i) indicated the operation of constant returns to scale in this cropping system since the scale coefficient has not deviated from unity significantly.

5.4.1.2 Jowar (L) + Pigeonpea (Non-adopters)

Small farms

66 per cent of the variation in the value of gross output was explained by two variables namely human labour and seed. The production elasticities of human labour and seed were 0.33 and 0.41 respectively. The variable of human labour was positively and signifciantly correlated with output at 5 per cent level. This showed that 1 per cent increase in human labour would increase the output by 0.33 per cent. Similarly a 1 per cent increase in the use of seed would increase the output by 0.41 per cent.

Medium farms

The regression coefficients of cattle labour and seed were 0.28 and 0.49, respectively and both were significant. These two variables together explained 58 per cent of variation in gross output. The results suggested that the increased use of these two variables would increase the gross output. For example a one per cent increase in cattle labour would increase the value of gross output by 0.28 per cent. Similarly, a 1 per cent increase in seed would increase the gross value of output by 0.49 per cent.

Large farms

The coefficient of multiple determination estimated in the function was 0.92. The variation in gross output to the extent of 92 per cent was explained by three variables namely seed, fertiliser and plant protection. The first two variables were positively correlated with output. While the former had a positive impact which was statistically significant and the latter variable though had positive production elasticity was not statistically significant. Further it was observed that plant protection had a negative and also statistically significant impact on gross output. This might be due to the indiscriminate use of plant protection chemical by large farmers. As such it warrants rational use of plant protection chemicals.

Overall

85 per cent of the variation in gross output was explained by three variables namely human labour, seed and manure. The regression coefficients of human labour, seed and manure were 0.46, 0.46 and -0.02, respectively. In the case of non-adopters it was found that seed had consistent, positive and statistically

significant impact on gross output. However, it was found that manure had negative and significant impact on output. This reflects on the excessive use of this input that is manure. There is need to curtail the use of this input.

Returns to scale

The sum of regression coefficients indicated the operation of constant returns on large farms and for the sample as a whole and decreasing returns to scale on small and medium farms.

5.4.1.3 Jowar Hybrid (Adopters)

The production elasticities of the variables included in the function are presented in Table 5.20.

Small farms

87 per cent of the variation in gross value of output was explained by three variables, namely seed, manure and plant protection. The production elasticity of seed was positive and statistically significant. The regression coefficient of 0.83 indicated that a 1 per cent increase in seed would increase the gross value of output by 0.83 per cent. The coefficients of manure and plant protection were not significant.

Medium farms

The coefficeint of multiple determination R^2 which was 0.73 indicated that the included variables in

Table 5.20 Production Elasticities and Related Statistics: Jowar(Hydrid) (Value in Rupees) Perform

Sl. No.	Particulars	Adopters			
		Small	Medium	Large	Overall
1	No. of farms				
	Constant log(a)	4.5846 (0.3626)	-0.4325 (1.9009)	14.0769 (1.6402)	3.4206 (0.7466)
2	Production elasticities				
	Land (ha)	-	-	-	-
	Human labour	-	-	-	-
	Cattle labour	-	0.9670* (0.3931)	-1.7105** (0.4170)	0.3893 (0.2147)
	Seed	0.8338** (0.1034)	0.6716* (0.2891)	1.9358** (0.2805)	0.6645** (0.1610)
	Manure	0.0299 (0.0290)	-	-	-
	Fertiliser	-	-	-0.4660** (0.0808)	-
	Plant protection	0.0576 (0.0355)	-	0.0252* (0.0096)	0.0284 (0.0142)
3	R2	0.8720	0.7364	0.9519	0.8768
4	Return to scale	0.9214*	1.6387*	-0.2155	1.0322*
5	Geometric means				
	Output	2853.69	4607.45	8688.97	4409.52
	Land	-	-	-	-
	Human labour	875.89	1294.54	1756.96	1186.10
	Cattle labour	359.61	469.45	777.38	475.36
	Seed	43.12	77.18	1258.74	68.29
	Manure	75.06	279.06	118.79	131.45
	Fertiliser	294.65	446.46	766.15	428.71
	Plant protection	6.08	7.93	95.45	13.03

the function had explained 73 per cent variation in the gross value of output. The regression coefficients of cattle labour and seed were 0.96 and 0.67 respectively and statistically significant. This indicates that one per cent increase in cattle labour would increase the gross value of output by 0.96 per cent. Similarly it would be possible to boost up the gross value of output by 0.67 per cent with one per cent increase of hybrid seed.

Large farms

It was found that four variables, namely cattle labour, seed, fertilisers and plant protection had explained - variation in gross value of output. The impact of cattle labour and fertiliser was found to be negatively significant while seed and plant protection had positive and significant impact on gross value of output. The regression coefficients of seed and plant protection were 1.90 and 0.02 respectively and statistically significant. The regression coefficeints indicates that one per cent increase in seed and plant protection would increase the gross value of output by 1.90 per cent and 0.02 per cent, respectively.

Overall farms

The regression coefficeints of cattle labour seed and plant protection estimated in the function were 0.38, 0.66, 0.02, respectively. Among these variables only seed had significant impact on gross value of output. These three variables explained 87 per cent of variation in gross value of output.

Returns to scale

The sum of regression coefficients for small farmers and for the whole sample indicated the operation of constant returns to scale. In the case of medium farms increasing returns to scale was found to be operating. Diminishing returns to scale were prevailing in case of large farms.

The foregoing discussion clearly indicated that hybrid seed had consistently influenced the value of gross output irrespective of farm size groups.

5.4.1.4 Castor (Aurna) adopters

Castor is cultivated exclusively under dryland conditions. It is a cash crop grown by farmers irrespective of the size of holding. The results of the production function analysis are presented in Table 5.21.

Small farms

The coefficient of multiple determination R^2 was 0.68. The variation in gross value of output to the extent of 68 per cent was explained by the included

Table 5.21 Production Elasticities and Related Statistics: CASTOR (Aruna)
(Value in Rupees) Perfarm

Sl. No.	Particulars	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1	No. of farms								
	Constant log(a)	3.8619	4.3464	2.7020	3.6179	0.3889	-0.4465	-2.2858	2.7449
2	Production elasticities								
	Land (ha)	-	-		-	-	-	-	-
	Human labour	-	0.7038*			1.4776**	1.5933**	1.3702*	0.7175**
			(0.2387)			(0.3685)	(0.1911)	(0.6141)	(0.0467)
	Cattle labour	0.3788**	-0.3153*	1.7223**	0.7775**	0.5060NS	-0.4887*		-
		(0.1098)	(0.3548)	(0.4239)	(0.1206)	(0.7535)	(0.1772)		
	Seed	0.4713**	-0.0046*	0.7827*	0.5167**				
		(0.1269)	(0.3520)	(0.5254)	(0.1212)				
	Manure	-0.0264						0.1129**	
		(0.0141)						(0.283)	
	Fertiliser	0.0563**	-		0.0505**	0.0325	-	-	0.0564**
		(0.0159)			(0.0165)	(0.0197)			(0.0136)
	Plant protection	-	-	-	-	-0.0467	-		-
						(0.0287)			
3	R2	0.6873	0.6107	0.6597	0.8254	0.9733	0.9623	0.7874	0.9614
4	Return to scale	0.8791*	0.7931*	0.5394*	0.9605*	0.9774*	1.1047*	1.4830	0.7739*
5	Geometric Means								
	Output	2627.45	6213.50	9951.17	4670.63	2297.30	2838.90	2969.15	3603.24
	Land	-	-			-	-	-	-
	Human labour	925.80	1503.17	3000.8[illegible]	1410.74	856.17	1213.12	1630.81	1581.15
	Cattle labour	270.53	545.97	978.1[illegible]	452.61	229.48	390.94	329.10	425.57
	Seed	40.45	81.71	150.4[illegible]	68.18	45.74	81.17	85.09	92.20
	Manure	6.55	3.31	2.93	4.39		-	5.67	3.66
	Fertiliser	35.85	162.11	406.08	100.38	9.98	7.47	42.25	17.03
	Plant protection	2.74	3.07	3.74	2.95	6.66	9.10	14.96	12.10

variables namely cattle labour, seed, manure and fertiliser. The regression coefficients of cattle labour, seed and fertilisers were positive and significant.

The production elasticities of cattle labour, seed and fertilisers were of the order of 0.38, 0.47 and 0.06 respectively. This indicates that a one per cent increase of cattle labour would increase the gross value of output by 0.38 per cent when other variables are kept constant. Similarly the gross value of output would increase by 0.47 per cent and 0.06 per cent by increasing the inputs seed and fertilisers by one per cent.

Medium farms

Human labour, cattle labour and seed explained 61 per cent of the variation in gross output. The regression coefficients of human labour, cattle labour and seed were 0.90, -0.91 and 0.80, respectively. Human labour and seed had positive and signifciant impact on gross output, while cattle labour had negative impact on the output. There is need to curtail the use of cattle labour since it was used excessively.

Large farms

Cattle labour and seed together explained 66 per cent of variation in gross value of output. The analysis revealed that a one per cent increase in cattle labour would increase the output by 1.92 per cent while similar increase in seed would bring down the gross value of output by 0.38 per cent.

Overall

82 per cent of the variation in output was explained by three variables namely cattle labour, seed and fertilisers. All these variables had positive and significant impact on gross output. Hence, the use of these inputs is to be stepped up in the production of castor to realise better returns.

Returns to scale

In the case of large farms the returns to scale were found to be decreasing as the summation of the regression coefficients Σ bi was 0.53 In all other cases the constant returns to scale were found to be operating.

5.4.1.5 Castor (Non-adopters)

Small farms

The regression coefficients of human labour and fertilisers had influenced the output positively, but the former was only statistically significant. A one per cent increase in human labour would increase the gross value of output by 1.5 per cent. The included variables had explained 97 per cent of variation in output.

Medium farms

96 per cent of the variation in gross output was explained by only 2 variables i.e., human labour and cattle labour. The former had positive impact with a regression coefficient of 1.59 which was statistically significant at 1 per cent level. The latter, had negative impact on output which was also statistically significant. This warrants the need to curtail the use of cattle labour.

Large farms

79 per cent of the variation in gross output was explained by only two variables i.e., human labour and manures. The production elasticities of both were positive and significant. However, the continuation of human labour was much pronouncing on output.

Overall

96 per cent of the variation in the gross value of output was explained by 2 variables namely human labour and fertilisers. The production elasticities of both these variables were significant and positive. A one per cent increase in human labour would increase the value of gross output by 0.72 per cent. However, the continuation of fertilisers to value of output was only marginal.

Returns to scale

It was observed that constant returns to scale prevailed in small, medium farmers group and on overall situation. However increasing returns to scale were found to be operating in large farmers.

5.4.1.6 Paddy (Adopters)

The size wise estimated production functions for paddy on adopter and non-adopter farms are presented in Table 5.22.

Small farms

It was observed that the production function fitted with all input variables revealed a high R^2 value of 0.71 (Appendix). This indicated that about 71 per cent of the variation in the output has been explained by the input variables included in the function. However, it is seen that coefficients of only two independant variables (out of five independant variables) viz., human labour and cattle labour were statistically significant. This behaviour was due to multi-colliniarity. Subsequently when the step down procedure applied three independant variables viz., human labour, cattle labour and fertiliser were turned out significant in influencing the output. There was no major deviation in the R^2 value for this relationship (0.69) as compared to the one which included an independent variable. Further the merit of this relationship is that the

Table 5.22 Production Elasticities and Related Statistics: Paddy
(Value in Rupees) Perfarm

Sl. No.	Particulars	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1	No. of farms Constant (log a)	1.8983	-2.9022	1.9716	0.4283	2.9989	2.0884	2.2222	2.8455
2	Production elasticities								
	Land (ha)	-	-	-		-	-	-	-
	Human labour	2.1275**	1.4746**	0.5387**	1.5574**	-	-	0.5702**	-
		(1.3672)	(0.2953)	(0.1614)	(0.2941)			(0.1932)	
	Cattle labour	-0.8053*	-	-	-0.3066	0.4851*	-	0.2402	0.2834**
		(0.3143)			(0.2393)	(0.1476)		(0.2204)	(0.0925)
	Seed	-	-	0.4872*		0.4132*	1.0307**	-	0.6674**
				(0.1761)		(0.1449)	(0.3195)		(0.0925)
	Manure	-	-		-	-	-	-	-
	Fertiliser	-0.8107*	-	-	0.3247	-	-	0.0456**	-
		(0.3476)			(0.2007)			(0.0195)	
	Plant protection	-	-	-		-	-	-	-
3	R2	0.6909	0.6751	0.9621	0.7751	0.8359	0.9702	0.8715	0.9442
4	Return to scale	0.5196*	1.4746	1.0259	0.9261	0.8983*	1.0307*	0.8559*	0.9612*
5	Geometric Means								
	Output	4425.28	7753.58	10563.82	6471.35	4031.40	5898.66	10778.19	5885.05
	Land	-	-	-	-	-	-	-	-
	Human labour	1950.95	3108.42	4020.57	2675.39	2321.29	3737.30	7267.08	3653.31
	Cattle labour	331.01	555.90	662.73	456.44	532.47	864.26	1511.76	822.80
	Seed	168.24	278.87	328.10	229.57	235.97	335.45	646.42	342.17
	Manure	52.08	15.62	111.36	47.16	195.27	199.86	364.37	226.50
	Fertiliser	449.37	622.29	844.82	579.92	11.13	46.88	175.48	37.57
	Plant protection	-	-	-	-	-	-	-	-

* Significant at 5 per cent probability (Figures in parentheses are SE of the coefficients)
** Significant at 1 per cent probability

coefficients of all the three independent variables were statistically significant, hence these coefficients are considered for interpretation. The results of the production function analysis with all important input variables and output (irrespective of significance of bis and zero order correlation matrix are presented in Appendix Tables III, IV, V and VI.

