ECONOMICS OF FARM MECHANIZATION

IN COASTAL AP

By

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CERTIFICATE

Ms. **Linga Reddy Thulasamma** has satisfactorily prosecuted the course of research work and that the thesis entitled "***Economics of farm mechanization in coastal AP***" submitted 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 previously submitted by her for a degree of any university.

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This is to certify that the thesis entitled "***Economics of farm mechanization in the coastal AP***" submitted in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Agriculture** of Acharya NG Ranga Agricultural University, Hyderabad is a record of the bonafied research work carried out by **Ms. Linga Reddy Thulasamma** 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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DECLARATION

I, Ms. **Lingareddy Thulasamma** here by declare that the thesis entitled ***ECONOMICS OF FARM MECHANIZATION IN COASTAL AP*** submitted to the **Acharya NG Ranga Agricultural University** for the degree of **Doctor of Philosophy** in **Agriculture** is the result of original research work done by me. I also declare that the thesis or part thereof has not been published earlier in any manner.

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ABSTRACT

The study was under taken with the specific objectives; to study the benefits of mechanization vis-à-vis traditional methods, to find out the important determinants of farm mechanization in the study area, to study the impact of mechanization on cropping intensity, production, productivity and income of the selected farms, to project the demand for farm machinery in the selected districts of Andhra Pradesh and to study the problems and constraints associated with farm mechanization.

The investigation was conducted in coastal districts of Andhra Pradesh. West Godavari, Nellore and Prakasam districts were selected for study based on their first three positions with respect to stock of farm machinery. Three stage random sampling method was followed to select a sample of 240 farms (120 under each category of mechanized and non-mechanized farms). Interview method was used to collect the data from the selected respondents for the year 1997-98. A combination of conventional, discriminatory and function analyses was used to arrive at the results and draw valid conclusions from the data.

The extent of machine labour costs was 25.61 per cent of the total costs, however it increased to 42.9 per cent, when the harvesting was carried out with harvest combine. Operations so far mechanized either partially or completely were ploughing, irrigation, transportation of manures, harvesting, threshing and winnowing. Costs incurred on all the operations were more on mechanized farms when compared to non-mechanized farms. The overview of the pattern and extent of labour absorption indicated only less than 2 per cent displacement of casual human labour and 100 per cent displacement of cattle labour due to mechanization through tractors and pumpsets. However the introduction of harvest combines resulted into a large displacement of casual labour (67mandays), about 34 per cent when compared to non-mechanized farms. *Cropping intensity* was found to be important factor having relatively maximum weightage to discriminate between

mechanized and non-mechanized groups and to some extent *per cent area irrigated* and *wages paid to casual human labour* also helped.

The tractor density in the study area was significantly determined by *per cent area irrigated*. The density of power tillers was determined by *per cent area irrigated* and *price* in West Godavari district, *agricultural productivity* in Nellore district while in case of Prakasam district along with the above *long term credit* was also influenced. Factors determining oil engine density were *agricultural productivity* and *price* in West Godavari district, *agricultural productivity* in Nellore district and *per cent area irrigated* in Prakasam district. Density of electric motors was determined by *price* in the study area. Harvesters' density in the study area was determined by their *price*. It was further influenced by *agricultural productivity* in Nellore and Prakasam districts. Similarly the density of plant protection equipment was influenced by their *price* in the study area and it was further influenced by *per cent area* irrigated in West Godavari district.

Mechanization had a significant positive impact on cropping intensity, production, productivity and income of the selected farms. The projected demand for farm machinery indicated a considerable increase in the number of tractors, electric motors, harvesters and plant protection equipment while the demand for oil engines and power tillers is likely to decline in future in the selected districts.

Non-availability and *high wages* were the important problems associated with casual labour. *Small farm size*, *high cost* and *non-availability of machinery* were important among the constraints to the use of farm machinery. Problems with purchase were *seasonal and uneconomical use*, *possession of small farm*, *non-availability of credit facilities* and *lack of repair after sale services* etc. There is a need for state government, to take initiatives like provision of farm machinery on hire basis and provision of both mobile and stationary repairing workshops through department of agriculture. Both public and private organizations should take active part in developing and modifying the farm machinery suitable to the existing field conditions and cropping pattern. There is need for extension agencies, to popularise the proven models of farm machinery and selective mechanization among the farmers, keeping in view of the needs and interests of farmers and agricultural labour.

INTRODUCTON

CHAPTER I

INTRODUCTION

"There is no necessary conflict between the manpower utilization and the introduction of machinery on large scale, provided the machine used is not for creating fresh unemployment" *-Pandit Jawaharlal Nehru*

Indian agriculture is highly dependent on rural agricultural labour and it provides occupation for more than 206 million people (Rao, 1998). But, due to changes in socio-economic conditions, rural labourers are increasingly migrating towards urban areas, causing shortage of labour during the peak season periods, thus causing delay in carrying out farm operations. In the context of scarcity and high cost of labour during crop seasons, modernization with less dependance on labour plays a key role through mechanization. Green revolution has brought up vast changes in agriculture and led it into a new era. With the improved technologies and package of practices, farmers could almost double the agricultural production and productivity. However the economic returns have not been commensurate with high input expectation. The future revolution, in terms of productivity and production of crops, should come through mechanization.

Many agriculturally developed countries in the world like Japan, Korea, Philippines, China, America etc., have mechanized agriculture completely. They use manpower in agriculture only to an extent of 3 to 5 (Sarma, 1999) per cent, whereas in India agriculture is dependent on manpower to an extent of 65 to 70 per cent.

Different sources of farm power in India

Human power: As mentioned earlier human energy is being predominantly used in Indian agriculture. Use of human power in crop production is reported to have increased marginally from 723 to 766 hours per hectare between 1971 to 1991(Rao, 1998). In terms of human energy it has increased from 1.33 Mega Jouls (MJ) in 1970-71 to 1.434 MJ per hectare in 1992-93.

Draught animal power: The draught animal power continues to be a major power source for field operations. However, the population of draught animals has decreased to 60 million (1992) from 80.4 million (1961). The total power available from the draught animals during 1995-96 was estimated at 16.8 million kilowatts (mkw) which accounts to 12.3 per cent of the total (136.8 mkw) farm power (Rao, 1998). The average use of animal energy per hectare has come down from 159 to 109 animal pair hours per hectare between 1971-72 to 1990-91, registering a negative growth rate of 1.5 per cent per annum. This may be due to the rising cost of animal maintenance and delayed operations leading to time overheads. Hence to ensure timeliness in field operations many farmers are diverting towards mechanization.

Mechanical energy: Use of mechanical power in agriculture has increased from 0.005 kW/ha to 0.59 kW/ha between 1950-51 and 1995-96. The use of mechanical power registered a growth rate of 5.6 per cent during the period from 1980-81 to 1990-91, while it was recorded 10.7 per cent during the period from 1960-61 to 1995-96. The ratio of mechanical power to total farm power has increased from 3.6 per cent to 80 per cent during 1950-51 to 1995-96 (Rao, 1998). During the year,

1995-96, the irrigation itself shared more than 64 per cent of the total farm power requirement. Machine power in terms of tractor has increased from a meagre 0.8 per cent in 1950-51 to 28.9 per cent during 1995-96. It does not compare reasonably well with countries like Japan, Korea, Philippines etc. as it was mentioned earlier. However the slow pace of mechanization of farm operations in India is probably because of several reasons such as small size of land holding, poor economic status of farmers etc.

Farm machinery Scenario in Andhra Pradesh

Andhra Pradesh has 26.4 lakh wooden ploughs, 3.9 lakh iron ploughs, 1.7 lakh oil engines, 9.6 lakh electric pumpsets and 56,275 tractors according to 1993 census. Wooden ploughs and oil engines decreased over the years, while iron ploughs, electric pumpsets and tractors increased as detailed in Table 1.1. It is apparent that the farm equipment required for carrying out critical operations are inadequate in spite of their increase over the years (one oil engine for 74.64 hectares of gross cropped area and one electric pumpset for 13.22 hectares and one tractor for 225.46 hectares of gross cropped area.)

Use of traditional implements has not helped in improving land conditions in many areas for making them suitable for growing a wide variety of crops. Even with the use of high yielding varieties and improved package of practices, some times the expected level of yields have not been achieved making the farming economically less viable. Increasing input costs and not getting commensurate yields would further make the farming a difficult enterprise. Major contributing factor towards high cost of production of crops is the expenditure incurred on labour for various

operations such as ploughing, puddling, sowing, transplanting, weeding, threshing, winnowing etc. Use of implements and machines in these farm operations can reduce drudgery, improve efficiency and timeliness and thus reduce the cost of cultivation, besides improving the productivity.

Table 1.1: Important farm machinery in A.P from 1977 to 1993

Machinery	**Units**	**1977**	**1983**	**1987**	**1993**	**No of GCA (ha) per unit**
Wooden ploughs	Lakhs	34.3	33.2	26.8	26.4	4.81
Iron ploughs	Lakhs	1.3	2.5	4.4	3.9	32.5
Total ploughs	Lakhs	35.6	35.7	31.2	30.3	4.19
Oil engines	Lakhs	2.1	2.5	2.3	1.7	74.64
Electric pumpsets	Lakhs	3.0	4.4	6.7	9.6	13.22
Tractors	Numbers	12594	21450	32537	56275	225.46

Source: Livestock census and statistical abstracts of respective years (1977,1983,1987,1993).

In addition all agricultural operations are time bound. Ploughing and land preparation, transplanting, weeding, harvesting etc., are to be done precisely in time, especially in case of dryland or rainfed agriculture. It requires that the area should be sown within a short span of time. Apart from sowing large areas on time while the soil moisture is at its optimum, the man power requirement will also be high and critical for several farm operations as per crop schedule.

The increasing emphasis on production per unit time necessitates greater energy use to ensure timeliness and precision in farm operations. The biological sources of energy, especially bullocks could not cope with the

requirements of the changed situation. Belief that mechanization is only possible in case of large farms, has been proved wrong in states like Punjab and Haryana. Mechanization of agricultural operations can be done irrespective of farm size if there is a combined effort of farmers, who are having small farm holdings.

Problem statement

Inspite of abundant natural resources and farmers readiness to accept challenges and adopt new technologies, mechanization of agriculture in the state has not reached the expectations. According to State Agriculture and Industries Development Institute (SAIDI), Hyderabad, the total number of tractors in the state are 1,35,000 for the net area sown of 84 lakh hectares, whereas in Punjab there are about 3,70,000 tractors under use for a net sown area of 42.10 lakh hectares.

SAIDI, Hyderabad pointed out that various agricultural implements that are now used in Punjab were developed from the base models collected from Andhra Pradesh during 1960s. These base models were modified and adopted locally in Punjab as per their requirement. While the industries, which had developed those base models, have disappeared now totally from the scene due to lack of state sponsorship to improve and popularize in Andhra Pradesh

In the state it is a common phenomenon that surplus labour from Telangana and Rayalaseema districts, migrates to the coastal districts during the period of transplanting and harvesting of rice crop. They demand higher wages due to shortage of labour and time to carryout those operations. Sometimes farmers have to forcibly go for contract labourers and they plant seedlings at a wider spacing

than the recommended in order to cover larger area in a shorter period. This has directly resulted in lower yields as the recommended rate of seedlings per unit area could not be maintained.

Moreover it is a common knowledge that cyclones and heavy rains in the coastal area have always inflicted heavy losses through damage of ready-to-harvest crops. To illustrate further, it is worthwhile to recall that in Guntur district alone the losses were estimated at 901 kg/ha in the year 1977-78 while it was 777 kg/ha in West Godavari district in 1986-87.

Further, it was estimated that if the harvesting is to be done by traditional method, 20 to 25 labourers per hectare per day are required to harvest. In addition, more labour is required for operations such as drying, heaping and threshing, which usually takes about 7 to 10 days of time. These manual operations would invariably lead to grain losses to the tune of 18 to 20 bags per hectare (Sarma, 1999). Such losses can be avoided in terms of time, grain and excess labour costs with mechanization.

Though the need and importance of farm mechanization has been felt since long, the required development could not be achieved so far. In the context of the above existing farming situation there is an urgent need to probe into the present status and future demand of farm mechanization in A.P. along with impact and problems associated with it. So far no study was conducted on these aspects of mechanization in the state. Keeping these facts in view, a study was undertaken to evaluate the economics of farm mechanization in coastal A.P with the following specific objectives:

Specific objectives

1. To study the benefits of mechanization vis-à-vis traditional methods.

    a) To assess the extent of farm mechanization in various farm operations.

    b) To estimate the comparative economics of mechanization of farm operations with traditional methods.

    c) To study the pattern and extent of labour absorption or labour displacement due to farm mechanization.

2. To identify the determinants of farm mechanization

3. To analyse the impact of farm mechanization on cropping intensity, production, productivity and income on selected farms.

4. To estimate the demand for farm machinery in the selected districts of coastal Andhra Pradesh.

5. To study the problems and constraints associated with farm mechanization.

Hypotheses of the study

In the light of above mentioned facts in the preceding pages and the review of literature presented in the next chapter, it is proposed to test the following hypotheses to meet the requirements of the objectives of the study.

1. Farm mechanization does not affect the costs of farm operations.

2. Farm mechanization does not influence the pattern and absorption of labour.

3. Farm mechanization has no significant influence on impact on cropping intensity, production, productivity and income.

Scope of the study:

The findings of the study are expected to throw light on the extent to which the mechanization is being shared in various farm operations and also help to know the impact of farm mechanization on various aspects considered. Results of empirical analysis done would indicate the possible determination of mechanization in the study area. Demand projections would give an idea about the future status of various farm machinery in the study area. Results of opinion survey conducted to find out the constraints of mechanization may throw some light on the actual problems that are restricting the farmers to adopt machinery. Thus the results of the study would benefit the scientists and farmers as well to probe into the farm mechanization. Based on the empirical results of the study, the farmers of the study area would be able to make the decisions regarding farm operations that can be mechanized in order to achieve better profits, save time and carryout the operations efficiently.

Limitations of the study

The study was undertaken in coastal districts of Andhra Pradesh for the year 1998-99 and it is based on the micro-level data obtained from a sample of 240 farms in coastal Andhra Pradesh. The primary data were obtained based on the recalled memory of respondents, which might have certain limitations and may not be true in all aspects. The inferences drawn from the data are based on the data

collected for one season (1998-99) only. Since this study is undertaken for the first time and in addition to that it was only for one agricultural season, it may require further investigation and validation.

Organization of thesis

The thesis is presented in six chapters.

Chapter I deals with the introduction highlighting the problem statement along with objectives and hypotheses and scope of the study.

Review of literature relevant to the study is presented in Chapter II.

In the Chapter III data requirements, sources and collection of data, sampling design and analytical framework used are presented.

The agro-economic features of the study area like physiography, geological features, soil types, climate and rainfall, land utilization, cropping pattern etc., are presented in Chapter IV.

Chapter V presents the results of the study and discussion with a view to draw some specific points for policy.

Chapter VI summarizes the study and draws the conclusions and suggestions for policy implications.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Attempts to mechanize farm operations in India could be traced back to early 20th Century. In the post-war II period, price of farm products had increased due to the scarcity of food and agricultural raw materials in the country. This provided a further impetus to intensive cultivation so as to raise the yields. With this some measure of emphasis came to be placed on the mechanization of farming operations.

Research is being conducted on different aspects of mechanization. The "economics of mechanization of agriculture" was first discussed by the Indian economists at the Ninth Conference of the Indian Society of Agricultural Economics held at Hyderabad in December, 1948. The study of this vast micro-problem in applied research and the interest of academics were continued in the period that followed. In this chapter an attempt is made to review the research efforts done on various aspects of farm mechanization by grouping them under the following heads.

2.1. Studies on economics of farm mechanization

2.2. Studies on impact of mechanization

2.2.1 Cropping intensity

2.2.2 Employment and income

2.3 Studies on demand for farm machinery

2.1. Studies on economics of farm mechanization

Andrew and David (1970) found from their study that an integrated public-private approach to mechanical harvesting of tomatoes for canning had sharply reduced labour requirements in California. Even if the displaced labour had been compensated for wage loss, net social returns were still highly favourable. It was also indicated a need for policies designed to distribute the benefits and costs of technological changes more equitably.

Venkatappaiah (1972) observed that developing countries would not have to follow a model of mechanization based on labour shortages as in the western industrial countries. Other strategies can put both land and labour to work more productively, creating rather than destroying jobs in agriculture and in supporting sectors of economy. Introduction of mechanization may positively help in the proper development of labour in relation to economic development as a whole. Further mechanization of agriculture creates significant employment in industrial sector through the demand for the farm machinery, in addition to that new employment opportunities arise through maintenance and after service facilities.

Namboodiri and Padmanabhan (1975) found that the tractor technology contributed a higher net returns compared with the bullock technology at the existing farm situation. Custom service was one of the main sources of income generating activity in tractor technology and it can be supported by the fact that with limited farm size, large investment cannot yield profitable net returns through crop production alone. Since the tractors are mainly involved in preliminary tillage operations, the question of labour displacement would not arise and hence there will

not be reduction in labour employment in tractor technology and the replacement of bullock labour with tractor was found to be profitable even without custom service. Finally it was concluded that tractorisation helped the increased use of inputs, more employment opportunities through extensive as well as intensive utilization of land, expanded output and maximization of net returns.

Yoav and Willis (1981) indicated that farmers demand new and large number of machines because the cost of farm labour, both the operating cost of family labour and wage of hired labour, increased relative to the prices of machinery services. Machinery manufacturers responded to this by expanding capacity through investment in both Research and Development of plant and equipment. They concluded that the technical change that emerged from mechanization occurred mostly in the manufacturing sector, which resulted into a decline in the relative cost of machinery.

Jayasuriya *et al* (1986) computed the amount of power services a machine had to work in order to break-even a given cost structure and custom hired. The results of his study indicated that the number of machines acquired by farmers in a given area would be small and hence utility to have a significant effect on timeliness of operations resulting in small output.

Ram and Vyas (1987) stated that there was a shortage of draught animal power energy in the arid zone of Rajasthan, even on the limited segment of below 10 hectares size-group farms, to the tune of 2.5 per cent in 1976-77. Tractor energy on the other hand was two to three times more than requirement on the basis

of 600 HP per hectare. The agro-economic conditions did not offer much scope for fuller utilization of available energy from both the sources.

Srivastava (1987) found that population engaged in agriculture/ farming activities was got reduced, which led to the shortage of farm labour and the problem had been sought to be met through mechanization of farms. His study also indicated that the operations related to irrigation, threshing, pest control, ploughing, harrowing have been mechanized 100 per cent and transplantation of paddy mechanized to the extent of 90 per cent or even more.

The study of Chatta and Grewal (1991) brought out that a vast majority of the farmers were making sub-optimal use of tractors. The average use per annum worked out to about 450 hrs against the recommended level of 1000 hrs. The available tractor HP per hectare also turned out to be 4.20 as against optimum requirement of 2.16 HP. The average size of operational holdings of the farmers has increased from 6.67 ha to 7.74 ha after purchase of tractor. There was a considerable market for second hand tractors, which emerged after 1975, because of a break through in paddy production technology. But non-availability of institutional credit was the main problem for such kind of second hand purchases.

Singh and Tewari (1994) analysed the farm investment on tractor in Bihar. Their results indicated that tractor farms had more area under commercial crops. Pattern of manure and fertilizer use was by and large similar on both tractor and bullock operated farms. Further the profitability of investment in tractor heavily depends on market for sale of tractor services. They concluded that the minimum

economic size of farm holding for owning a tractor of 35 HP with loan was 10 hectares.

Chatta and Grover (1995) indicated that the maintenance cost of machinery was substantial and it had a direct relationship with farm size, mainly due to the fact that the small farmers maintain second hand and relatively small HP machinery. It was also found that some machinery like tractors and threshers remained under utilized on all categories of farms.

Bill (1999) indicated IRRI-Stripper-harvester as an alternative to manual harvesting, mechanical reapers and small combines. The machine was not only lighter but could work in muddier soils allowing far more efficient and effective simultaneous harvesting and threshing operations.

Kamble and Kurpakar (1999) opined that mechanization of agriculture consisted of partly or completely replacing of animal and human labour by mechanical power wherever possible. Further mechanization meant the deployment of machinery in one way or other in almost all farming operations, ranging from breaking up of soil to the marketing. Important constraints in mechanization were average small size of holding in addition to that more than 60 per cent of farmers who belong to marginal category have an average holding of about 0.4 hectares. Next was rainfed farming and hilly land, which accounted to more than 70 per cent of area, low economic return and employment, non-availability and lack of after service facilities and also inadequate fuel and electricity.

2.2.1 Studies on impact of mechanization on cropping intensity

Kahlon and Sharma (1969) measured the economics of tractor in Ludhiana district of Punjab, for different levels of cropping intensity. Their results indicated that on a 15.4 acre farm, where soils were light and existing cropping pattern indicated a cropping intensity of 142.86 per cent, a small 10 HP tractor could be profitably employed as a multipurpose machine. This could be supplemented with a 7.5 HP diesel engine for stationary farm operations when the optimal shifts in cropping pattern were geared to the objective of higher profits and the cropping intensity was also raised to 191.88 per cent.

Grewal and Kahlon (1972) studied the impact of mechanization in south-western districts of Punjab. Their results indicated that the cropping intensity on tractor farms was slightly lower than bullock operated farms.

Rao (1972) compared mechanized tractor farms with non-mechanized farms. He concluded that tractorisation enabled an increase in output by raising cropping intensity and yield per acre.

Motilal (1973) conducted his study in Alipur block of Delhi. The study revealed that the cropping intensity was significantly higher on tractor operated farms and it had inverse relationship with the farm size. It was also observed that tractorisation proved to be economically more efficient, only with the increased cropping intensity.

Lai *et al.* (1976) conducted a study on resource productivity in relation to farm mechanization. They divided the sample farmers into 3 groups viz.,

mechanized, partially mechanized and non-mechanized farms and compared them with respect to various aspects. Their results indicated that tractorisation has led to a positive impact (increased) on cropping intensity, realising 177.5 per cent, 162.23 per cent and 121.4 per cent of cropping intensity on mechanized, partially mechanized and non-mechanized farms, respectively.

Mettreck *et al.* (1976) reviewed NCAER's study conducted in U.P. They found that there was a strong correlation between cropping intensity and mechanization. Mechanization led to more and more crops on the same fields in one year, thus resulted in higher production per unit area per unit time.

Balister and Singh (1983) studied labour absorption in relation to use of farm technology in Bichpuri block of Agra district. Their results indicated that the cropping intensity and area under HYV were highest on mechanized farms and lowest on non-mechanized farms when compared to partially mechanized farms.

Reddy *et al.* (1984) selected three categories of farms to study the impact of mechanized irrigation. This revealed that cropping intensity under non-mechanized rainfed farms was about 100 per cent whereas it was 151.5 per cent and 156.5 per cent on partially mechanized and mechanized farms respectively.

Thomas and Kshirsagar (1985) studied the village impact of machine threshing and implications for technology development in the semi-arid tropics of Peninsular India. Their results indicated that machine threshing did not increase cropping intensity nor did it significantly reduce the costs compared to traditional methods.

Jayasuriya *et al.* (1986) conducted their study on mechanization and cropping intensification. The study revealed that multiple use of machine led to an increase in cropping intensities. This tends to lower the per season work requirements of break even and help to increase regional machine densities, which means the machine is used for other operations during the same periods as it is required for land preparation. This will tend to offset the contribution towards a shorter turn-around period. However, even under such circumstances empirical evidence shows that cropping intensity will not change considerably.

Rao and Raju (1987) conducted a case study on impact of farm technology on farm employment. The results indicated that through mechanization, irrigation facilities were extended and which led to additional employment through increased cropping intensity and operations intensity.

Nandal (1988) studied the impact of mechanization of Haryana agriculture. The results of the study indicated that tractorisation had almost neutral effect on cropping intensity, while tube wells/pumpsets had been found to contribute significantly to increased cropping intensity.

Balister *et al.* (1993) revealed in their study on the impact of mechanization that, average cropping intensity was highest in all the size groups of mechanized farms when compared to partially mechanized and non-mechanized farms. The study further revealed that there was a positive correlation between the level of mechanization and cropping intensity in Madhura district of Uttar Pradesh where the study was conducted.

Lingard *et al.* (1994) studied farm mechanization vs rural development in Philippines. They concluded that mechanization was not a significant determinant of cropping intensity. It is clear that farmers adopted mechanization to reduce costs by substituting for labour but the incentives that resulted were often from input price distortions as per the government policies.

From the above reviewed studies it can be summarised that mechanization had led to increase in cropping intensity and there was a strong correlation existing between them. However the studies of Thomas and Kshirsagar (1985), Nandal (1988) and Lingard *et a*l (1994) revealed that mechanization had no significant effect on cropping intensity.

2.2.2 Studies on impact of mechanization on employment and income

Iyengar (1949) discussed the importance of automatic pickup hay baler, the self propelled combine, the cotton picker and harvester-thresher in US agriculture. The results of the study revealed that pickup hay baler reduced the labour requirement to one pair of hands instead of the normal four pairs of hands. The mechanized cotton-picker would harvest as much cotton in a day, as it could be picked up by 40-50 hand pickers.

Sarkar and Prahladachar (1966) studied the employment pattern following tractorisation and its impact on farming. The results indicated that, on the whole there was a reduction of 17.2 per cent in human labour and 24.5 per cent in bullock labour on selected holdings. They opined that the farmers in the study area

might not be able to utilise their tractor capacity more fully for want of irrigation facilities and might, in consequence, be unable to raise two or more crops in a year.

Shah and Singh (1970) studied the impact of new agricultural technology in northern UP and the results indicated that, inspite of high cropping intensity and operated area, the number of permanent labour on tractor farms was lower than on the typical farms. A comparison between the typical and tractor farms showed that there was a decrease in employment due to mechanization. Impact of technology on labour use reflected through HYV, fertilizers and irrigation was positive and significant on large farms. Income has significant influence on labour employment on the typical farms per acre was more than that on the tractor farms revealing decrease in labour use due to mechanization.

Agarwal and Kumar (1972) studied the impact of mechanization on income and employment in Ludhiana district of Punjab. They concluded that the introduction of tractor and tubewell had resulted in the displacement of 24.9 per cent labour as compared to the existing level of employment.

Grewal and Kahlon (1972) studied the impact of mechanization by comparing the utilization of labour on bullock operated and tractor operated farms in south-western districts of Punjab. The results indicated that labour utilization on bullock farms compared to mechanized farms declined per unit area as the size of the bullock farms under comparison increased.

The results of the study conducted by Rao (1972) indicated that certain type of mechanization such as the use of farm tractors need not lead to

unemployment in regions of expanding agricultural output because they are used in response to genuine shortage and high cost of draught power. The tractors saved the resources allocated for maintaining of draught animals and enabled an increase in output by raising crop intensity and yield per acre. The raise in cropping intensity and yield per acre made possible by tractorisation, can lead to a net rise in farm employment. The study also showed that employment per acre among tractor farms was higher by about 7 per cent when compared to non-tractor farms. But unlike tractors, combine harvesters displace human labour mainly. Finally the study recommended that selective farm mechanization especially of the land augmenting type like tractorisation can substantially increase the overall employment potential.

Johl (1973) revealed that there was no substitution of machinery for human labour in Punjab even at aggregate level. The increase in total unemployment in the state was the result of natural population growth and migration from other states. The opportunity cost of the land used for growing fodder for live stock was very high in Punjab i.e. worth of Rs.595 million per year or 1.14 million tonnes of foodgrains. The problems associated with mechanization were average small size of the farms, only partial mechanization and existence of strong operational relationship of farm size with the minimum power unit available to the farmer.

The study conducted by Motilal (1973) revealed that the overall yields were higher on tractor farms as compared to bullock farms. Similarly the adoption of HYV also was higher on tractor farms. Tractorisation might lead to higher employment but it is only with the introduction of multiple cropping. It was

concluded that the tractor operated farms were economically more efficient than bullock operated farms especially in the case of medium and large farms.

Kahlon (1976) concluded that the gross output per hectare on bullock farms was lower than tractor farms in Punjab, since the tractor farms had more acreage under cash crops like sugarcane and potatoes than the bullock operated farms. The results of production function analysis indicated that the tractorisation led to an upward shift of the present function and had induced a significant increase in MVP. The employment of human labour declined on the tractor farms by 5-6 per cent.

Lai *et al.* (1976) revealed that the yield of the important crops showed a positive trend with mechanization i.e. maximum yield on the mechanized farms followed by partially mechanized farms. The study suggested that, this could be because of timely accomplishment of tillage operations, more number of irrigations and higher use of fertilization on mechanized farms. Timely accomplishment of tillage operations has not only helped in avoiding the adverse impact of date of sowing on physical production but also facilitated in increasing the per acre expenditure on manure, fertilizer and irrigation was found highest on mechanized farms. The MVP of land was quite high on all the three categories of farms and reflected an increasing trend with the level of mechanization.

ITES (1977) studied the percentage distribution of labour in each operation. It was found that among the major operations on mechanized farms, ploughing displaced maximum bullock and human labour. Mechanized manuring

displaced the lowest, while threshing comes in between manuring and transporting of produce.

Binswanger (1978) stressed that tractorisation of agriculture in the subcontinent did not proceed very far. It was confined to higher wage areas, such as the Punjab, or to the more prosperous coastal areas of Tamil Nadu and Andhra Pradesh. Tractorisation had further been largely confined to operations such as tillage and transport. In particular it had not yet been used for the most labour intensive operations such as transplanting or weed control and threshing. The potential mechanical and chemical, labour-savings innovations would ensure a highly elastic labour supply from agriculture and the wage rates in the subcontinent started to rise due to vigorous non-agricultural labour demand.

Philip and Stanley (1978) examined the benefits and costs that could be expected as a result of mechanizing the harvest of one of the most labour intensive crops in America, the flue-cured tobacco. The results indicated that the impact was most directly felt by seasonally hired work force especially younger people, who were largely displaced by mechanization.

Krishna (1982) studied the impact of farm mechanization on income and labour employment in Mangalagiri block of Guntur district of AP. The results indicated that the level of mechanization increased with the average size of holding. Human labour utilization was less on mechanized farms when compared to partial and non-mechanized farms. Bullock labour utilization was the maximum on partially mechanized farms. Labour displacement was observed on all the crops except

commercial crops. However at aggregate level mechanized farms employed more labour because of more commercial cropped area.

Agarwal (1983) found that the output benefits that might have been anticipated from the use of tractors in Punjab farms have not been realised in practice. Though tractors add to cropping intensity, the effect was insufficient to make any significant impact on farm yield. In contrast, tubewells were found to contribute to high wheat yield, and also higher labour demand. Threshers did not directly contribute to output increase and these were found to reduce the demand for labour. However they could help to release bullocks for early tillage on bullock-ploughed farms, which enables timeliness.

The study of Balister and Singh (1983) indicated that the cropping intensity, productivity and area under HYV was the highest on mechanized farms and lowest on non-mechanized farms. But labour absorption per hectare of cultivated area as well as cropped area was the lowest on mechanized farms and followed by partially mechanized farms. There was a considerable displacement of human labour on mechanized farms in preparatory tillage, planting, harvesting and threshing operations. This indicated the fear of displacing human labour on mechanized farms, however the partially mechanized farms had a favourable effect on human labour absorption.

Ahammed and Herdt (1984) in their study indicated that a change from hand to mechanical thresher or a substitution of power tiller and small thresher by tractor and large thresher that directs income from hired labour to other classes, gave negative consumption linkages in all water regimes. A comparison

across water regimes revealed that the decline in employment arising from mechanization could be alleviated by more intensive irrigation characterized by high productivity, income and equity. Consumption effects might reinforce the initial change in employment. The study further indicated that higher the level of mechanization, the greater was consumption effect on employment expansion from an improvement in irrigation.

ILO (1984) revealed that tractorisation as such did not result in any significant displacement of labour. Installation of pumpsets and tubewells created demand for more casual labour in place of permanent labour. But the acquisition of tractors created demand for more permanent labour.

Reddy *et al.* (1984) conducted a study on the impact of minor irrigation on productivity and employment in drought prone area. The results indicated that net farm income per cultivator was about Rs.4,250 under new-well and Rs.5,061 under new well-with-pumpset minor irrigation schemes, besides increasing net farm incomes it had also provided additional employment opportunities in the form of non-recurring employment.

Oshiro (1985) revealed from his study conducted on the mechanization of rice production in Japan that mechanization had reduced the labour requirements for the rice crop as well as shortened the labour demand period. The burden of rice production had shifted primarily to the younger family members and the heads of households because of the faster pace of machinery. However, the labour saved through the use of machinery was not being utilized on these farms, instead it had increased the number of persons working off-farm.

Thomas and Kshirsagar (1985) concluded from their study conducted in semi arid peninsular India that, the main beneficiaries of machine threshing were machine owners, particularly the first owner who was able to get profit from a strong demand for machine hiring without sharing output with other machines. All farmers in the sample studied could hire machines, but threshing was more widely used by farmers who produced more sorghum, planted more hybrids, cultivated more land, and had less draught power. Machine threshing did not increase cropping intensity nor did it significantly reduce the costs compared to traditional methods. Main losers were male hired labourers, who were displaced by machine threshing. The demand for improved threshing techniques would increase if investment in irrigation opened up more opportunities for multiple cropping.

Jayasuriya *et al.* (1986) opined that there was substantial evidence that farmers, even in the less developed countries, act to maximise expected profits in machinery acquisition decisions. When the number of machinery acquired by the farmers in a given area were small, the utility to have a significant effect on timeliness of operations and hence on output would be little or not significant.

Singh *et al.* (1986) stated that cultivators got more yield per acre on large fields by using tractor, whereas the yield per acre obtained by them was significantly higher than smaller fields, where bullock was used. On the other hand, the cost per acre incurred for tractor was higher when compared to that of bullock labour, indicating the use of tractor on small holdings was not economical and the use of bullock labour was not only economical but also employment oriented.