Small farms

The regression coefficients in the function are nothing but production elasticities. The coefficient of human labour was positive and statistically significant at 5 per cent level in the estimated equation. The regression coefficient of human labour was 2.12. The coefficient of cattle labour and fertilisers were negatively significant. The regression coefficients of cattle labour and fertiliser were -0.80 and -0.81 respectively. The negative coefficients of cattle labour and fertiliser showed that these inputs were excessively used and thereby indicating the inefficiency in resource use or resource combination. It is suggested that the use of these resources sould be curtailed. This implied that gross income would fall by 0.8 per cent if the expenditure on cattle labour increased by 1 per cent. The same was the case with regard to fertiliser. The results also indicated that it woudl be possible to increase output by 2.12 per cent by increasing human labour by 1 per cent.

Medium farms

The results of functional analysis obtained with all input variables revealed that about 70 per cnet of the variation in output has been explained by the five input variables included in the function. However, none of the coefficients of these variable were statistically signifciant, which is a consequence of multicolliniarity. In contrast, the results obtained by applying the stepdown regression procedure identified human labour as the only independent variable which significantly affects the output.

The regression coefficient of human labour was 1.47. This variable explained 67.5 per cent of variation in gross value of output. It was significant to note that the elasticity of output with respect to human labour turned out to be not only positive but also fairly high.

Large farms

The coefficient of multiple determmination for the relationship obtained after applying step down procedure was 0.96, denoting that the independent variables have explained about 96 per cent of the variation in the gross value of output. The coefficients of expenditure on human labour and seed were highly significant at 1 per cent and 5 per cent level, respectively. The elasticity of production indicated one per cent increase in human labour would increase gross income by 0.53 per cent. Similarly, one per cent increase in seed would increase the gross income by 0.48 per cent. It is therefore suggested that it would be profitable to increase the use of these two resources, namely, human labour and seed in the production of paddy.

Overall

The included variables explained the variation in the gross value of input to the extent of 77 per cent. The regression coefficients of human labour, was statistically significant and positive. A one per cent increase in human labour would result in an increase of 1.56 per cent of gross income. Human labour was found to be dominantly influencing the output in all size groups and also for the sample as a whole. However, the coefficients of cattle labour and manure were negative but not significant.

Returns to scale

The sum of regression coefficients in the Cobb-Douglas function indicates the returns to scale. The sum of regression coefficients has been tested against unity. It is seen that while diminishing scale returns are operating on small farms, constant returns to scale is prevailing on medium and large farms and on the sample as a whole.

5.4.1.7 Paddy (Non-adopters)

Small farms

The step-wise regression procedure applied for fitting Cobb-Douglas production function revealed that the output was influenced mainly by cattle labour and seed. The partial regression coefficient for both these variables were highly significant. These coefficients which also represented the elasticities of these variables indicated that a one per cent increase in the cattle labour would result in increasing the output to the extent of 0.48 per cent when other variable viz., seed was kept constant. Similarly a one per cent increase in the seed would result in an increase of 0.41 per cent in the gross value of output.

The cattle labour and seed which constituted independent variable for the Cobb-Douglas function explained the variation in the gross value of output to the extent of 83.5 per cent.

Medium farms

Like small farmers, the output of medium farmers has also been influenced by seed, as identified from the step-wise regression procedure. Hence the Cobb-Douglas production function was fitted with only independent variable namely the seed, whose regression coefficient was highly significant at 1 per cent level.

The regression coefficient of seed was 1.03. This variable alone explained the variation in the output to the extend of 97 per cent.

Large farms

The variables identified as influencing the output of large farms were human labour, cattle labour and fertiliser. However, the coefficient of cattle labour was found to be statistically not significant. These three independent variables explained the variation in the output to the extent of 87 per cent. The partial regression coefficients which are also the elasticities of inputs indicated that the relative share of human labour was maximum (0.57) as compared to ferti- liser (0.04), in increasing the output. It would be therefore profitable to increase the use of human labour and fertiliser in paddy production.

Overall

It is observed that the variables which influenced the output varied in different groups. Among small and medium farms seed along with other variables were observed to be influencing the output, whereas it was not the case in large farms.

At the overall level, the variables identified as influencing the output were cattle labour and seed However, fertiliser was not identified as the output influencing variable in small, medium farm groups. In other words the analysis of this group identified a different set of variables other than those for the three gorups. Further within each group also there was no uniformity among the independent variables which were influencing the output. Hence due to this differential behaviour of the sub-groups, the results of the overall group cannot be considered for drawing meaningful inferences.

Returns to scale

Constant returns to scale was found to operate on all farm size groups on paddy farms in non-adopters.

5.4.2 RESOURCE USE EFFICIENCY

The efficiency of the resources used in the production of crops is estimated by comparing the marginal value product of inputs with the factor opportunity costs. MVP's per rupee of expenditure incurred on human labour, cattle labour, seed, manure, fertiliser and the MVP of land are computed and compared with the opportunity costs.

The opportunity costs for all the variables are considered to be one rupee except that of land, where the actual acquisition cost is taken since it is expressed in physical units.

The estimated MVP's of all the inputs for all the selected crops were tested using 't' test, to find out whether MVP and acquisition cost are significantly differing.

5.4.2.1 Sorghum (L) + Pigeonpea

The particulars of MVP's, opportunity costs and their retios are presented in Table 5.23.

Small Farms

The ratios of MVP to opportunity cost for human labour, cattle labour and fertilisers were 1.22, -2.97 and 6.07 in the case of small farms under adopter's category. MVP to opportunity cost ratio was more than one in case of human labour and fertiliser indicating the need to increase the expenditure on these inputs, whereas MVP to opportunity cost ratio to cattle labour was lowest and negative suggesting to reduce the expenditure on the input to obtain better results.

The ratios of MVP to opportunity cost were 0.95 and 33.30 for human labour and seed respectivtey under non-adopter category. This indicated that the expenditure on human labour should be reduced as the ratio was less than one. It was indicated that the need to increase the expenditure substantially on seed as the ratio was much greater than one.

Table 5.23 Marginal value Products, Opportunity Costs and Ratios of MVP to OC
Sorghum (L) + Pigeonpea Rupees Perfarm

Sl. No.	Particulars	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1.	Marginal Value Products								
	Land	-	-	-	-	-	-	-	-
	Human labour	1.22	-	-	0.96	0.95	-	-	1.42
	Cattle labour	-2.97	-	-	-2.94	-	3.30	-	-
	Seed	-	15.77	-	7.93	33.30	44.69	76.44	39.49
	Manure	-	15.13	-	13.53	-	-	-	-2.09
	Fertiliser	6.07	2.78	-	4.04	-	-	28.40	-
	Plant protection	-	-	32.83	-	-	-	-108.33	-
2.	Oppertunity Costs								
	Land	606.90	930.24	1377.72	1003.95	502.97	728.74	1847.58	1139.59
	Human labour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Cattle labour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Seed	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Manure	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Fertiliser	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Plant protection	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.	MVP to OC ratio								
	Land	-	-	-	-	-	-	-	-
	Human labour	1.22	-	-	0.96	0.95	-	-	1.42
	Cattle labour	-2.97	-	-	-2.94	-	3.30	-	-
	Seed	-	15.77	-	7.93	33.30	44.69	76.44	39.49
	Manure	-	15.13	-	13.53	-	-	-	-2.09
	Fertiliser	6.07	2.78	-	4.04		-	28.40	-
	Plant protection	-	-	32.83			-	-108.33	-

Medium Farms

In the case of medium farms the ratios of MVP to opportunity cost are 15.77, 15.13 and 2.78 for seed, manure and fertilisers, respectively under adopters. The analysis suggested the need to increase the expenditure on these three inputs as they were more than one, especially in the case of cattle labour and manure to obtain optimum level of benefits.

The ratios of MVP to opportunity cost are 3.30, 44.69 for cattle labour and seed respectivley under non-adopters. The analysis suggested the need to increase the expenditure on these inputs to attain better results.

Large Farms

The ratio of MVP to opportunity cost was 32.83 for plant protection under adopters which suggested the need to increase the expenditure on plant protection.

Similarly the analysis indicated the necessity of increasing expenditure on seed and fertiliser under non-adopters as the ratios of MVP to opportunity cost are 76.44 and 28.40. But the ratio of MVP to opportunity cost for plant protection was -108.33 which indicated the excessive usage of plant protection chemicals and need to reduce the expenditure on this item.

Overall

The expenditure on human labour and cattle labour has to be reduced in case of adopters as the ratios of MVP to opportunity cost are 0.96 and -2.94 for human labour and cattle labour respectively whereas these ratios were 7.93, 13.53 and 4.04 for seed, manure and fertilisers respectively, which indicated the need to increase the expenditure on these items to attain efficient resource-use.

The ratios of MVP to opportunity cost were 1.42, 39.49 and -2.09 for human labour, seed and manure respectively. The expenditure on the first two variables need to be increased, while for the 3rd variable the expenditure has to be cut down to obtain higher returns in non-adopter farms

The overall picture shows that in the case of adopters the human labour input was excessively used and for non-watershed, manure and plant protection were excessively used and for remaining variables they have to spend more to obtain efficient resource-use by both adopters and non-adopters.

5.4.2.2 Sorghum (hybrid) + Pigeonpea

The particulars of MVP's, opportunity costs and their ratios are presented in Table 5.24.

Table 5.24 Marginal value Products, Opportunity Costs and Ratio's of MVP to OC : Sorghum (Hybrid) + Pigeonpea (Value in Rupees) Perfarm

Sl. No.	Particulars	Adopters			
		Small	Medium	Large	Overall
1.	Marginal Value Products				
	Land	-	-	-	-
	Human labour	-	-	-	-
	Cattle labour	-	9.49	-19.12	3.15
	Seed	55.18	40.09	133.77	42.91
	Manure	1.14	-	-	-
	Fertiliser	-	-	-5.28	-
	Plant protection	27.03	-	2.29	9.61
2.	Oppertunity Costs				
	Land	810.00	1214.00	2361.00	1470.00
	Human labour	1.00	1.00	1.00	1.00
	Cattle labour	1.00	1.00	1.00	1.00
	Seed	1.00	1.00	1.00	1.00
	Manure	1.00	1.00	1.00	1.00
	Fertiliser	1.00	1.00	1.00	1.00
	Plant protection	1.00	1.00	1.00	1.00
3.	MVP to OC ratio				
	Land	-	-	-	-
	Human labour	-	-	-	-
	Cattle labour	-	9.49	-19.12	3.15
	Seed	55.18	40.09	133.77	42.91
	Manure	1.14	-	-	-
	Fertiliser	-	-	-5.28	-
	Plant protection	27.03	-	2.29	9.61

Small Farms

The ratios of MVP to OC for seed, manure and plant protection were 55.18, 1.14 and 27.03 respectively in the case of small farms under adopter category of farms. MVP to OC ratios were more than one for these three inputs indicating the need to increase the expenditure on these inputs.

Medium Farms

In the case of medium farms the ratio of MVP to OC for cattle labour and seed were 9.49 and 40.09 respectively under adopted category. There is a need to increase the expenditure on these items.

Large Farms

MVP to OC ratios were -19.12, 133.77, -5.28 and 2.29 for cattle labour, seed, fertiliser and plant protection respectively in case of large farms under adopter category.

The ratios were negative in the case of cattle labour and fertiliser suggesting the need to reduce the expenditure on these inputs. Whereas with regards to seed and plant protection inputs the expenditure has to be increased.

Overall

The expenditure on cattle labour, seed and plant protection are to be increased in the case of overall farms under adopted category as the ratios of MVP to OC were 3.15, 42.91 and 9.61 respectively.

5.4.2.3 Castor (Aruna)

The marginal value products, opportunity costs and their ratios for castor crop is presented in Table 5.25.

Small Farms

The utilisation of cattle labour, seed and fertilisers are to be increased sufficiently as the ratio of MVP to opportunity cost were more than one. The expenditure on manures has to be curtailed significantly to attain optimum level under adopters.

The ratios of MVP to opportunity cost were 4.01, -5.05, 7.46 and -16.07 for human labour, cattle labour, fertilisers and plant protection, respectively. The expenditure on human labour and fertiliser are to be increased whereas it has to be curtailed in the case of cattle labour and plant protection for better resource use efficiency on non-adopter farms.

Medium Farms

The ratios of MVP to opportunity cost were 3.74, -10.42 and 61.03 for inputs on human labour, cattle labour and seed, respectively which indicates the

Table 5.25 Marginal value Products Opportunity Costs and Ratios of MVP to OC CASTOR(Auruna) (Value in Rupees)

Sl. No.	Particulars	Adopters Small	Adopters Medium	Adopters Large	Adopters Overall	Non-adopters Small	Non-adopters Medium	Non-adopters Large	Non-adopters Overall
1.	Marginal Value Products								
	Land	-	-	-	-	-	-	-	-
	Human labour	-	3.74	-	-	4.01	3.73	-	1.64
	Cattle labour	9.71	-10.42	19.56	4.12	-5.05	-3.55	-	-
	Seed	30.61	61.03	-91.49	34.97	-	-	-	-
	Manure	-10.59	-	-	-	-	-	-	-
	Fertiliser	4.13	-	-	2.35	7.46	-	-	11.93
	Plant protection	-	-	-	-	-16.07	-	-	-
2.	Opportunity Costs								
	Land	725.90	1721.93	2712.80	1712.52	620.14	758.08	2925.00	1503.60
	Human labour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Cattle labour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Seed	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Manure	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Fertiliser	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Plant protection	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.	MVP to OC ratio								
	Land	-	-	-	-	-	-	-	-
	Human labour	-	3.74	-	-	4.01	3.73	-	1.64
	Cattle labour	9.71	-10.42	19.56	4.12	-5.05	-3.55	-	-
	Seed	30.61	61.03	-91.49	34.97	-	-	-	-
	Manure	-10.59	-	-	-	-	-	-	-
	Fertiliser	4.13	-	-	2.35	7.46	-	-	11.93
	Plant protection	-	-	-	-	-16.07	-	-	-

need to increase the utilisation of human labour and especially seed to a larger extent and to curtail the expenditure on cattle labour on adopter farms.

In case of non-adopters, the human labour input has to be increased and cattle labour has to be decreased as the ratios of MVP to opportunity cost were 3.73 and -3.55, respectively.

Large Farms

The input on seed has been excessively used in this group (MVP to opportunity cost ratio -91.49) whereas cattle labour is insufficiently used (MVP to opportunity cost ratio is 19.56). So the expenditure on seed has to be curtailed and cattle labour has to be increased to attain better ratios on adopter farms.

Overal Farms

The utilisation of cattle labour, seed and fertilisers are not at optimum level as the ratios of MVP to opportunity cost are greater than one (4.12, 34.97, 2.35 for cattle labour, seed and fertilisers, respectively). So, the expenditure on these items has to be increased to attain better resource-use efficiency on adopter farms .

In the case of non-adopters, the expenditure on human labour and fertiliser has to be increased as the ratio of MVP to opportunity cost were 1.64 and 11.93 for human labour and fertilisers respectively to attain the optimum level.

The overall picture shows that seed was inadequatley used except in case of large farms under adopters and cattle labour was excessively used under non-adopters. So expenditure on seed has to be increased and on cattle labour has to be curtailed under adopters and non-adopters, respectively to attain on optimum level.

5.4.2.4 Paddy (kharif)

The marginal value products, opportunity costs and ratios of MVPs to OC for Paddy crop is presented in Table 5.26.

Small Farms

The utilisation of human labour, cattle labour and fertilisers were not at optimum because the ratios of MVP to opportunity cost were not equal to one in the case of adopters. Cattle labour and fertiliser were used excessively and as such the use of these inputs are to be curtailed to get more returns. The human labour use is to be increased.

With regards to non-adopters the ratios of MVP to opportunity cost were 3.67 and 7.06 in case of cattle

Table 5.26 Marginal value Products Opportunity Costs and Ratios of MVP to OC Paddy (Value in Rupees)

Sl. No.	Particulars	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1.	Marginal Value Products								
	Land	-	-	-	-	-	-	-	-
	Human labour	4.826	3.678	1.415	3.767	-	-	0.846	-
	Cattle labour	-10.766	-	-	-4.347	3.673	-	1.712	2.027
	Seed	-	-	15.686	-	7.059	18.124	-	11.478
	Manure	-	-	-	-	-	-	-	-
	Fertiliser	-7.983	-	-	-3.623	-	-	2.801	1.629
	Plant protection	-	-	-	-	-	-	-	-
2.	Opportunity Costs								
	Land	-	-	-	-	-	-	-	-
	Human labour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Cattle labour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Seed	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Manure	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Fertiliser	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Plant protection	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.	MVP to OC ratio								
	Land	-	-	-	-	-	-	-	-
	Human labour	4.826	3.678	1.415	3.767	-	-	0.846	-
	Cattle labour	-10.766	-	-	-4.347	3.673	-	1.712	2.027
	Seed	-	-	15.686	-	7.059	18.124	-	11.478
	Manure	-	-	-	-	-	-	-	-
	Fertiliser	-7.983	-	-	-3.623	-	-	2.801	1.629
	Plant protection	-	-	-	-	-	-	-	-

labour and seed for non-adopters suggesting the need to increase the use of these two inputs.

Medium Farms

The utilisation of human labour was not adequate as the ratio of MVP to opportunity cost was 3.678 which is more than one. So, the expenditure on the input has to be increased sufficiently to obtain more returns on adopter farms.

The ratio of MVP to opportunity cost for seed was 18.124 which indicated a need to increase the expenditure on this input for better resource use on non-adopter farms.

Large farms

The expenditure need to be increased on human labour and seed as the ratios of MVP to opportunity cost were more than one (1.42 and 15.69 for human labour and seed respectively). Utilisation of more human labour and seed would result in better returns on adopter farms.

The expenditure on human labour has to be curtailed a little as the ratio of MVP to opportunity cost was less than one (0.85) whereas these ratios were 1.712 and 2.80 for cattle labour and fertilisers respectively which suggested the need to increase the expenditure on these inputs to obtain better returns on non-adopter farms.

Overall Farms

The analysis suggested to increase the utilisation of human labour as the MVP to opportunity cost ratio was 3.77. The utilisation of cattle labour and fertiliser were to be curtailed since the ratios of MVP to opportunity cost were -4.35, -3.62, respectively.

The ratios of MVP to opportunity cost were 2.03, 11.48 and 1.63 for cattle labour, seed and fertilisers respectively on non-adopter farms. The analysis indicated the need to increase expenditure on these inputs so as to get the better results.

The overall picture indicated that the expenditure on cattle labour and fertilisers has to be curtailed under adopter farms whereas the expenditure is to be increased sufficiently on cattle labour, seed and fertiliser in the case of non-adopters to more towards the optimum level.

5.5 ADOPTION OF TECHNOLOGIES

The important objective of the Operational Research Project of the Maheshwaram Watershed has been to demonstrate relevant technologies and their efficacy to the farmers. It is because of extension and training activities and the inputs support provided by the project staff, the spread and adoption of technology by the selected farmers has been quite significant and satisfactory. However, it was noticed that the extent of adoption or spread of technology has been scanty in the non-watershed area and this indicates that there is no horizontal diffusion of technology. In a pilot survey which was undertaken prior to implementation of watershed programme that a great majority of the farmers were unaware about the new technologies. By and large, they did not use any High Yielding Varieties or improved varieties in case of dryland crops. As much implementation of watershed management programme, it is believed that it has brought awareness about new dryland farming technologies. However, it is not known whether these technologies are adopted by farmers and the extent of spread of the same attempt has been made to study the adoption of technologies by the selected farmers in the adopters as well as non-adopters categories.

Adoption of technology - crop-wise

The results are presented crop-wise and technology or practice-wise. The technologies are classified into two groups viz., technologies having longrun impact, such as soil conservation, water harvesting, horticulture development etc., and technologies providing short run impact, such as improved varieties, fertiliser application, plant protection measures and recommended cultural practices such as inter cultivation and weeding.

The particulars on the adoption of technology by the selected farmers by the adopter groups are given in Table 5.27. It is observed that though a lot of importance is given to soil conservation bunding was done by only few farmers. The adoption of bunding was practiced by 7, 25.8 and 31.8 per cent of the farmers in the small, medium and large groups respectively. However, the adoption of *khus* grass plantation was very common among the adopters particularly large farmers. About 90.9 per cent of the farmers in the large farmers group adopted this practice. For the sample as a whole 63 per cent of farmers reported this practice. The same was 52 per cent on small farms and 64.5 per cent on medium farms. Adoption of this practice seems to be due to the good extension work undertaken by project staff in convincing the farmers about the efficacy of the khus grass plantation as a soil conservation measure. This practice is the cheapest and the quickest.

In dryland agriculture, water plays a crucial role. Therefore whatever quantum of rain water received it has to be harvested fully and properly. The important water harvesting structures are check dams. It was observed that only 3 per cent of the small, 22 per cent of the medium and 22.7 per cnet of the large farmers adopted this practice.

The *in situ* harvesting techniques i.e., the deep ploughing was adopted by 30 per cent the small farmers, 80.6 per cent of the medium farmers and 81.8

Table 5.27 Adoption of technology for long run impact of adopters

Name of technology	Small		Medium		Large		Overall	
	No.	P.C.	No.	P.C	No.	P.C	No.	P.C
1. Soil conservation	67		31		22		120	
a) Khus gross plantation	35	52.2	20	64.5	20	90.90	75	62.5
b) Bunding	5	7.5	8	25.8	7	31.8	20	16.6
2. Water harvesting structures	2	3.0	7	22.0	5	22.7	14	11.6
3. Insitu water harvesting Technology								
a) Deep ploughing	20	29.8	25	80.6	18	81.8	63	52.5
b) Sowing across the slope	60	89.5	27	87.0	22	100.0	109	90.8
4. Horticulture	2	3.0	4	12.9	7	31.8	13	10.83
5. Agroforestry (including pastures)	-	--	-	--	4	18.1	4	33.00

Table 5.28 Adoption of technology for longrun impact incase of non-adopters

S.No:	Technologies	Small		Medium		Large		Overall	
		No. 64	P.C.	No. 38	P.C.	No. 18	P.C.	No. 120	P.C.
1)	Soil conservation	--	--	--	--	--	--	--	--
	Khus gross plantation	--	--	--	--	--	--	--	--
	Bunding	--	--	--	--	--	--	--	--
2)	Water harvesting structures	--	--	--	--	--	--	--	--
3)	InsitU water harvesting tech.	--	--	--	--	--	--	--	--
a)	Deep ploughing	--	--	--	--	--	--	--	--
b)	Sowing across the slope	--	--	--	--	--	--	--	--
4)	Horticulture	--	--	--	--	4	22.0	4	3.0
5)	Agro-forestry (including pastures)	--	--	--	--	--	--	--	--

per cent of large farmers. For the sample as a whole, 53.0 per cent farmers adopted this practice. The low adoption of this practice on small group was due to the inadequacy of bullock power.

Another improved practice is sowing across the slope. This has become very common irrespective of farm size group. The adoption of this practice varied from 87.0 to 100.0 per cent in between farm size groups. The dryland scientists laid greater emphasis on this practice and due to good extension efforts, this practice has become very popular among the farmers.

Dryland horticulture is gaining momentum with rainfed dryland agriculture. Though dryland horticulture is a priority item in watershed management programme, very few farmers (11.0 per cent of the whole sample) has taken up the planting of horticultural crops.