Basant (1987) concluded that the use of tractors in India was land augmenting because tractors in conjunction with new seed, helped to break the labour supply bottleneck during the period of land preparation for the new crop, which would follow the harvesting of previous crop. The problem of labour availability at the time of harvesting also disappeared with the widespread use of harvest-combines. But its cost in terms of labour displacement was significant. But the tractor effect was by and large seemed to be neutral.

NCAER (1987) found that, per hectare labour input on small farms was higher, 5.7 per cent at TTT (tubewell, tractor and thresher) level of mechanization than on non-mechanized farms. On the other hand labour input per hectare was less on medium farms at TTT level of mechanization than non-mechanized farms. A tendency of increase in hired human labour input with mechanization and also an increase in the ratio of permanent labourers to casual labour was observed and the value of crop output raised progressively with each level of mechanization.

Rao and Raju (1987) stated that the tractorisation had a negative effect on labour employment compared to bullock farms with varying degrees based on the type of crop, type of labour, farm size and nature of operation. Irrigation differentiated the size of employment and it has created additional employment through intensification of crops and operations thereby the labour displaced by tractorisation would be absorbed in various operations of multiple cropping.

Nandal (1988) conducted a study on mechanization of Haryana agriculture and his study showed that the use of family labour had declined on

tractor-owning farms and thereby family members spent more time on entrepreneurial and management activities. It was concluded that tractors had almost neutral effect on agricultural productivity and thereby the benefits that might have been anticipated from the use of tractors were not being realised due to considerable increase in number of tractors. On the other hand tubewells/pumpsets were found to contribute significantly to agricultural productivity and human labour employment.

Moorthy (1992) found that total employment days were significantly high for non-tractor-weedicide farm (NTWF) which was nearly 51 days higher than the other farms. Use of weedicide had significantly reduced the employment days than tractor. The cost of cultivation was significantly higher at 1 per cent level of probability on NTWF. There was no statistical or actual difference in the yield per hectare on both tractor with weedicide farm and non-tractor-weedicide farm, but the regression coefficient showed that the weedicide had some power to increase the income on the sugarcane farms.

Balister *et al.* (1993) studied the impact of mechanization on human labour and farm productivity. The results indicated that the net returns per hectare on mechanized farms were 38 per cent higher than the non-mechanized farms. It was concluded that the mechanization had reduced the human labour use on small and medium farms, while it had increased on large farms.

Singh and Tewari (1994) concluded from their empirical investigation conducted in Muraul block of Bihar that, tractor farms applied larger number of irrigations but used same level of human labour compared to similar size

bullock farms. Further tractorisation had a favourable effect on farm productivity and income.

Pariyar *et al.* (1995) stated that the low level of mechanization was one of the factors responsible for the low productivity in Nepal agriculture. Higher production and increased employment could be achieved through selective mechanization. In view of the diminishing feed sources and low productivity of draught animals, the agricultural sector has to go for other power sources like machinery operated by power and tractor. The study further indicated that the improved tools and machinery would be important in increasing existing output in Terai plains.

Thakur *et al.* (1995) conducted a study to establish determinants of agricultural labour use in Bihar and it indicated that cropping intensity and machine labour utilization were main determinants of human labour utilization in the project area. For every 10 per cent increase in machine labour utilization and cropping intensity, there would be an increase of 8.81 and 11.43 per cent of human labour utilization, respectively.

AERC (1996) revealed that the employment generation through animal carts for the same load was relatively more because of slow speed of the cart but the total annual employment generation through tractorisation worked out to 114 days in comparison to 226 days through animal carts. Environment friendliness of bullock-cart was another advantage. Despite all these favourable points, growth of animals/carts declined sharply, whereas that of tractors tremendously increased.

From the above studies it can be summarised that mechanization resulted into displacement of labour in most of the studies. However studies of Johl (1973) and NCAER (1973) indicated neutral effect of mechanization on labour employment. While Pariyar *et al* (1991) and Thakur *et al* (1995) concluded that increased employment can be achieved through selective mechanization.

2.3 Studies on demand estimation for farm machinery

Rayner and Cowling (1968) reviewed and compared econometric studies conducted in US and UK on demand for farm tractors. All these studies used a single equation regression analysis of annual time series data. It was shown that HP per farm rose from 12 HP in 1947 to 42 HP per farm in 1962. It was also found that the price ratio of tractors to crops was significant whereas tractor to labour was not. In contrast to that, another study found the price ratio of tractor to labour and tractor to crops were important explanatory variables. The stock demand function presented in both the studies made the apriori assumption that the adjustment model was of the form $(S_t / S_{t-1}) = g(S_t^*/S_{t-1})$ where S_t^* desired stock level, g is adjustment coefficient.

Sisodia (1973) analysed the trends in farm mechanization in Madhya Pradesh, for the period 1956-57 to 1969-70. His results indicated that there had been a substantial increase in the number of all the three types of machinery viz., tractors, oil engines and electric pumps, but their spread was still restricted to a few districts of the state.

NCAER (1983) reported that an average tractorised farm possessed about 34.5 acres of land and had 88 per cent of the area under assured irrigation. It was expected that there would be an appreciable change in the tractor market both in extent and quality. The demand for tractor services would increase the demand for tractors to provide custom service. The demand for owner use was likely to decline appreciably in the future.

The study of Singh and Singh (1983) revealed that labour density, rural literacy percentage and per cent net irrigated area had influenced tractorisation significantly, while estimating demand for tractors in Punjab, agricultural productivity and labour force were the more crucial variables. The effect of tractor price and irrigation was rather low. The annual absorption of tractor would lie in the range of 10,000 to 16,000 tractors, which is quite comparable with the growth in labour force and agricultural productivity.

Singh and Singh (1993) found that the tractorisation of Indian agriculture had increased from the insignificant figure of 8,000 in 1950's to an impressive figure of more than one million by 1989. Tractor density had been the highest in Punjab. The demand built up for tractor was particularly because of the replacement demand, which was increased due to increase in number of tractors over time. The estimated annual demand figure for tractors indicated that it would be more than 25,000 but the structural changes that were going to take place in the agriculture sector in the wake of new economic policy would have its own bearing in increasing the demand for tractors.

Review of the available literature indicated that almost all the studies estimated the demand for tractors and the projections indicated that there would be an increase in demand for tractors in future due to increase in tractor services. Singh and Singh (1983) revealed that labour density, per cent net area irrigated and rural literacy were significantly influencing the tractorisation in the study area.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The study was taken up to analyze the economics of farm mechanization in coastal Andhra Pradesh. This chapter deals with the detailed sampling procedure, nature and mode of data collection and also analytical tools employed to achieve the set objectives of the study. Different concepts and methods followed in the course of study are also outlined.

3.1 Sampling design

The use of machinery in various farm operations has been increasing rapidly in recent years in Andhra Pradesh and it was observed more prominently in coastal districts, where paddy occupies majority of the cropped area. When the stocks of important farm machinery like tractors, power tillers, irrigation and plant protection equipment, harvest combines etc., were considered, West Godavari, Nellore and Prakasam districts stood at first, second and third places respectively. Hence these three districts were selected for the study. A multistage random sampling was followed for the selection of ultimate sample.

Data on different aspects such as operational holdings, demographic features, land use pattern, cropping pattern, irrigation, climate, soils and literacy levels were required in order to provide the background information with regard to structural organization of the sample farms.

Data relating to physical inputs such as human labour, both family and hired labour, inventory of land, implements and machinery, seed, manure and fertilizer costs, plant protection etc., were required to assess the income and employment levels of the farmers. The price of tractors, power tillers, pump sets, plant protection equipment etc., were required to project the demand for farm machinery. Prices of output including the harvest prices of the crop products and by-products were essential for computing the gross farm income.

A three stage random sampling was followed to get the ultimate sample of 240 operational holdings or farmers.

3.2 Selection of mandals and villages

The list of mandals where both mechanized and non-mechanized farms available, was prepared from Chief Planning Office (CPO) of each district. From the list, two mandals were selected at random from each of the selected district.

In order to select the villages also the list was prepared by the same procedure. A list of villages was obtained from the mandal statistical offices of selected mandals, and from the list two villages were randomly selected from each mandal. Finally, a total of twelve villages were selected from the three districts.

3.3 Selection of sample farms

The ultimate sampling unit was farm holding, which is the area consisting of all land operated either by a single cultivator alone or with the assistance of others.

The list of farmers both mechanized and non-mechanized was prepared for each selected village. From the list a sample of 20 farms both mechanized and non-mechanized from each village were selected randomly making a total of 240 farms from the three districts. Thus three districts, six mandals and twelve villages and 240 farmers formed the material for the study.

For assessing the impact of mechanization, factors determining mechanization and to study the human labour employment with respect to various farm operations, all the selected farms were grouped into two categories viz., mechanized and non-mechanized. The grouping was made mainly based on the use of machinery in various farm operations such as ploughing, transplanting, irrigation, harvesting etc.,

Keeping in view the extent of mechanization in various farm operations and area under crops, only Paddy crop was considered for the study. As it was presented in the Chapter IV " Ago-economic features" paddy crop occupies the majority of the cropped area in the selected districts. It was also observed that mechanization is more prominent on this crop. For the other crops the mechanization was very much limited and in a few crops, it was extended to operations such as ploughing and irrigation. However those crops were not grown in a considerable area on all the three districts. Hence for the sake of uniformity of the sample, to facilitate the comparison of both the categories of farms, operation wise only paddy farms were selected.

3.4 Sources of data

3.4.1 Primary data

The data pertaining to the selected farms, on the structure of the farms, physical inputs and output of crops and their respective prices were obtained through survey method and the data were collected with the help of well-structured and pre-tested schedules.

3.4.2 Secondary data

Data regarding districts, mandals and villages were collected from the District Planning Office, Mandal Revenue (Statistical) Office and Village Extension Office respectively. Other secondary data pertaining to stock of machinery, net area sown, area irrigated, prices of machinery etc., were collected from various sources like Bureau/ Directorate of Economics and Statistics and Directorate of Agriculture.

3.5 Analytical framework

In the present study, a combination of analytical tools such as conventional analysis, discriminatory analysis and functional analysis was used to achieve the set objectives of the study.

3.5.1 Conventional analysis

Averages and percentages were worked out through measures of central tendency, variability and ratios. The averages and percentages worked out were pertaining to basic characteristics of the selected farm holdings, cropping intensity, production, productivity, income and costs and extent of mechanization.

3.5.2 Test statistic used: 'Z' test

The averages obtained through conventional analysis were tested to know the difference between the two different populations, mechanized and non-mechanized farms, by using the 'Z' test. Two independent samples of size n_1 and n_2 (sufficiently large) were drawn from these populations with variance s_1^2 and s_2^2 respectively.

The null hypothesis to be tested is:

Ho: $\mu_1 = \mu_2$

Where, μ_1 and μ_2 are the means of the two populations.

Based on the sample observations the test criterion is defined as

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Where,

$\bar{X}_1$ and $\bar{X}_2$ are first and second sample means respectively.
n_1 and n_2 are sample sizes
s_1^2 and s_2^2 are the sample variances.

The criterion has Standard Normal Distribution. If Z (cal) $\geq$ Z (tab) value, the null hypothesis is rejected implying that there is significant difference between the means of the two populations. Z (tab) value = 1.96 at 5 % level of significance.

3.5.3 Discriminatory analysis

Discriminatory analysis is carried out for setting up a rule or criterion which can classify an observation vector into one of the two or several populations.

In the present study, there are two populations i.e. mechanized and non-mechanized farms. The criterion for discriminating is referred as discriminatory function Z. It is obtained on the basis of sample data recorded from the two populations as follows:

The discriminatory function Z is defined as

$$Z = \bar{X}^{1} L$$

Where X = Observation Vector consisting of 'p' variables
L = Vector of coefficients

Fisher, developed the discriminant function and is known as linear discriminant function. It is commonly used. This function unlike the other functions is robust in classification i.e., the procedure classifies the observations with relatively minimum of miss classification errors, even if the populations do not have normal distribution.

The vector of coefficients 'L' is obtained as follows:

$$L = S^{-1}d$$

Where S = Pooled covariance matrix of the two samples

$d = (\bar{X}_1 - \bar{X}_2)$, the vector of mean differences

The criterion for classification: The observation vector 'X' is classified to population 1 (mechanized farms) if $Z \geq \bar{Z}$, otherwise it is classified as belonging to Population 2 (non-mechanized farms).

Where $\bar{Z} = (\bar{Z}_1 + \bar{Z}_2)/2$

and $\bar{Z}_1 = \bar{X}_1^{1} L$

$\bar{Z}_2 = \bar{X}_2^{1} L$

The effectiveness of discrimination criterion i.e., Z depends on whether the two populations are distinct. For this purpose, we test the null hypothesis $\mu_1 = \mu_2$. The hypothesis can also be verified by using Mahalanobis D^2 statistic with the help of F test

$$F = \frac{n_1 n_2 (n_1 + n_2 - p - 1)}{(n_1 + n_2)(n_1 + n_2 - 2)} D^2$$

Where p = no. of variables

n_1 = No. of individuals in first group

n_2 = No. of individuals in second group

$D^2 = (\bar{X}_1 - \bar{X}_2)^{1} S^{-1} (\bar{X}_1 - \bar{X}_2)$

S = Pooled covariance matrix of the two samples

The criterion F has F distribution F with p and $(n_1 + n_2 - p - 1)$ degrees of freedom.

The null hypothesis is rejected when calculated F value is greater than or equal to F table value, which implies that the two populations are distinct.

The relative importance of discriminators can be obtained from the coefficient vector L. Corresponding to any variable, Li is the weightage of the Xi in discrimination. Hence the product 'di x Li' gives the distance of i^{th} variable in discriminating the two populations. Thus the percentage contribution of Xi in discrimination can be obtained from (Lidi)x100/ D^2 ($D^2 = \sum_{i=1}^{n} L_i d_i$).

In the present study, the observation vector consisted of the following ten variables

X_1 = Age of the farmer

X_2 = Farm size

X_3 = Area Irrigated

X_4 = Permanent labour

X_5 = Cropping Intensity

X_6 = Total Casual labour (MDs)

X_7 = Total Wages paid

X_8 = Productivity

X_9 = Income

X_{10} = Educational Status

The samples drawn from the two populations i.e. mechanized and non-mechanized farms were of size 40 each from each district.

3.6 Functional analysis

The functional analysis was used as an analytical tool, for establishing a relationship between farm machinery and various factors considered and to project the demand for various farm machinery, based on that relationship in the selected districts. The function was fitted between the farm machinery (in terms of density), as dependent variable and various explanatory variables such as agricultural productivity, long term credit, area irrigated as a percentage to net area sown. In order to study the changing significance of different factors that are considered determining mechanization over time, the functional analysis was carried out for a period of twelve years i.e. from 1981 to 1992. Owing to the non-

availability of machinery stocks it was not possible to extend the study after 1992. Two types of functions viz., Linear and semi-log regression analyses were tried and between the two the semi-log model gave the best fit. Hence the semi-log model was used for projecting the demand and to determine the factors influencing mechanization. The models were as given below

$X_5 = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \in$

$\ln X_5 = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \in$

Where b_1, b_2, b_3, b_4, are the regression coefficients corresponding to variables x_1, x_2, x_3, x_4 and x_6.

a is intercept

$\in$ is residual term.

Specification of variables was as follows:

X_1: Agricultural productivity, the average productivity of important crops grown in the district.

X_2: Price of machinery, a relative price of machinery was taken. That means price of each machinery related to a particular model and company over a period was considered as its relative price.

X_3: Long term credit, the long term credit was taken as percentage.

X_4: Irrigated area, the availability of irrigation is one of the important factors, which helps in the adoption of machinery in any area. Thus the irrigated area was expressed as percentage of net area sown in each district.

X_5: Density of farm machinery expressed as number of machines per thousand hectares of net area sown

3.6.1 Test for regression coefficients

Regression coefficients were tested for their significance. For that the null hypothesis (Ho), $\beta i = 0$ was tested against the alternative that $\beta i \neq 0$. The Test statistic for testing the hypothesis is:

$$t = \frac{bi}{S.E(bi)}$$

Where bi is the regression coefficient of i^{th} variable.

When t calculated value is greater than t table value then that particular coefficient is considered to be statistically significant and the corresponding explanatory variable can be concluded as a significant contributing factor for the changes in the dependent variable.

3.7 TERMS AND CONCEPTS USED

Operational holding: Total land cultivated by the farmer, that includes both owned and leased in.

Farm assets: They include land, farm buildings, wells, live stock, farm machinery and implements etc.,

Net Area Sown: It is the actual area under cultivation in an agricultural year.

Cropping Intensity: It is the ratio between gross cropped area to net area sown and is expressed in per cent terms.

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

Gross cropped area: It is the combined area of net area sown plus area sown more than once.

Manday: It is the work accomplished by a normal healthy human being in a day of 8 hours.

Cattle pair day: It refers to the work turned out by a pair of cattle along with the human labour in a day of 8 hours.

Cost of operation: This is the total of costs incurred to carry out an operation either on human labour or cattle or machine labour, which ever is involved.

Productivity: It is the ratio between total production and total area and it is expressed as production per unit area.

Gross income: This is the total value of main and by-products, produced on the farm during an agricultural year valued at market price.

Net income: It is the gross income over costs. This is the surplus over and above total costs.

Tillage machinery: Machinery used for preparatory cultivation, tractor, power tiller etc.,

Irrigation equipment: Machinery used for irrigating fields and they include machinery like oil engines, electric motors etc.,

Harvesting machinery: Machinery involved in harvesting includes various harvesters operated by hand to power. Harvest combines, multi crop harvesters etc.,

Plant protection equipment: Machinery used for application of plant protection chemicals. They have a wide range from hand operated to power and tractor operated.

3.8 METHODS OF COMPUTATION OF COST COMPONENTS

Human labour: It is imputed at the wage rate prevailing for the casual labour in the village. In case of permanent labour, payment made in kind are evaluated at the prevailing market rates and added to the cash payment. In case of casual labour the actual wage paid is taken into consideration. A manday of 8 hours is used as the basis to calculate the labour wages.

Cattle labour: Prevailing cattle labour wages for a 8 hour day was taken into account in computing cattle labour cost.

Tractor power: Generally payment for tractor power is made on hourly basis. Hence total number of tractor hours used was multiplied with hourly wage rate, to arrive at total cost incurred towards power. When tractor was used in transportation of products, payments were made on the basis of distance at the prevailing market rates.

Seed: The seed whether it is on-farm produced or purchased is evaluated on the basis of the prevailing local market rates.

Manures and fertilizers: Farm yard manure produced on farm is charged at the prevailing market costs. Chemical fertilizers and other manures purchased are charged at the rates they actually paid.

Plant protection chemicals: The original costs paid by the farmers for the plant protection chemicals are recorded.

Irrigation: These are paid based on the slab rates according to the horsepower of the pumpsets the farmer have. These charges are apportioned based on acreage of different crops under a particular motor. However in case of canal irrigated area the charges are paid in the form of cess to village panchayats along with land revenue.

Transportation: The costs incurred on transportation of the produce from farm to household or market and inputs from market to farm are the transportation charges. It varies according to the distance and mode of transportation.

AGRO-ECONOMIC FEATURES

CHAPTER IV

AGRO-ECONOMIC FEATURES

This chapter deals with brief explanation of agro-economic features of the study area like physiography, demography, climate and irrigation facilities etc. It also deals with socio-economic features viz., land holding distribution, cropping pattern, occupational distribution of the people, availability of farm machinery and implements etc. This will provide the necessary background for proper understanding and structuring of the problem and also for discussing the results of the study.

4.1. WEST GODAVARI DISTRICT

West Godavari is a premier coastal district of Andhra Pradesh, ranks first in agricultural production accounting for 11 per cent in area and 14.6 per cent in production of rice. The total area of the district is 7,780 square kilometers covering 46 mandals, of which 22 are in delta area. The delta is generally flat terrain, comprising the contour range 0^{1}-30^{1} above mean sea level. The soils are richly fertile, alluvial, black regur and red ferruginous besides a small belt of archeteous sandy soils along coastal belt.

4.1.1 Physiography of the district

West Godavari lies on the West of Godavari, which runs through the whole length of the district. The district is bound by Khammam district on the north and west, by Krishna district and Bay of Bengal on the south, by river Godavari on the east. It is situated between $16^{o}15^{1}$ and $17^{o}30^{1}$ of Northern latitude and $80^{o}55^{1}$ of Eastern longitude.

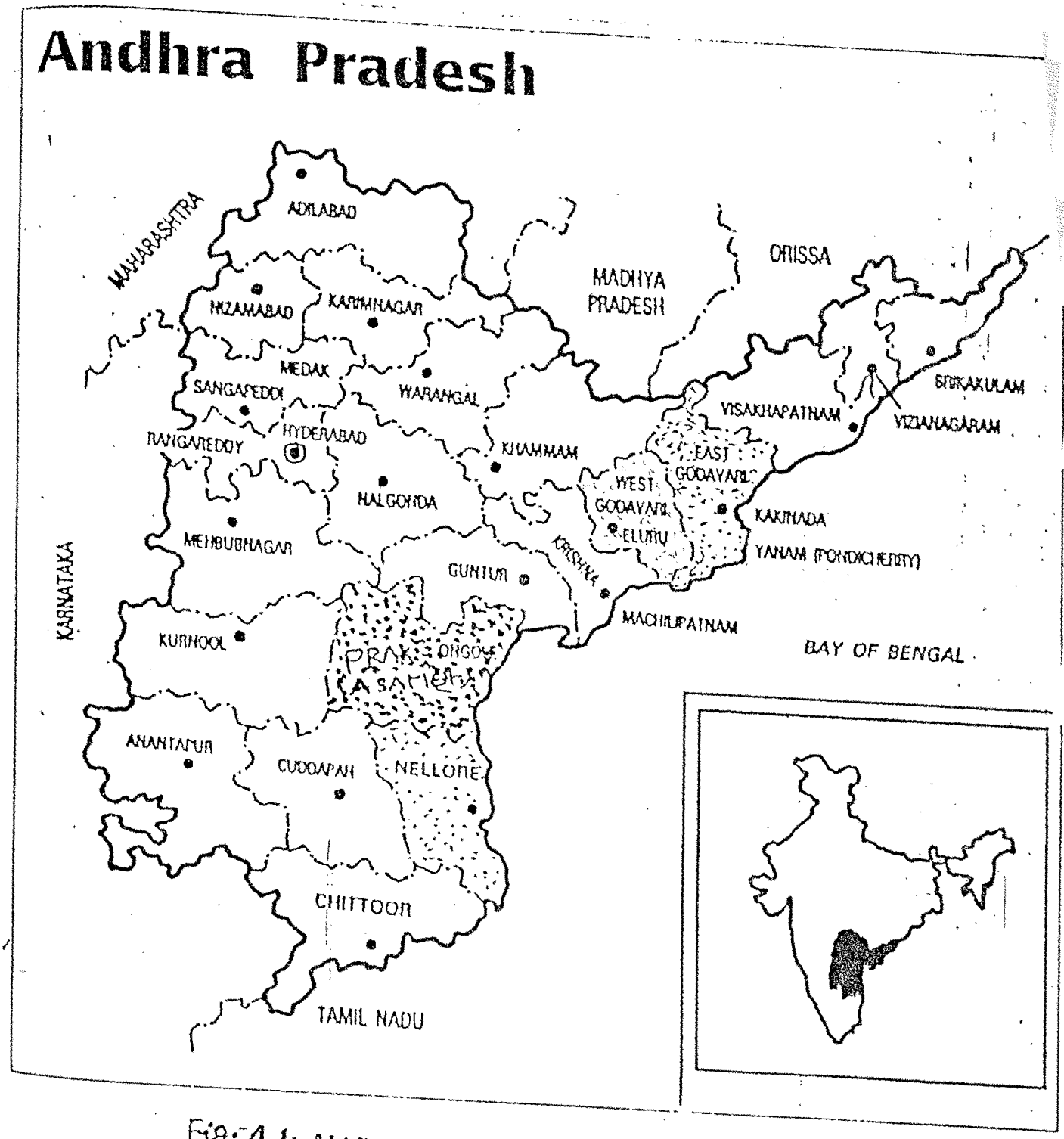


Fig: 4.1: MAP OF ANDHRA PRADESH

4.1.2 Demographic features

Table 4.1 Demographic features of West Godavari district (1991 Census)

	Particulars	Population	Per cent
1	Total population	35,19,051	100.00
	Males	17,64,754	50.14
	Females	17,54,594	49.86
2	Literates	15,99,459	100.00
	Males	8,94,497	55.92
	Females	7,04,962	44.08
3	Total workers	14,61,086	100.00
	Cultivators	2,19,893	15.05
	Agril. labour	8,05,935	55.16
	Others	4,35,258	29.79

Source: Hand book of district statistics 1998, Chief Planning Office (CPO), West Godavari

The demographic features of the West Godavari district are presented in Table 4.1. As per the 1991 census, the district has 856 inhabited villages, 35 un-inhabited villages and 10 towns. Out of the 10 towns, 8 are municipalities and the rest are panchayats. The population of the district is 35.19 lakhs and forms 5.29 per cent of the population of the state. Out of the total population rural population accounted for 27.89 lakhs (79.26%) and urban population accounted for 7.3 lakhs (20.74%). The population density of this district is 452 per sq.km. The total population consisted of 17.64 lakhs (50.14%) males and 17.55 lakhs (49.86%) females. The sex ratio is 994 females for 1000 males. With regards to literacy rate, out of 15.99 lakh literates 8.94 lakh (55.92%) are males and 7.05 lakhs (44.08%) are females.

4.1.3 Climate and Rainfall

The climatic conditions of the district come to an extreme type under tropical zone with high to very high temperature in summer to an extent of 48°C and fairly cool climates towards hilly areas of Polavaram and adjoining parts of Bay of Bengal in southern part of the district.

Table 4.2 Season-wise rainfall in West Godavari district

S. No	Season	Normal (mm)	Actual (mm)	Per cent
1	South-West monsoon	738.8	662.4	76.67
2	North-East monsoon	260.6	165.9	19.20
3	Winter season	10.4	12.9	1.49
4	Hot weather period	66.4	22.8	2.64
	Total rainfall	1076.2	864.0	100.00

Source: Hand book of district statistics 1998, CPO, West Godavari

Rainfall: The normal rainfall of the district is 1076.2 mm, of which the south west monsoon contributes to an extent of 76.67 per cent and North-East monsoon 19.20 per cent, besides winter and hot weather period together contributed 4.13 per cent. The rainfall recorded during 1997-98 was 864.00 mm. The pre-monsoon rains in the month of May and June facilitate sowings of various rainfed crops in upland areas and normal peak monsoon rains in July and August complete the transplantation of paddy and hasten-up the growth of the monsoon crops. However, the district is normally prone to constant threat of cyclones and severe dry spells making the crop yield prospects critical.

4.1.4 Seasons and crops

There are two important seasons in the district i.e. kharif and rabi. Kharif starts from June, with the onset of South-West monsoon and ends by September or October. Rabi extends from October-November to March. To some extent, in areas where assured irrigation facilities are available summer crops are also grown.

Table 4.3 Area covered under principal crops in West Godavari district

S. No.	Crop	Kharif (ha)	Rabi (ha)	Total (ha)	Per cent to total
1	Paddy	2,48,147	1,91,230	439377	79.90
2	Jowar	177	307	484	0.08
3	Maize	860	10,560	11420	2.08
4	Redgram	487	--	487	0.09
5	Greengram	132	5,569	5701	1.03
6	Blackgram	226	6,802	7028	1.27
7	Horsegram	39	1,318	1357	0.25
8	Other pulses	105	1,063	1168	0.21
9	Chillies	313	5,223	5536	1.00
10	Sugarcane	27,833	--	27833	5.06
11	Groundnut	624	4,996	5620	1.02
12	Sesamum	--	857	857	0.15
13	Cotton	2,669	--	2669	0.48
14	Banana	4,945	--	4945	0.89
15	Vegetables	2,124	1,926	4050	0.74
16	Tobacco	--	30,446	30446	0.53
17	Sunflower	--	923	923	0.17
	Total			549901	100

Source: Hand Book of District Statistics 1998, CPO, West Godavari

Most important crop grown in the district is paddy, which occupies an area of 2,68,147 hectares in kharif and 1,91,230 ha in rabi season and together it covers about 80 per cent of the total cropped area. Other principal crops grown in the district are pulses, maize, tobacco and sugarcane etc.,

4.1.5 Farm machinery and implements in the district

Use of improved farm machinery to carry out various agricultural operations is getting popularised in the district. Tractor has almost replaced the bullock labour in the delta region and now it is being used increasingly not only for preparatory cultivation but also for threshing and transportation operations. In addition to the tractors and power tillers, other machinery like harvest combines, oil engines and pump sets are also been in extensive use.

Table 4.4 Important farm machinery in West Godavari district

S. No	Machinery	Stock (Number)	Per cent
1	Tractors	5502	4.9606
2	Power tillers	248	0.223597
3	Oil engines	6376	5.748598
4	Electric motors	35655	32.14653
5	Plant protection Equipment	18892	17.03302
6	Harvesters	495	0.446292
7	Wooden Ploughs	37711	34.00022
8	MB Ploughs	3343	3.014047
9	Disc harrows	2499	2.253097
10	Seed-cum-Fertilizer drills	193	0.174009
	Total	110914	100

Source: Statistical Abstract (1993).

From Table 4.4 it is perceptible that there are 5502 tractors in the district, which is the highest of all districts in the state. Major contribution of total machinery was from electric motors (32.15 %), ploughs (34.45 %) and plant protection

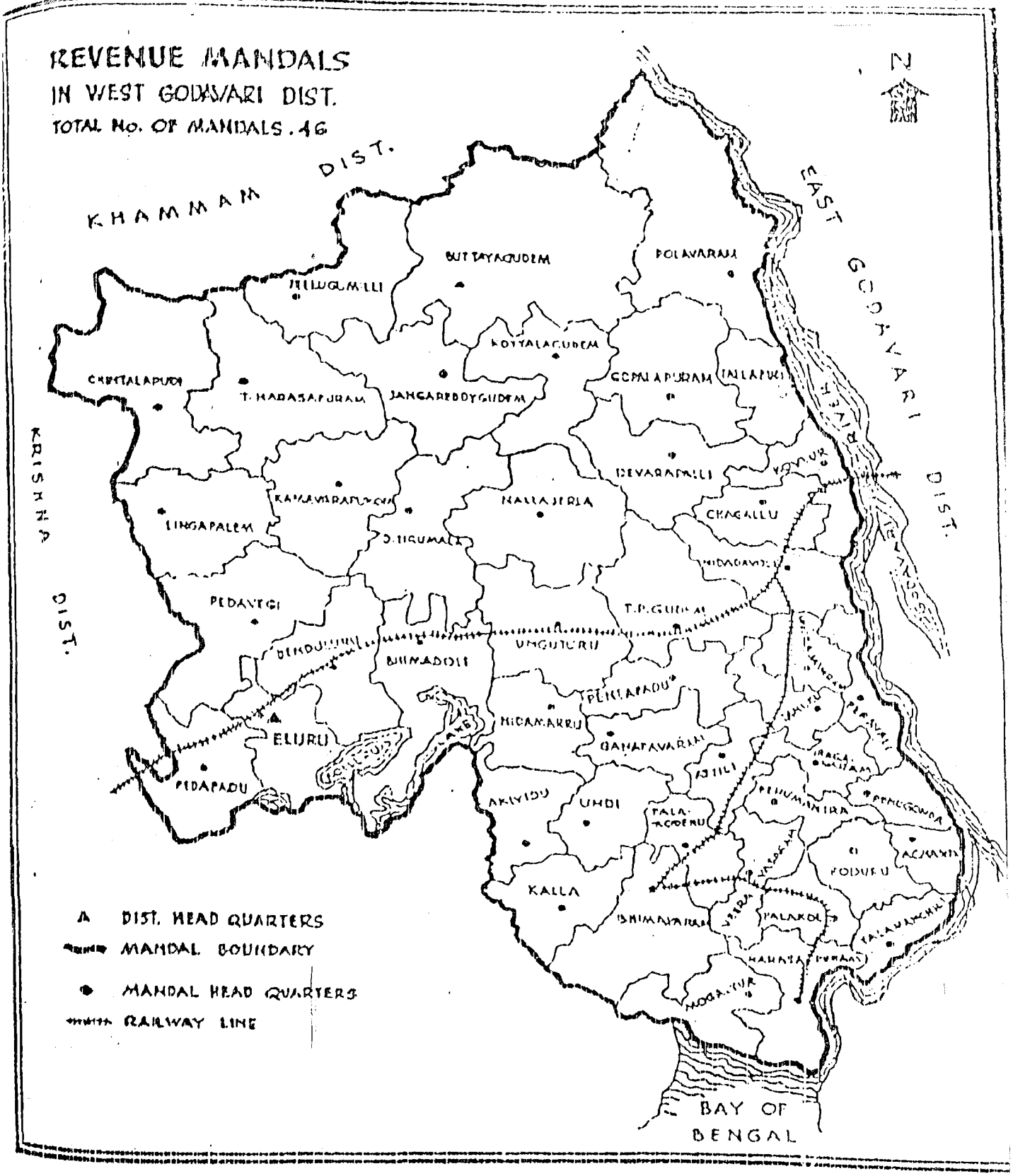


fig: 4.2 MAP OF WEST GODAVARI DISTRICT

equipment (17.03 %). The district also had a considerable number (495) of harvesters. The repairing facilities available in the district are not adequate. Only at Eluru and Tadepalli Gudem the repairing centres and workshops are available.

4.1.6 Irrigation facilities in the district

The total area under irrigation in this district is 3,71,100 hectares. Godavari and Krishna delta systems together cover 2,33,740 hectares and the remaining irrigated area is covered by other medium and minor irrigation sources.