Agro—forestry is another practice which is gaining importance currently. However in the study area not much publicity has been given for this. Among the adopter farmers, only in large size group, that too just few farmers resorted to this practice. Only four farmers adopted this practice. They raised plants along the bunds and borders. On small patches these farmers are also raised the pastures.

The data presented in Table 5.28 indicated that with regards to non adopters it was found that none of the technologies such as conservation, water harvesting structures and *in situ* water harvesting techniques were adopted. However four farmers took up the cultivation of horticultural crops around their wells, where some irrigation water is available.

Technology adoption-crop-wise

The details of the technologies pertaining to crop cultivation as adopted by the selected farmers of the adoption group are provided in the Table 5.29. The details are given crop-wise and practice-wise.

Sorghum (L) + Pigeonpea

Fifty two farmers in the adopter group have taken up sorghum (L) + pigeonpea crop combination. It is quite interesting to note that none of these farmers resorted to hybrid or improved varieties of sorghum. However all the farmers have gone for improved varieties of pigeonpea.

It was a herculian task for the extension staff to convince the farmers about the superiority of the hybrid varieties of sorghum. The farmers were of the strong opinion that the taste and keeping quality of hybrid sorghum were far from satisfactory. Further they added that in hybrid sorghum the production of fodder was less when compared with that of local varieties.

Table 5.29 Adoption of Technology by the selected farmers of the adopters group

Name of the crop	Small		Medium		Large		Overall	
	No.	P.C.	No.	P.C	No.	P.C	No.	P.C
1. Sorghum(L) + Redgram Improved.	25	—	16	—	11	—	52	—
a) Varieties of sorghum + Pigeonpea	Nil 25	-- 100.0	Nil 16	-- 100.0	Nil 11	-- 100.0	Nil 52	-- 100.0
b) Fertiliser	25	100.0	16	100.0	11	100.0	52	100.0
c) Plant protection chemicals	10	40.0	6	37.5	7	63.6	23	44.2
d) Recommended weeding	10	40.0	10	62.5	6	54.5	26	50.0
2. Sorghum (H) + Redgram	17	100.0	14	100.0	10	100.0	41	100.0
a) Improved varieties of of sorghum	17	100.0	14	100.0	10	100.0	41	100.0
Improved varieties of of P.Pea	17	100.0	14	100.0	10	100.0	41	100.0
b) Fertiliser	17	100.0	14	100.0	10	100.0	41	100.0
c) Plant protection chemicals	9	52.9	6	42.8	9	90	24	58.5
d) Improved weeding	9	52.9	6	42.8	6	60	21	51.2
3. Castor	42		29		21		92	
a) Improved varieties	42	100.0	29	100.0	21	100.0	92	100.0
b) Fertiliser	42	100.0	29	100.0	21	100.0	92	100.0
c) Plant protection measures	20	47.6	19	65.5	17	80.9	56	60.8
d) Improved Weeding	12	28.5	14	48.2	11	52.3	37	40.2
4. paddy	26		14		15		52	
a) Improved varieties	26	100.0	14	100.0	15	100.0	52	100.0
b) Fertiliser	26	100.0	14	100.0	15	100.0	52	100.0
c) Plant protection measures	20	76.9	12	85.7	15	100.0	47	90.3
d) Hand weeding								
2 times	20	76.9	14	100.0	11	73	45	86.5
3 times	--	--	--	--	4	26.6	4	7.6

They also opined that the quality of fodder is much inferior in hybrid sorghum as compared to that of local varieties.

All the 52 farmers used fertilisers on this cropping system, but with respect to plant protection only 40 per cent of small farmers, 38 per cent of medium farmers and 64 per cent of large farmers adopted this measure. Similarly the recommended intercultural and weeding practices were not found with all the adopters who practiced this cropping system. 40 per cent of small farmers, 63 per cent of medium farmers and 55 per cent of large farmers adopted this practice.

Sorghum (H) + Pigeonpea

On account of persistant efforts of the project staff extension training and demonstration, it could be possible to convince atleast some of the farmers to take up hybrid/improved sorghum varieties with improved pigeonpea. 41 out of 120 farmers had tried this combination. All the farmers who adopted this cropping system not only used the hybrid varieties of sorghum and improved varieties of pigeonpea, but also resorted to fertiliser application. However, the same was not true with plant protection measures. In the sample as a whole, (24 out of 41 farmers) about 58 per cent of the farmers adopted this practice. Among the farm size groups, it varied from 43 per cent in medium farms to 99 per cent in large farms. Among the small farmers 53 per cent adopted plant protection measures.

With respect to improved weeding about 51 per cent of the farmers adopted this practice for the sample as a whole. It ranged from 43 per cent on medium farms to 60 per cent on large farms.

Castor (Auruna)

Since castor is a cash crop it attracted the better attention of the farmers. 92 out of 120 farmers have raised castor (Aruna). Aruna variety is an improved one which has become very popular among the farmers of the area. It was observed that almost all the farmers, who raised castor adopted two important components of the technology viz., use of improved varieties and fertilisers applications. However, only 60 per per cent of the farmers have taken up plant protection measures. This practice indicated a direct relationship with farm size and it varied from 19 to 31 per cent. Though the small farmers are fully convinced about the efficiency of the plant protection measures in castor, prohibitive cost of plant protection chemicals prevented them in going for this practice with chemicals. However it was observed that the small farmers used the mechanical methods of physically destroying the red hairy caterpiller and also use bonfire with cycle and other rubber tubes etc. It was reported that this method is also very effective in controlling the pest.

With respect to weeding operations, few farmers resorted to improved weeding with small improved implements. This varied from 29 per cent of farmers in small farms to 52 per cent of farmers in large group with an overall average of 40 per cent of the farmers for the whole sample (who have grown castor).

Paddy (kharif)

The cultivators are raising paddy with irrigation water from the water tanks. Despite the strong persuation to switch over from paddy to irrigated dry crops, not much progress could be achieved. All the farmers, who had access to the water preferred to raise paddy despite knowing that it consumes more water than irrigated dry crops. The farmers also feel that paddy is the most stable crop and also required for family consumption they give preference to this crop.

All the farmers who raised paddy used improved varieties particularly Tella Hamsa. All farmers applied adequate doses of fertiliser. It was also found that about 90 per cent of the farmers have used plant protection chemicals to control pests and diseases for the whole sample. While all farmers in the large group resorted to plant protection measures, 77 and 96 per cent of the farmers respectively in small and medium six groups resorted to these measures.

The foregoing discussion amply proved that the adoption of improved technologies is more in case of paddy on irrigated crop than the dryland crops. Among the dryland crops castor receives the priority of the farmers as it is a cash crop. A great majority of the selected farmers have adopted the important technologies. In case of sorghum (HYV) + Pigeonpea also, the adoption was much better when compared to the sorghum local and pigeonpea.

NON-ADOPTERS

Adoption of technologies by the selected farmers of the non-adopted group are presented in Table 5.30.

SORGHUM (L) + PIGEONPEA

It was found that none of the farmers in the non-watershed area used sorghum (H) + pigeonpea in intercropping. They used only local varieties of sorghum with pigeonpea. Even pigeonpea is not completely improved. Many farmers used local varieties of pigeonpea. This clearly shows that there is no horizontal diffusion of technology or the flow of technology from watershed to non-watershed areas. At

Table 5.30 Adoption of technology by the selected farmers of the non-adopters groups

S.No:	Technologies	Small No.	Small P.C.	Medium No.	Medium P.C.	Large No.	Large P.C.	Overall No.	Overall P.C.
1)	**Sorghum(L)+pigeonpea**	49		37		14		100	
	a) Improved varieties of sorghum	--	--	--	--	--	--	--	--
	Improved varieties of redgram	10	20.	13	35	10	71	23	23
	b) Fertiliser	15	31	20	54	12	86	47	47
	c) Plant protection chemicals	--	--	--	--	2	14	2	2
	d) Recommended weeding	--	--	--	--	--	--	--	--
2)	**Castor**	9	100	13	100	8	100	30	100
	a) Improved varieties	9	100	13	100	8	100	30	100
	b) Fertiliser	2	22	4	31	3	38	9	30
	c) Plant protection measures	--	--	--	--	2	25	2	7
	d) Recommended weeding	--	--	3	28	--	--	3	10
3)	**Paddy**	29		34		18		81	
	a) Improved varieties	29	100	34	100	18	100	81	100
	b) Fertiliser	10	34	25	74	18	100	53	65
	c) Plant protection measures	--	--	10	29	15	83.33	25	31
	d) Recommended weeding								
	2 times	29	100	34	100	18	100	81	100

attempt is made to estimate the extent of adoption of technologies by farmers in watershed area in comparison with farmers in non-watershed area.

Regarding the fertiliser use, it was observed that all the adopters used chemical fertilisers in this cropping. However in the case of non-adopters it is clear that only 47 per cent of the farmers had gone for it. Thus, it is clear that technology adoption in this case was better in adopters. Further it is observed that relatively a large proportion of large farmers among non-adopters adopted improved practices such as use of improved seed, application of chemical fertilisers and use of plant protection chemicals. This might be due to their accessability to the knowledge of improved technologies and the needed resources to adopt the same. It is also interesting to note that none of the non-adopters resorted to weeding operations.

CASTOR (Aruna)

Though the use of improved varieties was 100 per cent of the farmers among non-adopters, the use of fertilisers and plant protection chemicals was not popular among many farmers.

For the sample as a whole 30 and 7 per cent of the farmers respectively resorted to fertilizer application and use of plant protection measures. It was found that none of the small and medium farmers adopted plant protection. Weeding was not a common practice among the farmers.

Paddy

All the farmers have used the improved varieties in case of paddy. However, 65 per cent of farmers only applied the fertilizers in the whole sample. It was found that the fertiliser number of farmers using has increased with increase in size of holding. The analysis revealed that 34 per cent of small farmers, 74 per cent of medium farmers and 100 per cent of large farmers applied fertilisers. The adoption of plant protection was much less with just 31 per cent of the farmers in the whole sample adopt the practice. It was found that none of the small farmer adopted this practice.

5.6 INCOME PATTERN

The details on income from different sources in different categories of households are presented in Table 5.31. For the sample as a whole the average total income of the adopters was Rs 18,735 as against Rs 16,536 per household in case case of non-adopters. Thus, an amount of about Rs 2,200 was additional income obtained in case of adopters. This might be due to increased crop production due to adoption of modern agricultural technology. The variation in the percen-

Table 5.31 Income from different sources/house hold

(In Rs)

Sl. No.	Source particulars	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1	Agriculture	5583 (42.3)	14241 (70.1)	25067 (74.4)	11367 (60.7)	5324 (43.7)	11257 (61.6)	24659 (86.8)	10103 (61.0)
2.	Dairy	2016 (15.4)	1332 (6.6)	2316 (8.3)	1986 (10.6)	1738 (14.7)	2072 (11.4)	2989 (10.5)	2058 (12.4)
3	Wages	4629 (35.4)	3753 (13.5)	1270 (3.8)	3787 (20.2)	4440 (36.5)	3136 (17.2)	346 (1.3)	3413 (20.6)
4	Professions	197 (1.5)	361 (1.3)	841 (2.5)	357 (1.9)	188 (1.5)	0 0	0 0	100 (0.6)
5	Employment	269 (2.1)	0 0	0 0	150 (0.8)	0 0	558 (3.1)	0 0	177 (1.1)
6	Other income	436 (3.3)	639 (3.0)	3705 (11.0)	1088 (5.8)	441 (3.6)	1232 (6.7)	400 (1.4)	685 (4.1)
	Total	13085 (100)	20326 (100)	33699 (100)	18735 (100)	12181 (100)	18255 (100)	28394 (100)	16536 (100)

Figures in parentheses indicates percentage to total.

tages of income to the total from different sources between the adopters and non-adopters was marginal. Agriculture was the main source of income as 60 and 61 per cent of the total income was obtained by adopters and non-adopters, respectively. The next important source of income was the wages obtained by hiring out of labour. For the sample as a whole 20 and 21 per cent of the income was obtained from this source by adopters and non-adopters respectively. Dairy occupied the next important source which provided 11 and 12 per cent of total income to adopters and non-adopters, respectively.