Table 4.5 Sources of Irrigation in West Godavari district

	Particulars	Area (ha)	Per cent
A.	Major	2,33,740	62.99
1.	Godavari delta	2,10,268	56.66
2.	Krishna Delta	23,472	6.33
B.	Medium	8,350	2.25
1.	Tammileru reservoir	5,100	1.37
2.	Yerra Kalva Irrigation system	3,250	0.88
C.	Minor irrigation sources	1,24,142	33.45
1.	Tanks	48,127	12.97
2.	Borewells and tube wells, filter points	76,015	20.48
D.	Lift irrigation projects (4)	8,118	2.19
	Total	3,71,100	100.00

Source: Hand book of district statistics 1997-98, CPO, West Godavari

4.1.7 Land utilization pattern of the district

The particulars of the land utilization are given in Table 4.6. The total geographical area of the district is 7.79 lakh ha. The net area sown in the district is 4.10 lakh hectares, which constitutes 52 per cent of the total geographical area. The district has only 10 percent (0.81 lakh ha) of its area under forests. The land under

cultivable wastes and barren and uncultivable lands is 5.78 per cent and 2.84 per cent respectively. This indicates that, most of the area is being utilized for agricultural purposes. But land put to non-agricultural purposes, accounts for 15.64 per cent, occupying next place to net area sown. The area under miscellaneous tree crops is negligible and some of the barren land could be used for growing trees. The area under current and other fallows is only 2.938 and 5.080 per cent respectively of the total geographical area. The area under permanent pastures and grazing lands is only 0.29 lakh ha, constituting 3.69 per cent of the total geographical area. The increased pressure on land for growing food crops could be considered as the factor responsible for such low proportion of area under this category.

Table 4.6 Land utilization pattern in West Godavari district

	Particulars	Area (ha)	Per cent
1	Geographical area	7,79,564	100.00
2	Forests	81,188	10.415
3	Barren and uncultivable land	45,033	5.776
4	Land put to non-agril. use	1,21,945	15.643
5	Cultivable waste	22,158	2.842
6	Miscellaneous tree crops	7,383	0.947
7	Permanent pastures and grazing lands	28,816	3.696
8	Current fallows	39,609	5.080
9	Other fallows	22,916	2.938
10	Net area sown	4,10,513	52.659

Source: Hand book of district statistics 1997-98, CPO, West Godavari

4.1.8 Soils of the district

Red sandy loams dominated the soils of the district comprising 35.05 per cent, followed by clay loams, covering 22.89 per cent. Other soils prevalent in the

district are alluvial and to some extent sandy soils, which fringes along the coast. Alluvial soils are considered to be more fertile followed by clay loams. The major types of soils existing in the district are furnished in Table 4.7. Red sandy loams and clay loams together occupied more than 50 per cent of soils in the district, which is followed by alluvial and sandy soils. The problematic soils like saline soils are negligible.

Table 4.7 Types of soils in West Godavari district

	Type of soil	Per cent
1.	Red sandy loams	35.05
2.	Clay loams	22.89
3.	Alluvial	14.00
4.	Sandy soils	12.58
5.	Deltaic alluvial	9.93
6.	Coastal sandy loams	3.14
7.	Heavy clays	1.98
8.	Saline soils	0.43
	Total	100.00

Source: Hand book of district statistics 1997-98, CPO, West Godavari

4.1.9 Agro-economic features of selected mandals

Two mandals, Bhimadolu and Nallajerla, were selected from West Godavari district for the study.

4.1.9a Bhimadolu mandal

Total geographical area of the mandal is 53,503 hectares. It is bound by Dwaraka Tirumala mandal on the north, by Eluru on the west, by Kaikaluru on the south and by Tadepalligudem and Nidamarru on the east.

As per the 1991 census total population of the mandal was 57,152. Out of which 28,658 males (50.14%) and 28,496 are females (49.86%). The SC and ST population in the mandal was 10,853. Of all the workers (24,419) in the mandal, 8,701 were cultivators (35.63%) and 15,718 were agricultural labour (64.37%). The mandal has 49.28 per cent literacy.

The mandal has a normal rainfall of 928.25 mm. The main sources of irrigation in the mandal are tube wells and canals. Out of the total irrigated area, the area covered under canal was 6438 hectares and tube wells was 4,921 hectares.

4.1.9a.1 Land utilization pattern of the mandal

Mandal has 46,647 hectares of total geographical area as presented in Table 4.9. The area under forests and permanent pastures was nill in the district. The net area sown in the mandal was 52.57 per cent of total area. However 4,700 hectares (10.08%) of cultivable wastes indicate the possibility of increasing net area sown in the mandal, if there is sufficient effort to bring them under cultivation.

4.1.9a.2 Soils of the mandal

Various types of soils are seen in this mandal. Most of the soils are loamy with a pH of 7 to 8. These soils are richly fertile and highly suitable for paddy cultivation. The area under different soils is given in Table 4.8. Among all categories sandy and clay loams occupied larger areas, 42.62 per cent and 21.17 per cent respectively. Proportion of alluvial soils was only 12.68 per cent.

4.1.9a.3 Cropping pattern

An overall view of cropping pattern revealed that more than 75 per cent of the total cropped area was occupied by paddy followed by pulses and sugarcane. The other crops grown in this mandal are in a very negligible area.

Table 4.8 Soil types of the selected mandals of West Godavari district

Soil type	Bhimadolu (%)	Nallajerla (%)
Sandy loams	42.62	38.76
Clay loams	21.17	23.43
Alluvial	12.68	13.61
Sandy soils	2.23	1.75
Heavy clays	1.74	3.46
Others	19.57	18.99

Source: Mandal Abstracts 1997-98, Mandal Development Office (MDO), Bhimadolu and Nallajerla mandals

4.1.9b Nallajerla Mandal

The total geographical area of the mandal is 58,001 hectares. It is bound by Koyyalagudem on the north, Devarapalli and Tadepalligudem on the east, Unguturu mandal on the south and Dwaraka Tirumala mandal on the west.

As per 1991 census total population of the mandal is 67,379 out of which 33,849 males (50.24 %) and 33,530 females (49.76%). Total number of workers in the mandal is 30,833. Among them cultivators are 5,932 (19.24%) and agricultural labourers(30.93%) are 9,536. The per cent of literacy in the mandal is 45.68.

Nallajerla mandal has a normal rainfall of 950.25 mm. The main sources of irrigation in the mandal are canals and tube wells. The total area irrigated is

7,291 hectares, out of which 4,380 hectares are irrigated under canals and the remaining area is under tube wells.

Table 4. 9 Land utilization pattern in the selected mandals of West Godavari

S. No	Particulars	Bhimadolu	Per cent	Nallajerla	Per cent
1	Total geographical area	46,647	100.00	58,001	100.00
2	Forests	--	--	5,370	9.26
3	Barren and uncultivable land	8,696	18.64	976	1.68
4	Land put to non-agril. use	4,161	8.92	7,252	12.50
5	Miscellaneous tree crops	--	--	1,217	2.10
6	Permanent pastures and grazing lands	--	--	--	--
7	Cultivable wastes	4,700	10.08	36	0.06
8	Current fallows	2,095	4.49	30	0.05
9	Other fallows	2,474	5.30	10,255	17.68
10	Net area sown	24,521	52.57	32,865	56.66

Source: Mandal Abstracts 1997-98, MDO, Bhimadolu and Nallajerla mandals

4.1.9b.1 Land utilization pattern of the mandal

Nallajerla mandal has (32,865 ha) 56.66 per cent of its total area (58,001ha) as net area sown. From table 4.9 it can be perceptible that the area under forests in the mandal is 5370 hectares (9.26 %). This indicates that there is a considerable area under forests. Area under cultivable wastes and current fallows is only 0.1 per cent. Hence the scope for further increase in net area sown is less.

4.1.9b.2 Soils of Nallajerla mandal

The types of soils in the selected mandals are presented in Table 4.8. It is observed that 52 per cent of the total soils in the mandal are sandy and clay loams, which are fertile and well suited for paddy and sugarcane cultivation. Further alluvial soils occupied 13 per cent of the total area. Sandy soils are of negligible extent in the mandal.

4.1.9b.3 Cropping pattern of the mandal

Important crops grown in the mandal are paddy, sugarcane, coconut, pulses, vegetables etc. The area under paddy occupies first place with more than 60 per cent of total cropped area, followed by sugarcane, coconut and pulses.

4.1.10 Agro-economic features of villages

Four villages selected from the two mandals of West Godavari district. The two villages were selected from Nallajerla mandal are Prakasaraopalem and Nallajerla and the other two villages, Pulla and Polasanipalli, are from Bhimadolu mandal. All the four villages are provided with weather motorable roads connecting nearby urban areas.

In all the four villages, major sources of irrigation are canals and wells. Paddy occupies most of the cropped area in all the selected villages followed by pulses and sugarcane. The land utilization pattern of the selected villages is given in Table 4.10.

Table 4.10 Land utilization pattern of selected villages in West Godavari

S. No.	Particulars	Bhimadolu (ha)		Nallajerla (ha)	
		Pulla	Polasani palli	Prakasa Raopalem	Nallajerla
1	Total geographical area	8,885 (100)	2,179 (100)	2,875 (100)	9,795 (100)
2	Forests	--	--	--	2,685 (27.41)
3	Barren and uncultivable land	408 (4.59)	--	140 (4.87)	44 (0.45)
4	Land put to non-agricultural use	937 (10.55)	402 (18.45)	327 (11.37)	581 (5.93)
5	Permanent pastures and other grazing lands	--	--	--	--
6	Miscellaneous tree crops	--	--	40 (1.39)	--
7	Cultivable wastes	334 (3.76)	304 (13.95)	21 (0.73)	15 (0.15)
8	Current fallows	310 (3.48)	--	716 (24.90)	1,588 (16.21)
9	Other fallows	46 (0.52)	139 (6.38)	30 (1.04)	--
10	Net area sown	6,850 (77.10)	1,334 (61.22)	1,620 (56.35)	4,882 (49.84)

Source: Handbook of Mandal Statistics, MDO, Nallajerla and Bhimadolu

Note: Figures in the parentheses indicate percentages

4.2 NELLORE DISTRICT

4.2.1. Location of the district

Nellore district lies between 13°30' and 15°51' northern latittude and 70°51' and 80°16' of eastern longitude. The mean sea level is 18.69 m. The district is bound by Prakasam district on the north, Bay of Bengal on the east, Chittoor district of A.P. and Chengalpet district of Tamil Nadu on South and Velugondalu range of hills on West, which separates Nellore district from Cuddapah district.

Nellore district is the southern most coastal district of Andhra Pradesh and is adjacent to Tamil Nadu. with about a length, of 150 km from north to south and a breadth of 100 km from east to west, the district is roughly rectangular as shown in the fig 4.3.

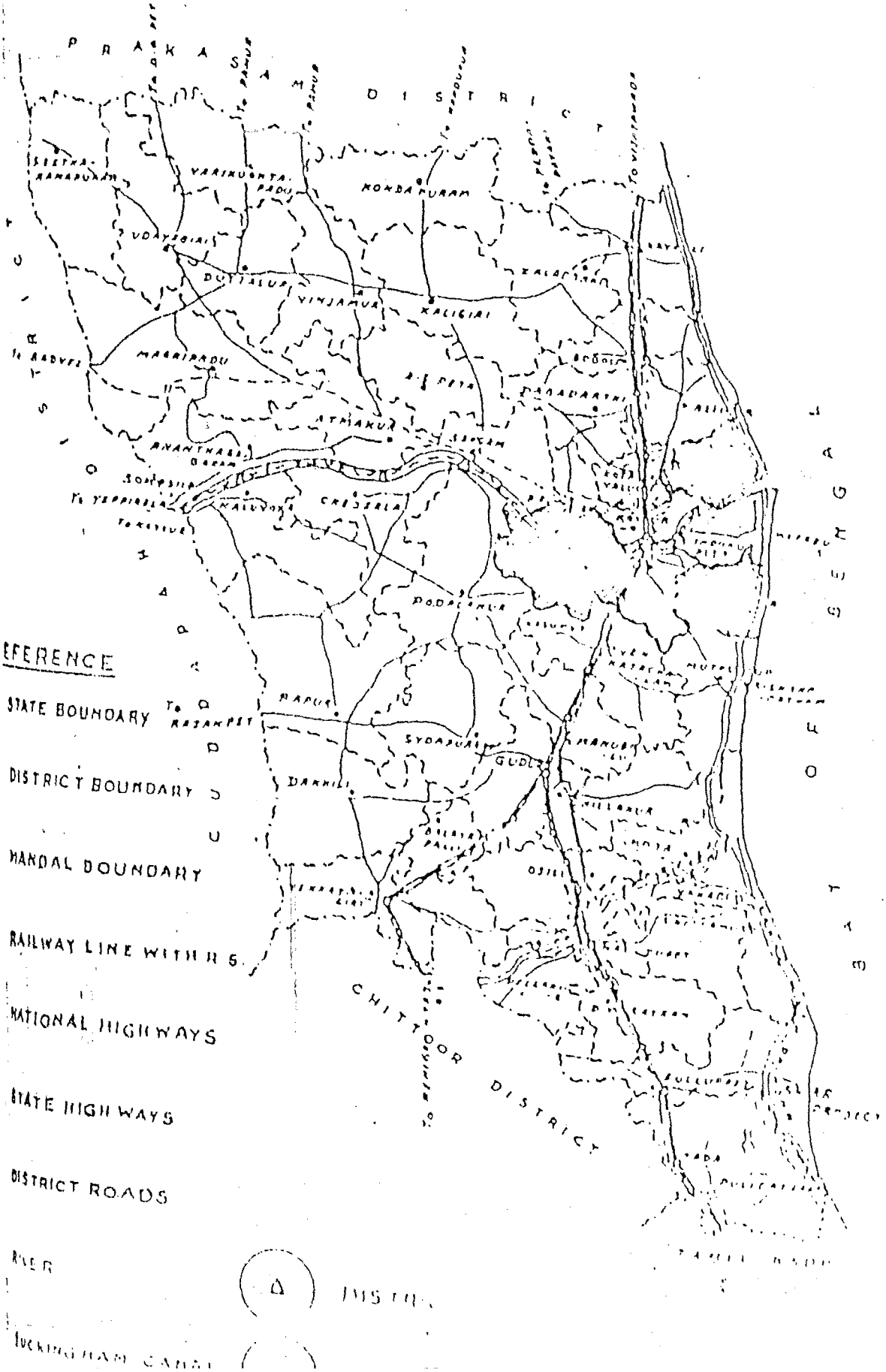
The district comprises of 46 revenue mandals, 3 revenue divisions extended over an area of 13,160 km. There are 928 grampanchayats with 3 municipal towns and 1204 villages in which 1131 are inhabited and 69 villages are uninhabited, 896 villages are electrified so far.

4.2.2 Demographic features

Table 4.11 presents the demographic features of the district. The population of the district as per 1991 census is 23,92,200 out of which 50.50 per cent males and 49.50 per cent females. About 60 per cent of the population lives in rural areas and the district has 40.59 per cent literacy. The population density is 182 per square kilometer. The cultivators in the district are 2,17,978 (9.11%) and agricultural labourers are 4,88,647 (20.43%) with 3,67,657 agricultural holdings.

NELLORE DISTRICT

Scale : Inch = 16 Miles



4.2.3 Rainfall and climate

The annual average rainfall of the district during 1997-98 was 1246.40 mm and number of rainy days were 52.

Table 4.11 Demographic features of Nellore district

S. No	Particulars	1991 (Lakhs)	Per cent
1	Total population	23.92	100.00
2	Males	12.08	50.50
3	Females	11.84	49.50
4	Rural	14.23	59.49
5	Urban	9.69	40.51
6	Literates	9.71	40.59
7	Cultivators	2.18	9.11
8	Agricultural labourers	4.88	20.40

Source: Handbook of District Statistics, Chief Planning Office, Nellore.

Table 4.12 Season wise rainfall distribution in Nellore district

	Season	Rainfall (mm)	Per cent
1.	South-West Monsoon	307.0	31.19
2.	North-East Monsoon	588.0	59.74
3.	Winter	26.6	2.70
4	Summer	62.6	6.36
	Total	982.1	100

Source: Hand Book of District Statistics, Chief Planning Office, Nellore.

Of the total rainfall, 59.74% is received during North-East monsoon. Nellore district is considered to be a rain shadow area for South-West monsoon and the

cropping programme relies heavily on North-East monsoon. Distribution of rainfall is mostly uneven not only season wise, but within season as well.

4.2.4 Season and crops

Normally two main seasons exist in this district, viz., kharif and rabi. For all practical purposes, the kharif is certain of net wet condition and rabi is most uncertain due to uncertain follow-up rains and periodical cyclones in October-November.

Fluctuations in seasonal conditions: Aberration in weather season has become hallmark of Nellore district. These fluctuations in the weather conditions have led some times to three crop seasons in the district. The main season is kharif, which is locally called Modalikaru or Peddakaru, second is late rabi and third one is early kharif.

Cropping pattern in the district: Particulars presented in Table 4.13 shows the major crops grown in the district and area covered under each crop. Paddy was grown in an area of 2,02,710 hectares (63.26 %) of the total cropped area. This is followed by groundnut with an area of 40,410 hectares (12.61 %). Apart from these two crops other crops like jowar, grams, chillies, tobacco, sesamum, citrus, mango etc., are also grown to a small extent.

4.2.5 Farm machinery in the district

Table 4.14 presents the particulars of important farm machinery in the district. It is perceptible that district has 43,352 electric motors, which is the highest among all the districts of Andhra Pradesh and this contributes to 30.28 per cent of the total machinery in the district. But major contribution is from ploughs. The district also

has 242 harvesters and a considerable stock of plant protection equipment, oil engines, seed-cum-fertilizer drills etc.,

Table 4.13 Area under principal crops in Nellore district

S. No	Crop	kharif (ha)	Rabi (ha)	Total (ha)	Per cent
1	Paddy	60,560	1,42,150	2,02,710	63.24
2	Jowar	11	13,000	13,011	4.06
3	Ragi	520	2,950	3,470	1.08
4	Greengram	475	9,540	10,015	3.12
5	Blackgram	30	2,300	2,330	0.73
6	Groundnut	9,200	31,210	40,410	12.61
7	Sesamum	3,840	1,100	4,940	1.54
8	Sugarcane	5,220	--	5,220	1.63
9	Chillies	300	9,100	9,400	2.93
10	Tobacco	--	9,000	9,000	2.81
11	Mango	6,107	--	6.107	1.91
12	Citrus	12,570	--	12,570	3.92
13	Cashew	1,363	--	1,363	0.43
	Total			3,14,445	100.00

Source: Hand Book of District Statistics 1997-98, CPO,Nellore

4.2.6 Irrigation facilities in the district

Rivers: Pennar and Swarnamukhi are the two major rivers, flowing from the west and to join in the Bay of Bengal in the East. Kandleru, Pydaru, Malidevi, Boggeru, Pillaperu and Kalangi rivers are the major drains passing through the district.

The total area under irrigation in this district is 3,19,050 ha. Pennar delta system of irrigation covers 1,01,300 ha and the remaining is covered by other sources in which the catching of rainfed tanks from the bulk sources of irrigation with single cropped wetlands, as ayacuts.

Table 4.14 Important farm machinery in Nellore district

S. No	Machinery	Stock (Number)	Per cent
1	Tractors	3854.00	2.70
2	Power tillers	59.00	0.04
3	Oil engines	9947.00	6.96
4	Electric motors	43352.00	30.34
5	Plant protection Equipment	15818.00	11.07
6	Harvesters	242.00	0.17
7	Wooden Ploughs	61165.00	42.80
8	MB Ploughs	2725.00	1.91
9	Disc harrows	1692.00	1.18
10	Seed-cum-Fertilizer drills	4042.00	2.83
	Total	142896.00	100.00

Source: Hand Book of District Statistics, CPO, Nellore

Table 4.15 Source wise area under irrigation in Nellore district

Source	Kharif (ha)	Rabi (ha)	Total (ha)	Per cent
Canals	49,709	61,719	1,11,428	34.93
Tanks	14,762	81,447	96,209	30.15
Filter points	19,258	26,716	45,974	14.41
Other wells	25,800	29,889	55,729	17.47
Other sources	1,928	7,781	9,709	3.04
Total	1,11,497	2,07,552	3,19,049	100.00

Source: Hand Book of District Statistics, Chief Planning Office, Nellore

Major irrigation: The major irrigation source is Pennar river. About 1,01,300 ha area is being irrigated under Pennar delta system. There are two anicuts to this river one at Sangam and the other at Nellore. These two, independently irrigate 28,000 hectares of land. Somasila project is one of the other major projects in execution. This project is

expected to complete within one or two years and it will be a major source of irrigation. It is expected to bring 17,457 ha of new area under irrigation in its first phase.

Medium irrigation: The medium irrigation projects of Nakkalagond, Mopad and Rallapadu are located in Prakasam district, which cater the irrigation to some ayacut area in Nellore district in Northern border. The other medium irrigation project Gaadipalem, located in Udayagiri Taluk is almost completed, and is expected to cover an ayacut of 6,400 ha. The field canals and distributories are in execution and water has been released to about 4,800 ha so far.

Minor irrigation: There are 827 PWD tanks and 932 tanks under Panchayat Raj Department in the district. Varying extents are also brought under irrigation through wells, tube wells, filter points, electric motors and oil engines also.

4.2.7 Land utilization pattern in the district

The land utilization pattern in the region gives a wide picture of land use, current fallows, land put to non-agricultural use and net area sown, which gives scope to understand the potentialities of the area. From Table 4.16 it is revealed that the district has 3,01,423.6 hectares of net area sown, which accounts to 23.17 per cent of the total area. Forest covers (2,43,846.8 ha) to an extent of 18.73 per cent of total area in the district. Land put to non-agricultural uses (1,96,227.6 ha) and barren and uncultivable lands (1,89,552.4 ha) together occupy to an extent of 29.63 per cent. The area under cultivable wastes and current fallows together was 13.72 per cent, indicating the scope for increasing the net area sown.

Table 4.16 Land utilization pattern in Nellore district 1997-98

S. No	Particulars	Area (ha)	Per cent
1	Total geographical area	13,00,802.4	100.00
2	Forests	2,43,846.8	18.73
3	Barren and uncultivable lands	1,89,552.4	14.57
4	Land put to non-agricultural uses	1,96,227.6	15.06
5	Permanent pastures and grazing lands	1,14,522.0	8.80
6	Miscellaneous grooves and trees not included in net sown area	17,099.8	1.31
7	Cultivable waste	60,017.6	4.61
8	Other fallows	1,08,065.6	8.31
9	Current fallows	70,352.0	5.41
10	Net sown area	3,01,423.6	23.17

Source: Agricultural Census, Chief Planning Office, Nellore (1997-98).

4.2.8 Soils of Nellore district

Various types of soils that are prevailing in the district are presented in Table 4.17. Red loams constitute the bulk (41 %) of cultivable land, along with clay loams (15 %) and alluvials, coastal sands (34 %) are extensively spread belt. Based on soil sample tests conducted for the past two decades over the entire district, it was found that the cultivated lands were generally low in Nitrogen, medium to low in Phosphorus and medium to high in Potash. Zinc, Boron and Magnesium deficiencies are also noticed in patches.

Table 4.17 Types of soils in Nellore district

	Type of soil	Distribution (%)
1	Red loams	41
2	Coastal sands	34
3	Clay loams (Black)	15
4	Laterite etc	5
5	Deltaic alluvium	5

Source: HandBook of District Statistics, Chief Planning Office, Nellore.

4.2.9 Agro-economic features of selected mandals

Two mandals were selected from Nellore district. They are Indukurpet and Bogolu mandals.

4.2.9.1 Indukurpet mandal

The total geographical area of the mandal was 15,310 hectares. It is bound by, Bay of Bengal on east, Thotapalliguduru on south, Nellore and Kovuru mandals on west and Vidavaluru mandal on the north as shown in the fig 5.3. As per the 1991 census the population of this mandal is 53,466 with a density of 282 per square kilometer. Of the total 27,108 are males (50.70 %) and 26,358 females (49.30 %). The district has 34.72 per cent literacy, according to 1991 census.

The normal rainfall in this mandal is 893.5 mm. Main sources of irrigation are filter points and canal i.e., Jafar Sahab canal. The area being irrigated under canal is 5,732 hectares, under filter points is 5,067 hectares and the remaining area is irrigated by other sources like tanks and wells.

4.2.9.1.1 Land utilization pattern of the mandal

Land utilization pattern of the mandal is presented in Table 4.18. Net area sown in the mandal is 11,310 hectares and it accounted to 73.87 per cent of the total area. Area under forests is only 1.65 per cent. Area under barren and uncultivable lands (457 ha) and land put to non-agricultural uses (786 ha) together accounted for 8.11 per cent of the total area. Cultivable wastes (315 ha) and current fallows (412 ha) together accounted for about 6.52 per cent of the total area. This suggests that, the land area in the mandal is being utilized efficiently.

4.2.9.1.2 Soils of the mandal

There are two main categories of soils in the mandal. They are loamy and sandy soils. Area under these categories was given in Table 4.19. From Table it is clear that about 75 per cent of the total soils are loamy with P^H ranging from 6.4 to 8.5. Soil Nitrogen and Phosphorus was low to medium and Potassium was medium to high in the soils of this mandal.

Table 4. 18 Land utilization pattern in the selected mandals of Nellore district

S. No	Particulars	Indukurpet	Per cent	Bogolu	Per cent
1	Total geographical area	15,310	100.00	17,865	100.00
2	Forests	253.00	1.65	1234.00	6.91
3	Barren and uncultivable land	457.00	2.98	3457.00	19.35
4	Land put to non-agril. Use	786.00	5.13	975.00	5.46
5	Miscellaneous tree crops	284.00	1.85	1497.00	8.38
6	Permanent pastures and grazing lands	906.00	5.92	963.00	5.39
7	Cultivable wastes	315.00	2.06	791.00	4.43
8	Current fallows	412.00	2.69	492.00	2.75
9	Other fallows	587.00	3.83	1538.00	8.61
10	Net area sown	11310.00	73.87	6918.00	38.72

Source: Mandal Abstracts 1997-98, Mandal Development Office (MDO), Indukurpet and Bogolu mandals

4.2.9.1.3 Cropping pattern in the mandal

The details of major crops grown in the selected mandals were given in Table 4.20. An overview of the cropping pattern revealed that, about 67.47 per cent of the total cropped area is occupied by paddy (9750 ha) in Indukurpet mandal followed

by pulses (22.49 %), groundnut (6.37 %) and sugarcane (2.47 %). The rest of the crops grown in the mandal were in negligible area.

4.2.9.2 Bogolu Mandal

Total geographical area of the mandal is 17,865 hectares. The mandal is bound by Kavali and Jaladanki mandals on the north, Chamadala on the west, Dagadarti, Nellore and Iskapalli mandals on the south and Bay of Bengal on the east.

As per 1991 census total population of this mandal was 48,144 with a density of 260 per square kilometer. The population of cultivators was 4,307 and agricultural labourers was 10,222 in the mandal. The normal rainfall was 895 mm. Main sources of irrigation were canals and filter points. About 4,565 hectares area was irrigated by the canal system and only 674 hectares area was irrigated under filter points. The remaining area was irrigated by wells comprising to the total irrigated area 6,294 hectares.

4.2.9.2.1 Land utilization pattern of the mandal

Land utilization pattern of the mandals is presented in Table 4.18. Net area sown was 6,918 hectares and it accounted to only 38.72 per cent of the total area. Area under forests is only 6.91 per cent. Area under barren and uncultivable lands (3457 ha) and land put to non-agricultural uses (975 ha) together accounted for 24.81 per cent of the total area. Cultivable wastes (791 ha) and current fallows (492 ha) together accounted for about 7.18 per cent of the total area. This suggests that, the mandal had a large extent of barren and waste lands which may not be brought under cultivation due to lack of sufficient irrigation facilities.

4.2.9.2.2 Soils of the mandal

Different types of soils are seen in the mandal. The per cent area under each category is given in Table 4.19. Most of the soils are loamy and other types contributing to an extent of 80 per cent of the total area with a pH ranging from 7 to 8.5. Soil Nitrogen & Phosphorus are low to medium and Potassium is medium to high in the soils of the mandal.

Table 4.19 Soil types in the selected mandals of Nellore district

S. No	Particulars	Bogolu (%)	Indukurpet (%)
1	Black	5%	--
2	Red	5%	1%
3	Sandy	10%	24%
4	Loamy	30%	75%
5	Others	50%	--

Source: Mandal Abstracts 1997-98, MDO, Indukur pet and Bogolu mandals

4.2.9.2.3 Cropping pattern

Details of major crops grown in this mandal are given in Table 4.20. An overview of the cropping pattern revealed that, about 60.44 per cent of the total cropped area is occupied by paddy in the mandal followed by pulses (33.23 %), sugarcane (2.17 %) and betelvine (2.08 %). Area under groundnut, vegetables and gingelly crops is of negligible extent.

Table 4.20 Cropping pattern in the selected mandals of Nellore district

S. No	Crop	Indukurpet (ha)	Per cent	Bogolu (ha)	Per cent
1	Paddy	9750	67.47	5220	60.44
2	Groundnut	920	6.37	96	1.11
3	Pulses	3250	22.49	2870	33.23
4	Gingelly	52	0.36	8	0.09
5	Sugarcane	350	2.42	187	2.17
6	Vegetables	89	0.62	75	0.87
7	Betelvine	28	0.19	180	2.08
8	Banana	12	0.08	--	0.00
	Total	14,451	100.00	8,636	100.00

Source: Mandal Abstracts 1997-98, MDO, Indukur pet and Bogolu mandals

4.2.10 Agro-economic features of selected villages

Four villages were selected from the two selected mandals, for the study. Indukurpet-II and Jagedevipet villages were selected from Indukurpet mandal. Similarly from Bogolu mandal also two villages, Kovurupalli and Mungamuru were selected. All the four villages were provided with weather motorable roads connecting nearby urban areas.

In all the four villages the major sources of irrigation are canals and filter points. The land utilization pattern in the villages is given in Table 4.21. In all the selected villages, major crops grown are paddy and pulses and paddy is grown in both the seasons.

Table 4.21 Land utilization pattern in the selected villages of Nellore district

S. No	Particulars	Indukurpet mandal		Bogolu mandal	
		Indukur-pet	Jagadevi-pet	Munga-muru	Kovuru-palli
1	Total geographical area	3065 (100)	5724 (100)	1505 (100)	2692 (100)
2	Forests	--	--	--	--
3	Barren and cultivable land	42 (1.37)	734 (12.82)	332 (22.06)	734 (27.27)
4	Land put to non-agricultural uses	656 (21.40)	1019 (17.80)	348 (23.12)	471 (17.50)
5	Permanent pastures and grazing lands	114 (3.72)	156 (2.73)	3 (0.02)	178 (0.61)
6	Miscellaneous tree crops and grooves not included in net sown area	96 (3.13)	168 (2.94)	--	--
7	Cultivable waste	52 (1.70)	1586 (27.71)	54 (3.59)	48 (1.78)
8	Other fallow lands	74 (2.41)	203 (3.55)	49 (3.26)	17 (0.63)
9	Current fallows	7 (0.23)	38 (0.66)	--	--
10	Net area sown	2024 (66.04)	1820 (31.80)	719 (47.77)	1244 (46.21)

Source: Mandal Abstracts 1997-98, MDO, Indukur pet and Bogolu mandals

Note: Figures in the parentheses indicate percentages

4.3 PRAKASAM DISTRICT

4.3.1 Physiography of the district

Prakasam district is situated in tropical region between 14^{o}-57^{1}-00^{11} to 16^{o}-17^{1}-00^{11} Northern latitude and 78^{o}-43^{1}-00^{11} to 80^{o}-25^{1}-00^{11} Eastern longitude. The district spreads in an area of 17,626 square kilometers. It accounts for 6.41 per cent of the total area of the state and is ranked 4^{th} in size. The district is having 102 km of coastal line spreading over in 10 mandals.

The district is having 25 per cent of total geographical area under forests. The central portion of the district contains large tracks of low shrubs, jungle diversified with rocky hills and stony plains, which focus a distinctive feature of the district. The western portion of the district, which included the erstwhile taluks of Giddalur and Markapur, is an upland area.

4.3.2 Demographic features

As per the 1991 census, the total population of the district is 27.59 lakhs. It accounts for 4.56 per cent of the total population of the state and was ranked 14^{th} in the size of population. The female population of the district is 13.59 lakhs, which accounted for 49.24 per cent of the district population and 4.41 per cent of the state population and the male population accounted for 50.76 per cent.