The analysis clearly indicated the existance of wide variations existed not only in the amount of income obtained per household but also in the composition of income from different sources among the small, medium and large farmers. While the small farmers obtained 42 per cent of total income from agriculture, the medium and large farmers obtained 70 and 74 per cent of income respectively from agriculture. Thus, it is observed that the proportion of income per household from agriculture to total income has indicated an inverse relationship with farm size in both adopters and non-adopter categories. The income from agriculture ranged from Rs 5,538 per household in small farmer group to Rs 25,067 in large farmer group in adopters. In case of non-adopters it ranged from Rs 5424 on small farms to Rs 24659 in large farms per household. The same in the case of non-adopters ranged from 44 per cent on small farm to 87 per cent on large farms. The small farmers obtained a substantial portion of the income (35 per cent of the total income) from wages by hiring out the family labour. About 18 and 4 per cent of the income was obtained by medium and large farmers from this source in adopters as against 17 and 1 per cent in non-adopters. Dairy formed another important source of income. On an average around 12 per cent of total income was derived from this source in both the categories. Relatively larger share was obtained by small farmers.

5.6.1 Employment

The details of number of worker members in different categories of households and the number of days employed per worker per year for adopter and non-adopter categories are presented in Table 5.32. The total number of male workers in the adopters category was 180 as against 136 in non-adopters category. Out of 252 days of employment per worker per year the worker member for the whole sample found employment for 67 days (26.6%) for off-farm activities. A male worker was employed for 53 days (21.0%) on farm work, while he could get employment on his own farm for 50 days (19.8%). In adopters, dairy and self-employment provides 39 days (15.5%) and 35 days (13.9%) employment.

Table 5.32 **Employment days per worker/year**

	Adopters									Non-adopters							
No.of Group	No.of workers	Farm	Off-Farm	Profe-ssion	Busi-ness	Own Farm	Diary	Self-Employment	Total	No.of workers	Farm	Off-Farm	Profe-ssion	Busi-ness	Own Farm	Diary	Self Employment	Tot
		Male									Male							
Small	101	58	87	4	2	40	28	29	248	76	87	91	1	10	48	36	22	29
		(23.4)	(35.1)	(1.6)	(0.8)	(16.1)	(11.3)	(11.7)	(100)		(29.5)	(30.8)	(0.3)	(3.4)	(16.3)	(12.2)	(7.5)	(10
Medium	42	64	62	0	12	55	42	33	268	41	49	102	0	23	75	32	24	30
		(23.9)	(23.1)	-	(4.5)	(20.5)	(15.7)	(12.3)	(100)		(16.1)	(33.4)	-	(7.5)	(24.6)	(10.5)	(7.9)	(10
Large	37	27	18	0	12	71	64	53	245	19	8	12	0	60	118	58	36	29
		(11.0)	(7.3)	-	(4.9)	(29.0)	(26.2)	(21.6)	(100)		(2.7)	(4.2)	-	(20.5)	(40.4)	(19.9)	(12.3)	(10
Total	180	53	67	2	6	50	39	35	252	136	65	83	1	21	66	38	24	29
		(21.0)	(26.6)	(0.8)	(2.4)	(19.8)	(15.5)	(13.9)	(100)		(21.8)	(27.9)	(0.3)	(7.0)	(22.1)	(12.8)	(8.1)	(10
		Female									Female							
Small	72	84	58	1	2	33	10	33	221	69	75	72	0	4	35	6	35	22
		(38.0)	(26.2)	(0.5)	(0.9)	(14.9)	(4.6)	(14.9)	(100)		(33.0)	(31.7)	-	(1.8)	(15.4)	(2.6)	(15.5)	(10
Medium	35	85	58	0	4	39	3	32	220	39	56	34	0	14	37	8	43	19
		(38.6)	(26.4)	-	(1.8)	(17.3)	(1.4)	(14.5)	(100)		(29.1)	(17.7)	-	(7.3)	(19.2)	(4.2)	(22.4)	(10
Large	32	5	0	0	1	45	2	45	98	17	9	0	0	15	42	5	56	12
		(5.1)	-	-	(1.1)	(45.9)	(2.0)	(45.9)	(100)		(7.1)	-	-	(11.8)	(33.1)	(3.9)	(44.1)	(10
Total	139	66	44	1	2	37	6	36	192	124	60	50	0	9	37	6	40	20
		(34.4)	(22.9)	(0.5)	(1.0)	(19.3)	(3.1)	(18.8)	(100)		(29.6)	(24.8)	-	(4.5)	(18.3)	(3.0)	(19.8)	(10

Figures in parentheses indicates percentages.

Employment :- The details of number of workers membersin different categories of house holds and the number of days employed worker year for adopter and non-adopters categories.

With regards to non-adopters on the sample as a whole a male worker could be employed for 65 days (21.8%) and 66 days (22.1%) on others farm and owned farms, respectively. Off-farm activities provided employment for 83 days (27.9%) for male worker. Dairy and self-employment could provide work for 38 days (12.8%) and 24 days (8.1%), respectively. Among the three size groups of farms the maximum number of days of employment was found on owned farm by large farmers. The employment on own farm increased with the increase on farm size. However, the employment in off-farm activities decreased with increase in the size of holding. It was found that the employment on dairy has increased with increase in the size of holding. Similar was the case with respect to self-employment.

In non-adopters the own farm employment of male worker increased with increase in the size of holding with 48 days (16.3%) on small farms to 118 days (40.14%) on large farms. The self-employment was found to be increasing with the increase in size of holding. It was found that the non-adopter male worker in small farmers group found employment for 295 days in a year as agianst 305 days by medium and 292 days by large farmers. The above analysis clearly indicates that the workers in different sizes of households did not employ fully throughout the year.

5.6.1.1 Female Employment: The number of days employed by female worker both for the adopters and non-adopters group was relatively lower when compared to the number of days employed by the male workers in both the groups. In the sample as a whole, the difference between the adopter female worker and non-adopter female worker in the total number of days employed was only 10. In the sample as a whole the female in adopter families was employed for 66 days (22.9%) own farm provided 37 days (19.3%) of employment. Self-employment was found by the female workers to the extent of 36 days (18.8%) in a year.

The women in the large families could be employed only for 98 days in a year. Thus, for most part of the year the female workers in the large families remained unemployed.

Hiring out of labour both on-farm and off-farm was maximum in the case of female workers of non-adopters group with 60 days (29.6%) and 50 days (24.8%) respectively. It is also observed that the number of days employed decreased with increase in size of holding.

5.6.2 Household Expenditure

The particulars on family expenditure per household per year are presented in Table 5.33. The difference in expenditure on various household items was

Table 5.33 Family budget per household per year (Rs.)

Sl. No.	Particulars	Adopters				Non-adopters			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
1	Food items	6943 (78.9)	8245 (80.3)	9431 (80.1)	7736 (79.5)	3947 (78.5)	5350 (77.6)	5233 (76.90	4584 (77.9)
2	Clothing	969 (11.0)	934 (9.2)	1009 (8.6)	967 (9.9)	582 (11.6)	678 (9.8)	733 (10.8)	635 (10.8)
3	Fuel and lighting	137 (1.6)	177 (1.70	170 (1.4)	153 (1.6)	40 (0.8)	116 (1.7)	114 (1.7)	75 (1.3)
4	Education	124 (1.4)	148 (1.4)	158 (1.3)	137 (1.4)	116 (2.3)	102 (1.5)	39 (0.6)	100 (1.7)
5	Medicine	460 (5.2)	565 (5.5)	784 (6.7)	547 (5.7)	49 (1.0)	211 (3.1)	146 (2.1)	115 (2.0)
6	Others	170 (1.9)	197 (1.9)	224 (1.9)	186 (1.9)	291 (5.8)	434 (6.3)	538 (7.9)	373 (6.3)
	Total	8803 (100)	10266 (100)	11775 (100)	9726 (100)	5025 (100)	6891 (100)	6803 (100)	5882 (100)
	Expenditure per person	1740	1939	2123	1397	1157	1479	1458	1310
	Expenditure per converted adult unit	2303	2770	2813	2520	1393	1881	1759	1606

Figures in parentheses indicates percentage to total.

quite glaring between the adopters and non-adopters. The total expenditure per annum per household was Rs 9726 and Rs 5882 on adopters and non-adopters respectively. Among the size gorups, the expenditure per household in adopters group ranged from Rs 8,803 to 11,775 per annum. Similarly, the expenditure in case of non-adopters varied from Rs 5025 to Rs 6803. Wide difference was also noticed in the per capita expenditure and the expenditure per standardised adult unit between adopters and non-adopters. The expenditure was high in case of adopters than that of non-adopters. Food constituted to be one of the most important items of expenditure both in case of adopters and non-adopters. About 79 per cent of the expenditure was incurred on food and 10 per cent on clothing and 6 per cent on medicine by adopters. Non-adopters spent 78 and 11 per cent of expenditure on food and clothing. Fuel and lighting accounted for about 2 per cent of the total expenditure. Education accounted for 1 per cent of the expenditure. The above analysis clearly established that the households were incurring high proportion of expenditure on essential requirements of consumption and the expenditure on education, medicine and recreation was too small to have any impact on quality of life. The standard of living of the respondents, by and large, appeared to be low.

5.6.3 Lorenz Curves and Gini Concentration ratio

The decile groups of adopters and non-adopters in case of land and income were presented in Table 5.34 and 5.35.

Lorenz curves were drawn for adopters and non-adopters separately to know the distribution of income and land. The Lorenz curve for income in case of non-adopters is distributed more evenly than the adopters. The Gini Concentration Ratio for adopters was 0.3049 as against 0.1792 for non-adopters. In case of land distribution, there is not much difference as far as the distribution pattern is concerned for adopters and non-adopters. This could be seen from the Gini Concentration Ratios of 0.4241 for adopters and 0.4247 for non-adopters.

The Lorenz curves for adopters and non-adopters of income distribution and land distribution were presented in charts. (Fig 3 and 4)

5.7 Comparitive Economics of Technology

The development of new technology for dryland farming has remained as neglected area until recently. It is evident that since early 1970s some increase in research resource allocation to dryland agriculture has taken place. The present study attempted to assess the impact of technology on dryland conditions and arrived

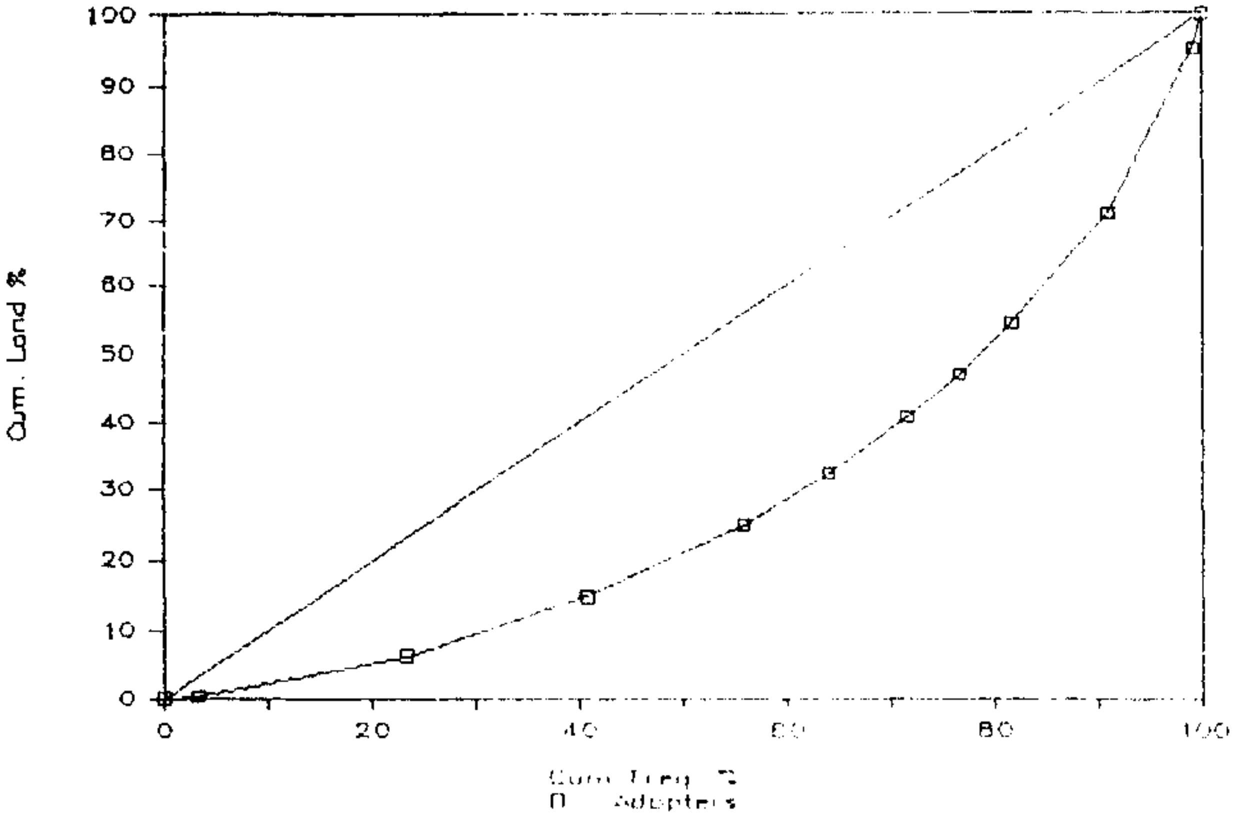
Table 5.34 The decile groups of adopters and non-adopters incase of land

Mid point	Adopters Frequency	Cu.(P.C) Frequency	(P.C) Cum.land	Mid point	Non-adopters Frequency	Cu.(P.C) Frequency	(P.C) Cum.land
		P	Q				
0.25	4	3.33	0.33	0.25	2	1.67	0.15
0.75	24	23.33	6.22	0.75	15	14.17	3.59
1.25	21	40.83	14.81	1.25	26	35.83	13.51
1.75	18	55.83	25.12	1.75	21	53.33	24.73
2.25	10	64.17	32.49	2.25	15	65.83	35.04
2.75	9	71.67	40.59	2.75	10	74.17	43.44
3.25	6	76.67	46.67	3.25	6	79.17	49.39
3.75	6	81.67	54.34	3.75	7	85.00	57.40
4.50	11	90.83	70.54	4.50	11	94.17	72.52
7.50	10	99.17	95.09	7.50	2	95.83	77.10
15.00	1	100.00	100.00	15.00	5	100.00	100.00

General Mean :- 2,5458
GCR :- 0.4241

General Mean :-2,7292
GCR :- 0.4247

LORENZ CURVES AND GINI CONCENTRATION RATIOS



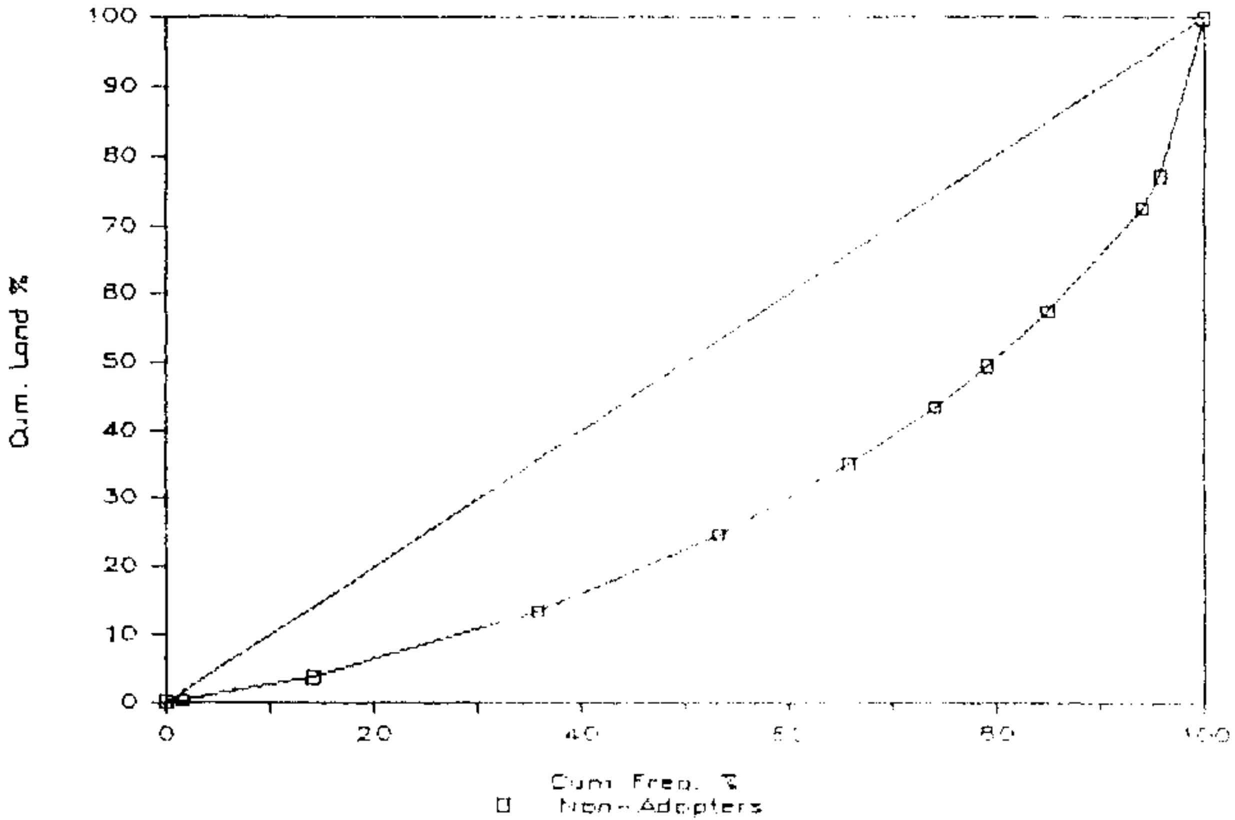


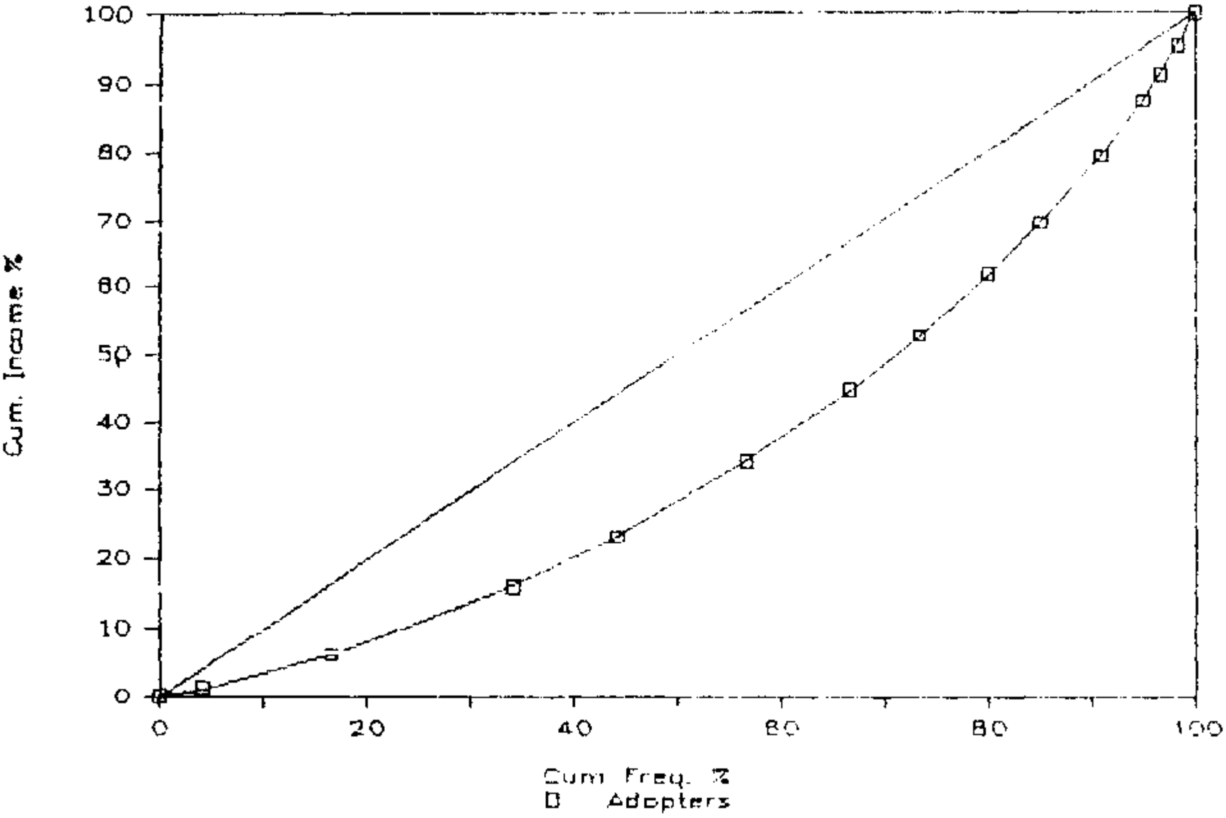
Fig. 3 The decile groups of Adopters and Non-adopters in case of Land.

Table 5.35 The decile groups of adopters and non-adopters incase of income

Mid point	Adopter Frequency	Cu.(P.C) Frequency	(P.C) Cu.income	Mid point	Non-adopter Frequency	Cu.(P.C) Frequency	(P.C) Cu.income
3500.00	5	4.17	1.17	5000.00	7	5.83	2.96
5000.00	15	16.67	6.19	7000.00	31	31.67	21.28
7000.00	21	34.17	16.01	9000.00	35	60.83	47.89
9000.00	12	44.17	23.21	1100.00	27	83.33	72.97
1100.00	15	56.67	34.27	1300.00	9	90.83	82.85
1300.00	12	66.67	44.70	1500.00	3	93.33	86.66
1500.00	8	73.33	52.72	1700.00	5	97.50	93.83
1700.00	8	80.00	61.82	1900.00	1	98.33	95.44
1900.00	6	85.00	69.44	27000.00	2	100.00	100.00
21000.00	7	90.83	79.27				
24000.00	5	95.00	87.30				
28000.00	2	96.67	91.04				
32000.00	2	98.33	95.32				
35000.00	2	100.00	100.00				

General Mean :- 12462,5
GCR :- 0.3049

General Mean :- 9866.6667
GCR :- 0.1792



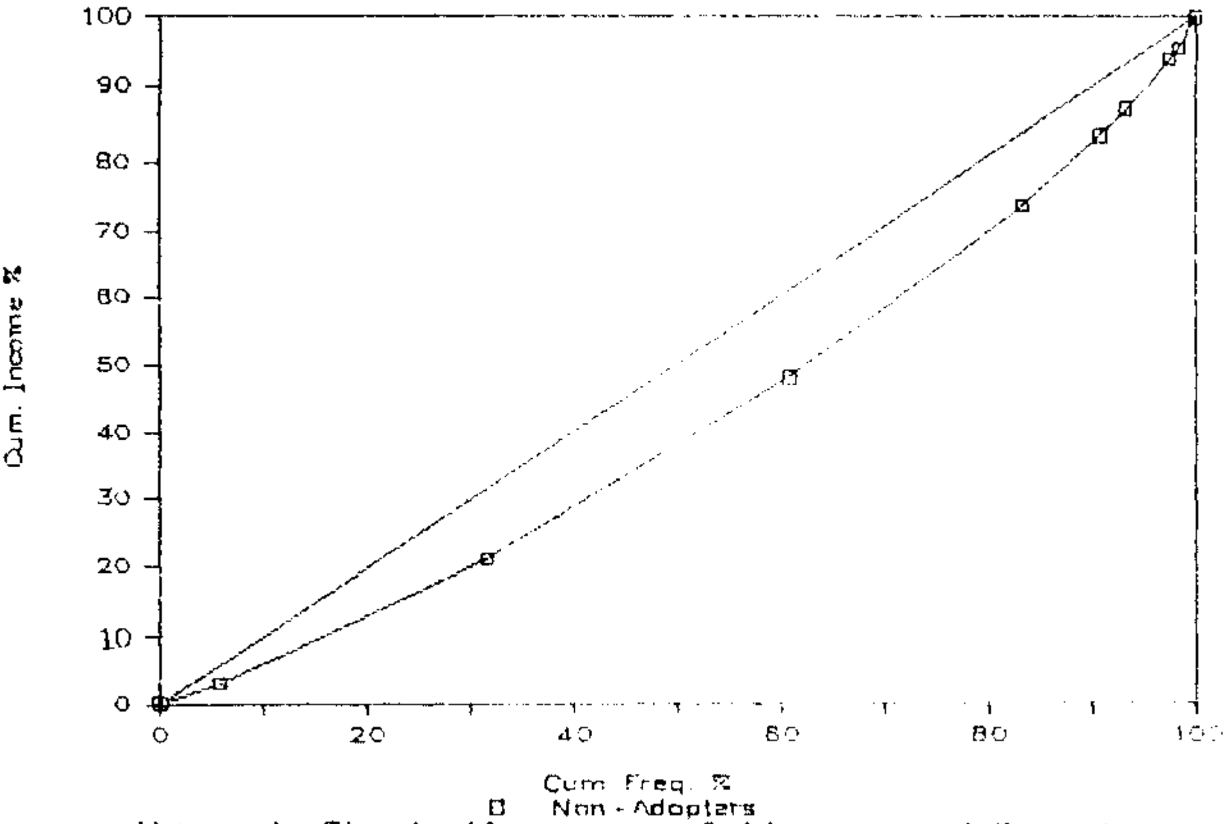


Fig... 4 The decile groups of Adopters and Non-adopters in case of Income

Table 5.36 Comparative Economics of Technology

S.No.	Particulars	Adopters	Non-adopters	Additional cost/returns of adopters over non-adopters
Sorghum (L) + Pigeonpea				
1.	Yield qt/ha	9.03 +1.30(p.pea)	7.56 +1.34(p.pea)	1.43
2.	Variable cost/ha	2739.00	1499.00	1240.00
3.	Gross returns	3338.00	3140.00	198.00
4.	Benefit cost ratio	1.20	2.09	0.16
	Castor (Aruna)			
1.	Yield qt/ha	7.73	4.80	2.93
2.	Variable cost/ha	2051.00	1700.00	351.00
3.	Gross returns	5113.00	3360.00	1753.00
4.	Benefit cost ratio	2.49	1.98	4.99
	Paddy (Kaharif)			
1.	Yield qt/ha	43.01	29.31	13.70
2.	Variable cost/ha	4559.00	4478.00	81.00
3.	Gross returns	8412.00	6090.00	2322.00
4.	Benefit cost ratio	1.85	1.36	28.66