The urban population of the district is 4.54 lakhs forming 16.45 per cent of the total population and 2.54 per cent of the state urban population. The rural population of the district is 23.05 lakhs, which accounted for 83.55 per cent of the total population and 4.74 per cent to that of the state population. The SC population in the

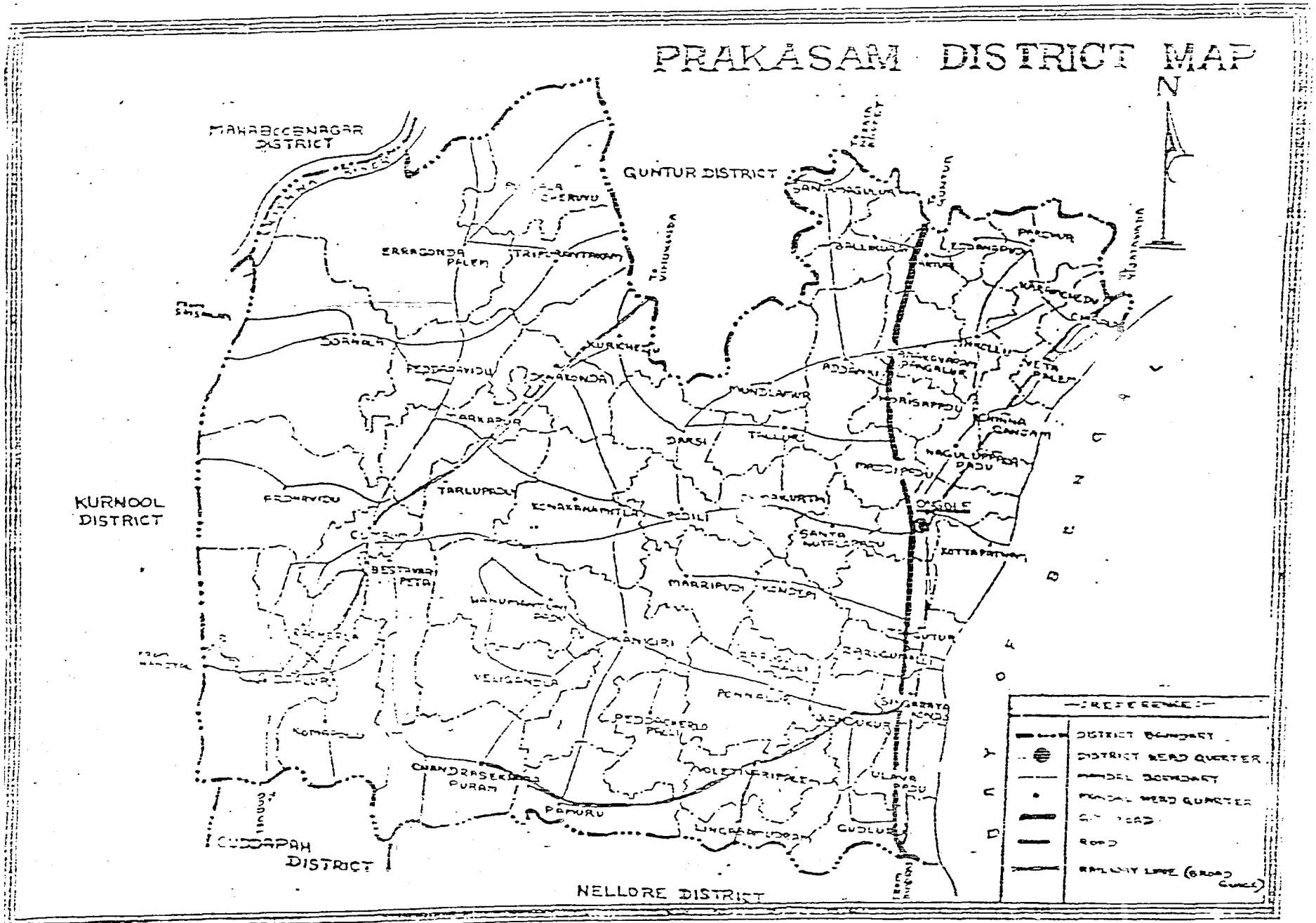


Fig. 4.4 MAP OF PRAKASAM DISTRICT

district was 5.53 lakhs which works out to 20.03 per cent of the district. The ST population of the district is 0.99 lakhs which formed about 3.58 per cent of the total district population.

4.3.4 Climate and rainfall in the district

Two types of climate are observed in the district, the sea breeze of the coastal areas renders the climate moderate both in winter and summer in the coastal area of the district. In the rest of the district the heat in the summer is severe especially the tracks adjoining the hills. The maximum and minimum normal temperatures recorded in the district were 38.2°C and 19.7°C respectively.

The district receives its rainfall from South-West as well as North-East monsoons. The district has a poor normal rainfall of 750.9 mm as compared to that of state 925 mm. Among the total rainfall 43.06 per cent was received from South-West monsoons and 45.44 per cent during North-East monsoon period. The district is effected by frequent droughts and cyclones.

Table 4.22 Rainfall distribution in Prakasam district

S. No	Season	Normal rainfall (mm)	Average rainfall (mm)	Per cent
1	South-west monsoon	88.1	72.25	34.39
2	North-east monsoon	66.04	115.62	55.03
3	Summer/Hot weather	22.77	22.25	10.59
	Total	176.91	210.12	100.00

Source: Hand book of district statistics 1997-98, CPO, Prakasam

4.3.4 Season and crops of the district

Normal crop seasons in the district are Kharif and Rabi. But in some areas crop cultivation is seen throughout the year including summer season in coastal areas, where irrigation is assured. In most of the mandals only Kharif is in wet conditions and rabi is in dry conditions.

Table 4.23 Cropping pattern in Prakasam district

S. No	Crop	Area (ha)	Per cent
1	Paddy	127,900.28	19.79
2	Jowar	35,546.43	5.50
3	Bajra	30,309.38	4.69
4	Ragi	10,394.77	1.61
5	Redgram	32,668.70	5.06
6	Chillies	26,046.00	4.03
7	Groundnut	72,053.58	11.15
8	Sunflower	14,054.00	2.17
9	Sesamum	7,564.00	1.17
10	Castor	26,027.80	4.03
11	Cotton	63,954.60	9.90
12	Tobacco	59,965.26	9.28
13	Sugarcane	503.83	0.08
14	Fruit crops	90,315.45	13.98
15	Vegetables	48,945.36	7.57
	Total	646249.44	100.00

Source: Hand book of district statistics 1997-98, CPO, Prakasam

Cropping pattern: It is clear from Table 4.23 that paddy occupied first place in area i.e., 19.89 per cent. Only paddy and sugarcane are cultivated under irrigated conditions while most of the others are dryland crops. However the area under sugarcane is only

0.08 per cent. Apart from field crops, area under fruits and vegetables together accounted for 21.66 per cent of the total area. Commercial crops like cotton, tobacco, groundnut, chillies, sesamum and castor together account for 45.18 per cent to the total cropped area. Food crops occupy 53.33 per cent of the gross cropped area and non-food crops occupy 46.46 per cent of gross cropped area.

Table 4.24 Important farm machinery in Prakasam district

S. No	Machinery	Stock (Number)	Per cent
1	Tractors	3403.00	2.29
2	Power tillers	299.00	0.20
3	Oil engines	7962.00	5.36
4	Electric motors	20338.00	13.69
5	Plant protection equipment	27405.00	18.45
6	Harvesters	147.50	0.10
7	Wooden Ploughs	63376.00	42.66
8	MB Ploughs	2532.00	1.70
9	Disc harrows	986.00	0.66
10	Seed-cum-Fertilizer drills	22128.00	14.89
	Total	148576.50	100.00

Source: Hand book of district statistics 1997-98, CPO, Prakasam

4.3.5 Farm machinery in the district

The details of farm machinery in the district are presented in Table 4.24. From Table it can be perceptible that Prakasam district has less stocks of machinery compared to the other two districts except the plant protection equipment and seed-cum-fertilizer drills. This is perhaps because the district has larger area under commercial crops like cotton, chillies, tobacco etc., for which farmers are habituated to spray pesticides continuously. Most of the area in the district is rainfed and in rainfed

areas it is common practice to do sowing and fertilization simultaneously, to utilize soil moisture in a better way. However the district has considerable stocks of oil engines, electric motors, ploughs, tractors etc.,

Table 4.25 Land utilization pattern of Prakasam district

S.No.	Particulars	Area (ha)	%
1	Forests	84,43,439	25.81
2	Barren and uncultivable land	1,85,636	9.08
3	Land put to non-agril. uses	1,65,824	9.67
4	Permanent pastures and other grazing lands	1,13,256	6.61
5	Land under misc. tree crops and grooves	1,11,045	6.48
6	Cultivable waste	75,458	14.40
7	Other fallow lands	55,681	3.24
8	Current fallow lands	86,271	5.03
9	Net area sown	5,43,743	31.72
10	Total geographical area	17,14,061	100.00

Source: Hand book of district statistics 1997-98, CPO, Prakasam district

4.3.6 Land utilization pattern of Prakasam district

Total geographical area of the district was 17,14,061.63 ha. As per the 1996-97 estimates, area under forest cover is 4,43,439 ha, which formed 25.81 per cent of the total geographical area. The net area sown was 31.72 per cent and the cultivable waste accounted for 4.2 per cent, which indicated that there exists scope for further expansion of net area sown. Barren and uncultivable land and land put to non-agricultural uses are 9.03 per cent and 9.3 per cent of geographical area respectively. The extent of area sown more than once formed 8.93 per cent of the net sown area.

4.3.7 Irrigation facilities of the district

Source wise irrigation facilities in the district are presented in Table 4.26. From Table it can be revealed that, about 80 per cent of the cropped area is under canals and tanks. The contribution of tube wells and filter points has increased from a mere 0.85 per cent in 1988-89 to an all time high of 12.54 per cent in 1992-93, occupying an area of 60,993 ha.

Table 4.26 Source wise irrigation available in Prakasam district

S. No.	Source	Area in hectares			Per cent
		Kharif	Rabi	Total	
1	Canals	1,38,920	67,124	2,06,044	59.36
2	Tanks	23,475	42,645	76,060	21.91
3	Tube wells and filter points	17,685	13,308	60,993	17.57
4	Dug wells	2,465	1,545	4,010	1.16
	Total	182,545	124,622	347,107	100.00

Source: Hand book of district statistics 1997-98, CPO, Prakasam district

4.3.8 Soils of the district

The major soil types of Prakasam district are red loam, black cotton and sandy loams. Area under red loams and black cotton is more in the district. Sandy loams occupied to the extent of 51 per cent while black cotton soils occupy 41 per cent. The black cotton soils are rich in nutrients and suitable for growing dryland crops like cotton, tobacco, chillies and jowar. Even the red soils, though they are less fertile, suitable for millets and oilseeds production. However they are now occupied by sunflower for the past three years.

Table 4.27 Soil types in Prakasam district

S. No	Soil type	Area (ha)	Per cent
1			
2	Red loam	8,71,016.66	51.00
3	Black cotton	7,00,229,08	41.00
4	Sandy loam	1,36,630.06	8.00

Source: Handbook of district statistics 1997-98, CPO, Prakasam district

4.3.9 Agro-economic features of selected mandals

Two mandals, Yeddanapudi and Ulavapadu mandals were selected from the district. The agro-economic features of the selected mandals are discussed in detail below

4.3.9.1 Yeddanapudi mandal

Yeddanapudi mandal has its boundaries Parchuru on the east, Guntur on the north, Martur on the west and Inkollu on the south. Total area of the mandal is 46,120 hectares. Important crops grown are paddy, redgram, chillies, cotton, greengram and tobacco. As per 1991 census, total population of the mandal was 31,290 in which 15,535 males (49.65%) and 15,755 females (50.35%). Of the total cultivators population was 4,920 and 17,591 were agricultural labourers.

4.3.9.1.1 Land utilization pattern of the mandal

From Table 4.28 it is clear that net area sown constitutes around 89 per cent of the total area of the mandal. Further land put to non-agricultural uses occupied 10.12 per cent of the total area and others are of negligible extent.

Irrigation facilities: From the above table 4.29 it is clear that canals are the major irigation sources in the mandal, followed by tanks and other sources. Canal irrigated area accounted for 75 per cent of the total irrigated area in the mandal.

Table 4.28 Land utilization pattern of Yeddanapudi mandal

S.No.	Particulars	Area (ha)	%
1	Forests	--	0
2	Barren an uncultivable lands	21	0.08
3	Land put to non-agril. uses	2643	10.12
4	Permanent pastures	--	0
5	Land under miscellaneous trees	--	0
6	Cultivable wastes	77	0.29
7	Other fallow lands	45	0.17
8	Current fallow lands	103	0.39
9	Net area sown	23,215	88.86
10	Total geographical area	46,120	100.00

Source: Mandal Abstracts 1997-98, MDO, Yeddanapudi and Ulavapadu mandals

4. 29 Source-wise irrigation facilities in the mandal

S. No	Source	Area irrigated (ha)	%
1	Canals	9,775	75.44
2	Tanks	1,286	13.78
3	Wells	449	3.47
4	Others	948	7.32
	Total	12,958	100.00

Source: Mandal Abstracts 1997-98, MDO, Yeddanapudi mandal

4.3.9.1.2 Soils of Yeddanapudi mandal

Details of soils prevailing in the mandal are given in table 4.30. Various types of soils are observed in the mandal. Black soils occupy to an extent of 42 per

cent followed by red soils (26 %). Sandy soils are found in coastal belt to an extent of 11 per cent of the total soils. Loamy soils occupy a negligible area of 2.00 per cent of total soils.

Table 4.30 Soil types of the selected mandals

S. No	Particulars	Yeddanapudi (%)	Ulavapadu (%)
1	Black	42	36
2	Red	26	28
3	Sandy	11	16
4	Loamy	2	7
	Others	19	13

Source: Mandal Abstracts 1997-98, MDO, Yeddanapudi and Ulavapadu mandals

4.3.9.1.3 Cropping pattern of the mandal

Major crops grown in the selected mandals are given in Table 4.33. An overview of cropping pattern revealed that about 49.01 per cent of the total cropped area is occupied by paddy in Yuddanapudi mandal followed by chillies, cotton and redgram. The rest of the crops occupied a negligible area.

4.3.9.2 Ulavapadu mandal

The mandal has its boundaries Singarayakonda mandal on the north, Kandukuru mandal on the west, Bay of Bengal on the east and Gudlur mandal on the south. There are 28 villages in the mandal. Total area was 248 square kilometers. Important crops are paddy, greengram, blackgram, groundnut, chillies, tobacco, mango etc. As per 1991 census, total population of the mandal recorded was 46,480 of which 24,248 are males and 22,232 are females. There are 10,270 cultivators and 13,789 agricultural labourers.

4.3.9.2.1 Land utilization pattern of the mandal

From Table 4.31 it is clear that the net area sown constitutes 44.56 per cent of the total geographical area of the mandal. Barren and uncultivable lands (3.83 ha) and land put to non-agricultural uses (4.65 ha) together occupied 8.48 per cent of total. Current fallow lands and cultivable wastes are of negligible extent.

Irrigation facilities: The data presented in Table 4.32 indicated that total area irrigated in the mandal was 15,179.5 ha. Canal and tank irrigation contributed to more than 60 per cent of the total irrigated area, followed by wells and other sources.

Table 4.31 Land utilization pattern of Ulavapadu mandal

S.No.	Particulars	Area (ha)	%
1	Forest	531.6	1.09
2	Barren and uncultivable land	1,872.0	3.83
3	Land put to non-agril. uses	2,273.6	4.65
4	Permanent pastures	440.4	0.90
5	Land under miscellaneous trees	4.0	0.01
6	Cultivable wastes	764.4	1.56
7	Other fallow lands	532.6	1.09
8	Current fallow lands	312.5	0.64
9	Net area sown	21,780	44.56
10	Total geographical area	48,875	100.00

Source: Mandal Abstracts 1997-98, MDO, Ulavapadu mandal

4.3.9.2.2 Soils of the mandal

Different types of soils are observed in the mandal. The area under different categories given in Table 4.30. Most of the soils are black cotton (36 %) and red (28 %) soils. To some extent sandy soils (16 %) are seen on the coastal belt. Black and red soils together occupy more than 60 per cent of the area.

Table 4.32 Source-wise irrigation facilities in the mandal

S. No	Source	Area irrigated (ha)	Per cent
1	Canals	11,126	73.29
2	Tanks	3,275.5	21.58
3	Wells	157	1.04
4	Others	621	4.09
	Total	15,179.5	100.00

Source: Mandal Abstracts 1997-98, MDO, Ulavapadu mandal

4.3.9.2.3 Cropping pattern in the manadal

Major crops grown in the mandal are given in Table 4.33. An overview of the cropping pattern revealed that, about 50 per cent of the total cropped area is occupied by paddy followed by pulses (35.15 %) and groundnut (12.91 %). vegetables, banana, betelvine etc., have negligible area.

Table 4.33 Cropping pattern in the selected mandals

S. No	Crop	Yeddanapudi (ha)	%	Ulavapadu (ha)	%
1	Paddy	12,875	49.01	14,750	49.53
2	Groundnut	3,435	13.08	3,845	12.91
3	Pulses	8,745	33.29	10,468	35.15
4	Gingelly	456	1.74	48	0.16
5	Sugarcane	78	0.30	0	0.00
6	Vegetables	560	2.13	488	1.64
7	Betelvine	--	0.00	86	0.29
8	Banana	120	0.46	95	0.32
	Total	26,269	100.00	29,780	100.00

Source: Mandal Abstracts 1997-98, MDO, Yeddanapudi and Ulavapadu mandals

4.3.10 Agro-economic features of selected villages

Four villages were selected from the two selected mandals of Prakasam district. From Yeddanapudi mandal, Punuru and Yeddanapudi villages were selected. Karedu and Ramayapatnam villages were selected from Ulavapadu mandal. All the four villages are located in accessible places. All the villages have weather motarable roads except for Punuru where there is a problem of transportation during rainy season due to frequent floods.

In all the four villages, irrigation sources are canals and tube wells. Important crops grown in the villages were paddy, pulses, groundnut and to some extent chillies. Cotton is also grown in some areas of Yeddanapudi and Punuru. Others crops are grown in negligible area. Land utilization pattern of the selected villages is given in Table 4.34.