at valid conclusions. The yield/profit acts as a measuring rod to assess the performance of technology adoption. To have an overall picture of technology adoptiion the comparitive economics of technology has been worked out and presented in Table 5.36. It is clearly evident from the table that adopters of technology had a clear advantage over non-adopters in their gross returns over their additional variable cost. It can be seen that additional gross returns for every additional rupee spent was highest for Paddy (Rs 28.67), followed by Castor (Rs 5.00) and Sorghum (L) + Pigeonpea (0.16) per hectare. In the case of Sorghum(L) + Pigeonpea the additional returns did not commensurate with the additional investment made on recommended crop production technology. This needs further research efforts to perfect the technology. With regards to Castor that additional benefit cost ratio indicated that the technology improved the returns substantially in the case of adopters when compared to non-adopters.

Though paddy is not a dryland crop the impact of dryland technology that is taking place may have a direct or indirect influence on increased returns. Accordingly it is noticed that additional benefit cost analysis is much higher due to application of improved seed, fertilizers or plant protection chemicals.

SUMMARY AND CONCLUSIONS

CHAPTER VI

SUMMARY AND CONCLUSIONS

Though the transfer dryland technology at the field level has been taking place since the last two decades, the adoption and spread of the same is not upto the desired extent. As such there is need to ascertain the reasons for slow adoption as well as for non-adoption of technology. Further wherever the adoption of dryland technology has taken place, it resulted in a significant impact on production, income and employment. An attempt is made in the present study to assess and quantify the impact of dryland technology on income and employment.

Objectives

1. To identify the dryland technology developed by different institutions.

2. To measure the variation in the production levels of selected crops, size-wise between adopters and non-adopters of technology.

3. To evaluate the income inequalities among the different size groups of farms of adopters and non-adopters.

4. To study the patten of resource use and productivity among adopters and non-adopters.

5. To study the impact of dryland technology on production, farm income and employment of adopters and non-adopters.

6. To examine the consumption pattern of adopters and non-adopters.

Sampling Procedure, Collection and analysis of data:

Maheswaram Watershed in Ranga Reddy district was purposively selected because this watershed was funded by World Bank for the development of dryland farming and close proximity to the University. Six villages at the rate of one in each sub-watershed, were selected based on random sampling. For the purpose of comparison three villages were selected. These villages are located outside the watershed but well within the close vicinity. Finally, one hundred and twenty farmers in watershed area and one hundred and twenty farmers in non-watershed area were selected by adopting stratified random sampling proportionate to stratum size. The information and data were collected from the respondents through interview method in a specially designed pre-tested schedule. The reference period was 1988-89. Lorenz curve, Gini Concentration ratio, Mahalanobis "D^2" static and Cobb-Douglas type of production function were the statistical tools and techniques used in this study in addition to tabular analysis.

Technologies developed:

The identified dryland farming technologies developed by various institutions are land and water conservation, crops and cropping systems, fertiliser use in dryland agriculture, plant protection measures, inter-cultivation and weeding and improved agricultural implements. The different technologies developed on mentioned items with ultimate objective to increase the production substantially and prove superiority over the traditional practices both at the institution as well as farmers field levels.

Assets of selected households:

The average size of family for the sample as a whole was 5.18 and 4.49 in adopters and non-adopter families, respectively. The value of farm assets including land per hectare ranged from Rs 25,811 to Rs 39,251 with an overall average of Rs 29,569 for the sample as a whole in case of adopters. The same for non-adopters it varied from Rs 35,352 to Rs 39,745 with an overall average of Rs 38,039 for the sample as a whole. It is also seen that the value of non-landed assets ranged from Rs 1,917 to Rs 4,362 with an overall average of Rs 2,732 for the sample as a whole in adopters. In the case of non-adopters it varied from Rs 2,004 to Rs 5,624 with an overall average of Rs 3,439 per hectare for the whole sample. The analysis of the assets of the selected households revealed that the value of assets per farm was higher on non-adopter farms as compared to that of adopter farms.

The total value of implements, livestock and land possessed per household was Rs 2,392, Rs 4,406 and Rs 66,767 for the whole sample in the case of adopters. The same for non-adopters it was Rs 3,102, Rs 6,620 and Rs 97,798 in the same order and indicated higher values on all size groups when compared to adopter farms.

The average size of holding in the case of adopters was 2,49 ha as against 2.80 ha in case of non-adopters. Sorghum (L) + pigeonpea and castor were the most important crops in *kharif* season. Paddy occupied a considerable area in both *kharif* and *rabi* seasons.

Impact on Productivity

The productivity of Sorghum (L) + pigeonpea was 9.03 + 1.30 quintals per hectare in the case of adopters as against 7.56 + 1.34 in the case of non-adopters. The productivity of castor was 7.73 quintals per hectare for adopters as against 5.01 quintals for non-adopters. The productivity of *kharif* paddy was 43.01 quintals per hectare for adopters as against 29.31 quintals for non-adopters. It is clearly evident that the productivity was higher on adopter farms for all crops when compared to non-adopter farms.

Costs and Returns

The cost of cultivation of sorghum (L) + pigeonpea per hectare was Rs 3,800 in the case of adopters as against Rs 2,674 in case of non-adopters. The proportion of variable cost was 72.1 per cent on adopter farms as against 56.1 per cent on non-adopter farms. The total cost of cultivation of sorghum (H) + pigeonpea was Rs 3,756 for adopters. The farmers in non-watershed area did not adopt the cropping system with improved varieties. The cost of cultivation of paddy (kharif) was Rs 6,891 per hectare for adopters as against Rs 6,287 for non-adopters. The variable costs in most of the cases were relatively higher on adopter farms as compared to that of non-adopter farms. This indicated that the farmers in the adopter category used more inputs in the production of crops when compared to non-adopters. Human labour and bullock labour constituted the major share of the total costs in almost all the crops. The next important item of expenditure was fertilisers in case of adopters, while it was farmyard manure on non-adopter farms.

Seed was the next important item of expenditure. Higher amount was spent on seed by adopters, when compared to non-adopters. Plant protection was the other important item of expenditure for adopters. The cost of cultivation is also worked out according to cost concepts. The gross returns and net returns were higher for almost all the crops excepting sorghum (L) + pigeonpea in adopters when compared to non-adopters. Positive and significant impact of technology was observed on productivity, Gross returns and net returns.

Mahalanobi's "D^2" test indicated that there was a significant difference between adopters and non-adopters in their input and output values for each of the crops grown.

Resource Allocation and its Efficiency

Total Returns, returns to scale and resource use efficiency for differnt crops in differnt size groups were estimated using the Cobb-Douglas form of production function.

The analysis showed in general the operation of diminishing factor returns and constant returns to scale irrespective of crops or size groups. The MVP to opportunity cost ratios indicated high degree of resource use inefficiency on all farm-size groups and for all the inputs. To increase profitability and returns on dry-land farms there is need to reduce the use of human and bullock labour and increase the expenditure on seed and fertilisers.

Adoption of Technologies

Technologies having long run impact are soil conservation, water harvesting, horticulture development etc. Technologies providing short run impact are improved varieties, fertiliser application, plant protection measures and recommended cultural practices such as, inter-cultivation and weeding.

Contour bunding was practised by 7 , 26 and 32 per cent of the small, medium and large farms respectively. While khus grass plantation was done by 52 per cent, 65 per cent and 91 per cent of the farmers in the same order in the adopters group. The works of checkdams completed constituted 3, 22 and 23 per cent on the small, medium and large farms, respectively. These works wereplanned, designed , implemented and completed by Department of Agriculture, Government of Andhra Pradesh. About 53 per cent of the selected farms adopted the practice of deep ploughing as farmers were provided iron plough under subsidised prices by the Department of Agriculture, Government of Andhra Pradesh. About 11 per cent of the farmers has taken up planting of horticultural crops. Horticulture saplings (ber, guava, pomogranate, custard apple etc.) were supplied to farmers in watershed area. None of the above practices excepting planting some fruit trees around the wells was adopted by the farmers belonging to non-adopters category due to non involvement of Government agencies as was done in the case of watershed villages.

The analysis on adoption of technologies showed that the adoption of improved technologies is more in case of paddy, an irrigated crop than in dryland crops. The important technologies were adopted for castor by almost all the farmers. None of the farmers in non-adopters group adopted the croping system of sorghum (L) + pigeonpea with high yielding varieties. Almost all the farmers used chemical fertilisers in adopters category whereas only 47 per cent of the non-adopters used chemical fertilisers. Thus variation in adoption levels/rates was observed between adopters and non-adopters.

Income Pattern

The analysis clearly indicated the existence of wide variations not only in the amount of income obtained per household but also in the composition of income from different sources among the small, medium and large farmers. The total income of adopters was Rs 18,735 per household as against Rs 16,536 in case of non-adopters, while the small farmers obtained 42 per cent of total income from agriculture, the medium and large farmers in the adopters group obtained 70 percent and 74 per cent of income from agriculture, respectively. Small farms obtained more income from hiring out their own faimly labour and dairying. Similar trend was also noticed in non-adopters.

Lorenz Curves

It is clear from Lorenz curve that the income is distributed more evently in case of non-adopters than in the case of adopters. It is also observed that Gini Concentration ratios showed that there was not much difference in the land distribution among different categories of farmers between adopters and non-adopters.

Employment

On an average a male worker found employment for 252 days in a year in the adopters category as agaisnt 298 days in the non-adopters category. The female worker could find employment for 192 days and 202 days in adopters and non-adopters categories, respectively. The level of employment was high in non-adopters category as people from non-adopter villages were engaged in soil conservation measures in adopters area as they agreed for low wages but people from adoption area demanded more wages and they are busy with their own other activities. The employment on own farm increased with the increase in farm size. However, the employment in off farm activities decreased with the increase of size of holding, due to social status improvement. The self-employment increased with the increase in size of holding.

Household Expenditure

The total family expenditure per annum per household was Rs 9,726 and Rs 5,882 on adopters and non-adopters, respectively.

POLICY IMPLICATIONS

The results obtained during the investigation has revealed certain policy implications, which are mentioned hereunder:

1. Soil and moisture conservation:

Since soil fertility and moisture play an important role in increasing the production in a sustained manner, the soil and moisture conservation measures should be given top most priority in dryland agriculture. Not only the massive programmes like construction of bunds, check dams but also vegetative barriers like *khus* grass plantation should be taken up. The Government has to take up soil and moisture conservation programmes, since they involve large investments. However, peoples participation in this programme should be ensured. *In situ* water harvesting techniques may be adopted and also awareness should be created among the farmers through extension education..

2. Supply of quality seed

The impact of quality seed was consistently observed in increasing the crop production in dryland agriculture. Hence the supply of quality seed is of paramount importance. The Department of Agriculture and State Seed Development Corporation should take up this responsibility to supply certified quality seeds well in time at reasonable price in the village, as farmers are facing problems to get good seeds from any agency with higher prices. Therefore "Seed Bank" needs to be created for proper supply.

3. Inputs supply

The impact of modern inputs like fertiliser and plant protection chemicals was significant. The input delivery system should be improved by utilising the existing institutions such as Cooperatives and Agros. The ideal system should be to supply all the essential inputs under a single roof. This needs the establishment of single window delivery system.

4. Technologies

The technologies suitable for dryland farming should be feasible and cost effective. Hence institutions need to develop different levels of feasible technologies to meet the requirement to different categories of farmers.

5. Crops and Cropping Systems

The existing crops and cropping systems should be replaced by high value and efficient to provide better incomes to the farmers, rather than replacing with hybrid varities only.

6. **Credit**

The study clearly indicated that the technologies were strikingly superior to the traditional practices, the adoption of the same was rather slow and low. It was due to lack of finances. Therefore, credit should be provided in a big way at right time to farmers of dryland agriculture by financing institutions. Timely, adequate and cheap credit is the need of the hour. It is high time to think of providing loans at a comparatively cheaper rates of interest in dryland farming areas due to uncertain climatic conditions and flunctating yields.

7. **Creation of Permanent Assets**

Provision of crop life saving irrigation will help in boosting the yields and minimising the crop losses. For this purpose water harvestings structures such as farm ponds, check dams etc., may be constructed. As it is not possible by the individual farmers, it needs to be taken up by Government agencies only.

8. **Extension and Training**

For motivating and enlightening the farmers on different aspects of dryland farming technology, extension and training programmes will have to be taken up more intensively to cover the farmers in all dryland areas.

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APPENDIX

Appendix A

Growth phases of cashew plantations during the period of study

Month	Fort-night	Growth phases during		
		1986-87	1987-88	1988-89
Jun	I	-	F	F
	II	-	F	F
Jul	I	F	F	F
	II	-	-	F
Aug	I	-	F	F
	II	F	F	F
Sep	I	F	F	F
	II	F	F	F
Oct	I	F	F	F
	II	-	F	-
Nov	I	-	F	-
	II	-	-	-
Dec	I	F	-	-
	II	I	F	-
Jan	I	I	I	I
	II	I	I	I
Feb	I	N	I	I
	II	N	N	I
Mar	I	N & A	N	N
	II	N & A	N & A	N
Apr	I	N & A	N & A	N & A
	II	N & A	N & A	N & A
May	I	-	N & A	-
	II	-	-	-

F = Flush I = Inflorescence N = Nuts A = Apples

Appendix B

Fortnightly means of weather data recorded during 1986-8[illegible]

Month	Fort-night	Max. temp.	Min. temp.	R.H.	Rainfall (mm)
Jun	I	3[illegible].76	28.[illegible]	[illegible]7.13	[illegible].[illegible]/1
	II	31.81	26.[illegible]	69.67	29.9/[illegible]
Jul	I	37.77	[illegible].0[illegible]	6[illegible].6	29.2/3
	II	33.97	24.9[illegible]	7[illegible].31	94.8/8
Aug	I	31.55	24.[illegible]	80.27	166.5/8
	II	33.86	25.64	78.56	66.3/3
Sep	I	33.38	25.[illegible]	78.87	48.0/4
	II	33.92	25.[illegible]1	81.13	45.9/5
Oct	I	31.73	24.[illegible]	87.4	[illegible]1.8/[illegible]
	II	31.13	22.4[illegible]	85.75	37.3/3
Nov	I	29.49	22.61	94.0	116.3/9
	II	30.97	18.94	80.6	0.0/0
Dec	I	30.22	18.6[illegible]	81.67	-
	II	29.82	18.[illegible]	86.94	[illegible]2.0/1
Jan	I	29.53	17.59	87.93	12.0/1
	II	29.88	18.[illegible]	8[illegible].38	-
Feb	I	30.05	16.[illegible]	82.6	-
	II	30.75	1[illegible].[illegible]	84.38	-
Mar	I	30.8	19.18	83.17	7.9/3
	II	32.81	[illegible]1.94	79.38	-
Apr	I	36.37	25.13	70.87	-
	II	34.17	25.[illegible]	73.6	25.0/2
May	I	35.13	26.11	73.47	12.2/1
	II	36.24	27.8	69.94	-

Rainfall = Total rainfall / No. of rainy days

Appendix [illegible]

Fortnightly means of weather data recorded during 1987-88

Month	Fort-night	Max. temp.	Min. temp.	R.H.	Rainfall (mm)
Jun	I	39.8	[illegible]	[illegible]	[illegible]
	II	38.34	[illegible]	64.67	51.3/6
Jul	I	33.93	[illegible]	71.2	[illegible]
	II	35.54	[illegible]	68.31	[illegible]
Aug	I	[illegible]	[illegible]	81.0	[illegible]
	II	33.48	[illegible]	71.69	[illegible]
Sep	I	34.71	25.84	77.07	[illegible]
	II	[illegible]	[illegible]	79.07	[illegible]
Oct	I	31.91	[illegible]	83.73	[illegible]
	II	31.29	[illegible]	[illegible]	[illegible]
Nov	I	[illegible]	[illegible]	[illegible]	313/9
	II	[illegible]	[illegible]	[illegible]	[illegible]
Dec	I	29.63	[illegible]	[illegible]	[illegible]
	II	28.56	[illegible]	[illegible]	-
Jan	I	29.15	[illegible]	[illegible]	-
	II	[illegible]	[illegible]	[illegible]	-
Feb	I	[illegible]	[illegible]	[illegible]	-
	II	31.14	[illegible]	[illegible]	-
Mar	I	32.05	[illegible]	[illegible]	-
	II	33.65	[illegible]	[illegible]	-
Apr	I	34.03	[illegible]	[illegible]	-
	II	35.07	[illegible]	[illegible]	[illegible]
May	I	[illegible]	[illegible]	70.93	[illegible]
	II	40.09	[illegible]	[illegible]	[illegible]

Rainfall = Total rainfall / No. of rainy days

Appendix D

Fortnightly means of weather data recorded during 1998-99

Month	Fort-night	Max. temp.	Min. temp	R.H.	Rainfall (mm)
Jun	I	39.61	[illegible]	[illegible]	[illegible]
	II	[illegible]	[illegible]	[illegible]	[illegible]
Jul	I	[illegible]	[illegible]	[illegible]	[illegible]
	II	[illegible]	[illegible]	[illegible]	134.4/[illegible]
Aug	I	[illegible]	[illegible]	[illegible]	[illegible]
	II	[illegible]	[illegible]	[illegible]	[illegible]
Sep	I	[illegible]	[illegible]	[illegible]	[illegible]
	II	[illegible]	[illegible]	[illegible]	[illegible]
Oct	I	[illegible]	[illegible]	[illegible]	[illegible]
	II	32.85	[illegible]	[illegible]	-
Nov	I	30.86	[illegible]	[illegible]	[illegible]
	II	[illegible]	[illegible]	[illegible]	-
Dec	I	[illegible]	[illegible]	[illegible]	[illegible]
	II	[illegible]	[illegible]	[illegible]	-
Jan	I	[illegible]	[illegible]	[illegible]	-
	II	[illegible]	[illegible]	[illegible]	-
Feb	I	[illegible]	[illegible]	[illegible]	-
	II	31.45	[illegible]	[illegible]	-
Mar	I	[illegible]	[illegible]	[illegible]	[illegible]
	II	[illegible]	[illegible]	[illegible]	-
Apr	I	[illegible]	[illegible]	80.6	-
	II	[illegible]	[illegible]	[illegible]	-
May	I	[illegible]	[illegible]	[illegible]	-
	II	40.58	[illegible]	[illegible]	-

Rainfall = Total rainfall / No. of rainy days

Appendix E

Fortnightly ranges of weather data recorded during 1986 to 1989

Month	Fort night	1986-87 Max. temp	1986-87 Min. temp	1986-87 R.H.	1987-88 Max. temp	1987-88 Min. temp	1987-88 R.H.	1988-89 Max. temp	1988-89 Min. temp	1988-89 R.H.
Jun	I	33.7 to 44.3	25.3 to 30.3	42-80	36.0 to 43.7	25.1 to 31.0	44-87	33.1 to 44.2	[illegible]	[illegible]
	II	31.0 to 37.9	23.4 to 28.8	55-94	32.2 to 42.5	23.6 to 29.5	48-79	33.0 to 40.6	24.1 to 29.[illegible]	[illegible]-93
Jul	I	33.4 to 39.5	23.0 to 29.4	43-87	31.0 to 37.9	23.5 to 27.0	51-93	30.1 to 38.6	24.3 to 26.4	59-94
	II	26.7 to 36.9	23.0 to 26.7	59-98	32.4 to 39.3	24.5 to 28.1	49-81	28.1 to 35.9	22.4 to 26.8	69-96
Aug	I	25.0 to 35.1	21.9 to 25.9	69-93	28.4 to 39.4	23.0 to 28.3	53-96	31.6 to 33.6	22.[illegible] to 2[illegible]	60-97
	II	32.7 to 36.3	24.0 to 27.3	70-88	26.1 to 36.4	23.3 to 27.4	65-86	28.7 to 35.6	22.8 to 26.[illegible]	[illegible]-95
Sep	I	30.6 to 36.8	23.8 to 27.8	65-85	30.3 to 39.9	23.5 to 27.0	67-85	31.1 to 33.6	24.1 to 27.[illegible]	78-93
	II	32.4 to 35.4	21.9 to 27.5	67-91	32.7 to 36.0	20.5 to 27.8	69-91	27.2 to 33.3	23.4 to 26.[illegible]	67-98
Oct	I	27.6 to 33.8	22.6 to 26.6	77-97	29.0 to 33.6	23.0 to 25.9	83-95	29.9 to 33.8	21.0 to 27.8	76-91
	II	23.8 to 33.0	20.8 to 24.4	77-98	29.9 to 32.6	21.5 to 25.2	81-95	31.8 to 34.4	20.2 to 24.7	69-87
Nov	I	24.9 to 31.9	19.8 to 24.0	85-99	25.4 to 31.8	19.3 to 24.1	81-100	27.8 to 32.0	19.0 to 22.[illegible]	65-94
	II	30.1 to 33.1	17.9 to 20.3	72-93	29.3 to 32.3	15.3 to 24.0	77-97	29.0 to 32.4	17.4 to 18.9	70-84
Dec	I	29.2 to 31.0	15.7 to 21.4	71-95	26.3 to 31.3	16.7 to 22.8	74-96	24.7 to 31.5	[illegible] to 21.[illegible]	72-96
	II	28.5 to 30.5	12.8 to 21.5	80-95	27.9 to 30.7	14.6 to 21.3	67-91	28.0 to 29.7	1[illegible].2 to 21.[illegible]	[illegible]1-99
Jan	I	28.7 to 30.9	14.9 to 21.6	69-100	28.2 to 30.4	15.3 to 17.3	88-100	28.3 to 30.8	15.0 to 18.1	82-98
	II	29.4 to 30.6	15.5 to 20.3	84-95	28.8 to 31.5	15.5 to 19.8	93-100	28.3 to 30.3	14.7 to 19.6	82-98
Feb	I	28.4 to 31.6	14.0 to 17.8	69-100	29.4 to 31.4	15.3 to 19.8	77-94	29.1 to 34.5	15.0 to 17.[illegible]	77-98
	II	29.2 to 32.9	14.5 to 21.9	70-97	30.6 to 31.9	19.5 to 25.8	70-90	30.0 to 33.6	15.8 to 19.9	[illegible]-98
Mar	I	28.1 to 31.8	16.0 to 22.5	75-95	31.1 to 32.6	18.8 to 25.9	71-90	30.1 to 34.7	16.6 to 23.3	[illegible]7-94
	II	31.3 to 35.0	19.8 to 25.8	67-87	32.4 to 35.4	20.8 to 28.1	73-93	30.0 to 35.9	19.3 to 24.[illegible]	60-87
Apr	I	31.9 to 42.6	20.3 to 28.5	48-85	33.1 to 35.6	23.0 to 28.7	65-85	32.0 to 37.7	21.3 to 26.3	70-95
	II	32.9 to 36.2	21.0 to 28.5	67-79	32.2 to 38.8	22.0 to 28.6	57-79	32.4 to 43.4	22.4 to 28.0	57-79
May	I	33.3 to 39.3	23.3 to 28.4	63-85	26.2 to 44.0	22.3 to 29.6	53-82	33.3 to 43.5	23.0 to 28.8	[illegible]3-76
	II	34.5 to 40.4	25.3 to 29.1	54-77	35.6 to 43.6	25.5 to 30.5	50-80	33.3 to 43.5	21.4 to 31.0	36-83