Table 4.34 Land utilization pattern of the selected villages

S. No	Particulars	Yeddanapudi		Ulavapadu	
		Yeddana-pudi	Punuru	Karedu	Ramayapatnam
1	Total geographical area	4,079 (100)	4,921 (100)	3,564.5 (100)	4,753.3 (100)
2	Forests	--	--	--	--
3	Barren and cultivable lands	--	--	278.4 (7.81)	336.5 (7.08)
4	Land put to non-agricultural uses	312 (7.65)	690 (14.02)	378.5 (10.62)	338.6 (7.12)
5	Permanent pastures and grazing lands	--	--	--	28.6 (0.60)
6	Misc tree crops and grooves not included in NSA	--	--	161.5 (4.53)	187.7 (3.95)
7	Cultivable waste	11 (0.27)	18 (0.37)	25.8 (0.72)	61.3 (1.29)
8	Other fallow lands	--	--	34.3 (0.96)	22.6 (0.48)
9	Current fallows	2 (0.05)	22 (0.45)	--	--
10	Net sown area	3,754 (92.03)	4,191 (85.17)	2,685 (75.34)	3,778 (79.49)

Source: Mandal Abstracts 1997-98, MDO, Yeddanapudi and Ulavapadu mandals

Note: Figures in the parentheses indicate percentages

RESULTS AND DISCUSSION

CHAPTER V

RESULTS AND DISCUSSION

The aim of this study was to evaluate the economics of farm mechanization. Keeping in view of the problem statement, a detailed study was carried out to probe into the economics of mechanized and non-mechanized farms. This chapter is devoted to discuss the results in the following order.

5.1. General particulars of selected farm holdings

5.2. Benefits of mechanization vis-a-vis traditional methods.

5.2.1 Extent of mechanization in various farm operations

5.2.2 Comparative economics of mechanization of farm operations with traditional methods.

5.2.3 Pattern and extent of labour absorption or labour displacement due to farm mechanization.

5.3 Factors determining farm mechanization

5.4 Impact of mechanization on cropping intensity, production, productivity and income on the selected farms.

5.5 Demand estimation for farm machinery in the selected districts of coastal A.P.

5.6 Problems and constraints associated with farm mechanization.

5.1 GENERAL PARTICULARS OF SELECTED FARM HOLDINGS

General particulars of the sample farms are categorized and presented as follows

5.1.1 Family composition

The details of average size and composition of the selected farm families in both mechanized and non-mechanized farms with respect to male, female and children in the study area are presented in Table 5.1. The average family size of the mechanized farm family (5.36) was less when compared to non-mechanized farm family (5.64). Further the average number corresponding to men, women and children was also less in case of mechanized farm families when compared to non-mechanized farm families. In both categories, the average number of children was more compared to men and women.

Table 5.1 Average size of and composition of selected farm families

S. No	Family Composition	Mechanized		Non-mechanized	
		Frequency	%	Frequency	%
1.	Male	1.70	31.72	1.78	31.56
2.	Female	1.63	30.41	1.78	31.56
3.	Children	2.03	37.87	2.08	36.88
	Total	5.36	100.00	5.64	100.00

5.1.2 Family labour composition

The average number of family labour available on mechanized farms was 1.59, of which 89.31 per cent were male workers and only 6.92 per cent were female workers. While in case of non-mechanized farms the average number of family labour was 3.07. The family composition indicated that, male workers were 55.05 per cent and female workers were 28.34 per cent. However the composition of child labour was less in both mechanized (3.77 %) and non-mechanized (16.61 %) farm families. The results suggested that contribution of female and child labour to the total labour was higher on non-mechanized farms than on mechanized farms. This may be because most of the non-mechanized farms were small (1.43 ha) and most of the family members had to work. Within the family, male workers were more available for the farm work followed by female and child labour on both the farms.

Table 5.2 Family labour composition of selected farm holdings

S. No	Family labour composition	Mechanized		Non-mechanized	
		Frequency	%	Frequency	%
1.	Male	1.42	89.31	1.69	55.05
2.	Female	0.11	6.92	0.87	28.34
3.	Children	0.06	3.77	0.51	16.61
	Total	1.59	100.00	3.07	100.00

5.1.3 Educational status of the farmers

Education, being source of knowledge, is of prime importance for the development of economy. Education as it enhances the knowledge, helps farmers in decision making regarding various farm business activities.

The details furnished in Table 5.3 indicated that the educational status of sampled farmers was positively associated with farm mechanization. Among the mechanized farmers, only 3.33 per cent were illiterates, whereas in non-mechanized farm holdings 22.50 per cent were illiterates. About 53.33 per cent of non-mechanized category farmers had only primary education, whereas in case of mechanized category 42.50 per cent of farmers completed high school education and 35.83 per cent of farmers studied up to college, among them 12.50 per cent were graduates.

Table 5.3 Educational status of the selected farmers

S. No	Particular	Mechanized		Non-mechanized	
Educational status		**Frequency**	**%**	**Frequency**	**%**
1.	Illiterates	4.00	3.33	27.00	22.50
2.	Literates	116.00	96.67	93.00	77.50
3.	Up to 5	7.00	5.83	64.00	53.33
4.	5 – 10	51.00	42.50	24.00	20.00
5.	Up to College (Intermediate)	43.00	35.83	4.00	3.33
6.	Graduates	15.00	12.50	1.00	0.83

Thus it can be concluded that the literacy levels of farmers had positive association with mechanization. This emphasizes the fact that education helps in understanding and adopting new technologies in carrying out farm operations.

5.1.4 Land holdings pattern and distribution

Land holding size is one of the crucial factors, which strongly influence decision making regarding the magnitude of production and cropping pattern etc. Similarly, the size of farm holding has a significant influence on mechanization of farm operations, since the farm size restricts the mechanization in many cases, the details of which are presented in Table 5.4. The average size of mechanized farm was 3.22 hectares whereas that of non-mechanized farm was 1.43 hectares. Further it can be suggested that mechanized farms had a strong relation with irrigated area, as 84.78 per cent of mechanized farms were irrigated whereas among non-mechanized farms only 13.29 per cent were irrigated.

The frequencies of mechanized and non-mechanized farmers, with respect to farm size are presented in Table 5.4. The frequencies indicated that about 72.50 per cent of mechanized farms were large (>2 ha), while 95.00 per cent of non-mechanized farms were small (<2 ha). This suggests that, the farm size and area irrigated were strongly associated with mechanization. Further it can be suggested that, the small size of the non-mechanized farms, which may not merit the need for mechanization, apart from various other reasons such as credit availability, capital position etc.,

Table 5.4 Pattern of land holdings of respondents

Particular	Mechanized		Non-mechanized	
	Frequency	%	Frequency	%
I. Farm size (ha)				
a) Less than 1	8.00	6.67	74.00	61.67
b) 1 – 2	25.00	20.83	40.00	33.33
c) 2 - 4	40.00	33.33	6.00	5.00
d) More than 4	47.00	39.17	0.00	0.00
Total	120	100.00	120	100.00
II. Average size of holding (ha)	3.22		1.43	
III. Average size of irrigated holding (ha)	2.73		0.19	

Table 5.5 Livestock particulars of selected holdings.

S. No.	Particulars	Mechanized		Non-mechanized	
		Number	Per ha	Number	Per ha
1	Milch animals	7.86	2.44	3.89	2.72
		(47.90)		(44.61)	
2	Draught purpose animals	3.24	1.01	2.07	1.45
		(19.74)		(23.74)	
3	Young stock	5.31	1.65	2.76	1.93
		(32.36)		(31.65)	
	Total	16.41	5.10	8.72	6.10
		(100)		(100)	

Note: Figures in the parentheses indicate percentages

5.1.5 Livestock particulars

Livestock has been a part of agriculture, providing draught power for agricultural operations and manures to improve soil fertility. Apart from this livestock also provides milk and meat for family consumption.

Details presented in Table 5.5 indicated the average animal holdings of mechanized and non-mechanized farms, with respect to milch, draught purpose and young stock. The average number of animals of all categories was higher on mechanized farms. The average animal holding on mechanized farm was 16.41 whereas on non-mechanized farms was only 8.22. On both the farms milch animals (48% and 44%) were more when compared to the other categories. However the average number of all categories of animals were more on mechanized farms than on non-mechanized farms. This suggests that mechanized category of farmers, are able to maintain large animal holdings. However the average number of animals per hectare was higher on non-mechanized farms (6.10) when compared to mechanized farms (5.10). From this it can be concluded that though the mechanized category of farmers had large animal holdings, the number of animals per hectare was relatively higher on non-mechanized farms.

5.1.6 Farm machinery and implements

Similar to livestock, every farmer maintains his own stock of farm machinery and implements, depending upon the requirement and his capacity to invest. Farm machinery and implements contribute to the inventory of the farmer. Even if the farmer does not have the machinery or implements he can hire whenever it is required. However possession indicates the readiness to use the machinery. The

details presented in Table 5.6 indicated the stock of machinery and implements of selected farms. As the name indicated mechanized farms had more stock when compared to non-mechanized farms. Further the average number of implements like ploughs, sickles, spades etc., was also higher on mechanized farms. This might be because of the large farm size of mechanized category.

Table 5.6 Farm machinery and implements of selected farm holdings

S. No.	Particular	Mechanized		Non-mechanized	
		Stock	Per ha	Stock	Per ha
1	Tractors	0.73 (2.15)	0.23	0.00 (0.00)	0.00
2	Electric motors	4.21 (12.38)	1.31	0.02 (0.09)	0.01
3	Bullock carts	0.78 (2.29)	0.24	0.22 (1.17)	0.15
4	Ploughs	2.53 (7.44)	0.79	1.24 (6.61)	1.57
5	Sickles	18.93 (55.64)	5.88	11.32 (60.39)	7.92
6	Crowbars	1.45 (4.26)	0.45	1.13 (6.03)	0.79
7	Spades	1.86 (5.47)	0.58	1.43 (7.63)	1.00
8	Pick axe	1.27 (3.73)	0.39	1.21 (6.45)	0.85
9	Others	2.26 (6.64)	0.70	2.18 (11.63)	1.52
	Total	34.02 (100.00)	10.57	18.75 (100.00)	13.81

Note: Figures in the parentheses indicate percentages

5.2 MECHANIZATION VIS-A-VIS TRADITIONAL METHODS OF AGRICULTURAL OPERATIONS

Mechanization of agriculture means the involvement of machinery in carrying out of various agricultural operations such as irrigation, ploughing, sowing, harvesting etc., in place of human and animal power. Mechanization is that part of farm technology, which stands for the utilization of machinery in all farming operations right from land preparation to the marketing of produce. Mechanization has tremendous impact on the whole of the economy because it normally leads to proper use of land resource, abundant agricultural surpluses and higher farm income. Farm mechanization therefore has a considerable bearing on further development of agriculture and agro-industries. But still there are some views against mechanization such as displacement of human and cattle labour. Hence an attempt was made to study the extent and economics of mechanization and also to study the changes in the pattern of labour employment due to mechanization.

5.2.1. Extent of mechanization in various farm operations

Mechanization may be either partial or complete, when an operation is done with machine displacing the human or cattle labour, it can be said that the operation is mechanized and if all operations on a farm are mechanized, then it can be called as complete mechanization. When only a part or some of farm operations is/are mechanized, it is said to be partial mechanization. But in our Indian conditions especially in Andhra Pradesh, partial mechanization is seen mostly. Many times mechanization is restricted to particular operations and particular crops.

Reasons behind this may be numerous. However an attempt was made to assess the extent of mechanization in various farm operations.

As mentioned in the preceding Chapter III 'Materials and Methods', paddy growing farms were selected exclusively considering the extensive area under paddy in the study area and uniformity of the sample which facilitates the comparison of mechanized and non-mechanized farms. Further, in the study area paddy crop was the one, which was mechanized amongst all other crops, with respect to the operations like ploughing, transportation, irrigation (pumpsets), harvesting, threshing and winnowing etc. Here the mechanized farms were those on which the above mentioned operations were mechanized either partially or completely.

5.2.1.1 Ploughing

Among various operations ploughing is the only operation, which was mechanized completely on all mechanized farms replacing the cattle ploughing. Of the total costs of ploughing Rs.1,684, machine labour wages were Rs.1,588 per hectare and it contributed to more than 95 per cent of the total cost of ploughing. The remaining expenditure was incurred in the form of human labour wages for the preparation of bunds etc., The frequency of the farms, on which ploughing operation was mechanized, indicated that 100 per cent of the farmers adopted tractor for ploughing operation.

5.2.1.2 Harvesting

Harvesting was considered to be the next important operation based on its extent of mechanization, involvement of more number of human labour and higher wages. The results indicated that harvesting was done in two ways on the mechanized farms alone. One way was using harvest-combines, which could do harvesting, threshing and winnowing simultaneously and the other was by employing human labour for harvesting. In the first method there was no human labour employment in harvesting while in the second method no machine involvement. Thus harvesting can be carried out either with 100 per cent or zero per cent mechanization depending on the method the farmers adopted. The frequencies presented in Table 5.9 indicated that among the 120 mechanized farms, 85 farms (70.88 %) used harvest combines and only 35 farmers employed human labour for harvesting.

When the expenditure incurred was considered, the money spent on harvesting with harvest-combine was found to be Rs.3,145 per hectare, but it included the costs of threshing and winnowing operations also. Hence in order to compare this with other method of harvesting, costs of threshing and winnowing were also added to that and it accounted to Rs.3,650 as against Rs.3,145 with harvest combines as depicted in the Fig 5.1. This indicates that there was a difference of Rs.500. Thus by using harvest combine a farmer could save about Rs.500 per hectare and finish threshing and winnowing operations simultaneously.

From the above analysis it is evident that wherever the harvesting was done by harvest-combine the extent of mechanization was 100 per cent. If the

human labour was employed to carryout this operation, then the extent of mechanization was zero per cent.

As mentioned earlier 70.83 per cent of the mechanized category of farmers, used harvest-combines for harvesting. However this adoption was observed in recent years. This may be because of two reasons, firstly higher demand for human labour at the time of harvest, which escalates the wages and secondly to save the time, when it should not be delayed. Hence farmers are becoming more positive towards mechanization of harvesting, rather than waiting or paying high wages for casual labour.

5.2.1.3 Irrigation

It is the mechanization of irrigation that makes all other mechanized and non-mechanized operations, profitable by enhancing yields through the best utilization of inputs. Mechanization of irrigation indicates the irrigation by tube wells or bore wells with the help of oil engines and electric pumpsets. On a mechanized farm, the contribution of costs incurred on pumpsets (Rs.1,486 per hectare) to the total irrigation costs (Rs.3,211) was about 46.28 per cent. The cess for canal (Rs.625) and human labour wages (Rs.1,100) together accounted for about Rs.1,725 per hectare.

From the foregoing analysis it can be suggested that the extent of mechanization in irrigation operation was about 46 per cent. The frequency of the farms indicated that 100 per cent of mechanization for the irrigation operation on mechanized farms.

Table 5.7 Extent of machine labour costs per hectare, in the total costs of various farm operations

S. No.	Operation	Total costs (Rs)	Costs on Machine (Rs)	Extent (%)	Farmers	
					Freq.	%
1	Ploughing	1664.17	1586.67	95.34	120.00	100.00
2	Seeds & Sowing	914.58	---	---		---
3	Manures & application	1696.37	500.52	29.51	98.00	81.67
4	Fertilizers & application	3033.12	---	---		---
5	Weeding	573.02	---	---		---
6	Transplanting	1179.69	---	---		---
7	Plant protection chemicals & application	846.35	---	---		---
8	Irrigation	3211.47	1486.19	46.28	120.00	100.00
9	Harvesting	1310.71	---	---		---
10	Threshing	1278.57	721.43	56.42	35.00	29.17
11	Winnowing	1063.57	---	---		---
12	Harvesting with HC	3145.64	3145.64	100.00	85.00	70.83
13	Total without HC	16771.63	4294.80	25.61		
14	Total with HC	15639.41	6719.01	42.96		

HC: Harvest Combine

5.2.1.4 Threshing

As mentioned earlier, threshing was done by two ways, one was by harvest combines and other was by tractor. The extent of mechanization in the former case was 100 per cent while in the latter with tractor was 56 per cent. The frequency of farmers indicated that more than 70 per cent of the farmers have adopted harvest-combines and carried out the threshing operation with complete

mechanization, while the remaining 20 per cent of farms mechanized the threshing operation only partially with tractor. But all the 120 mechanized farms have mechanized threshing operation either partially or completely.

5.2.1.5 Winnowing

Winnowing operation was mechanized only on the farms, where harvesting and threshing was carried out by harvest-combines. All the three operations were carried out by harvest combine machine simultaneously. Hence wherever the harvest combine was used all the three operations were mechanized. If the harvesting was done by harvest-combines, the extent of mechanization of the winnowing operation was upto 100 per cent, otherwise this operation had to be carried out by human labour and in that case, the extent of mechanization was zero per cent. Though there were some blowers and fans for artificial wind creation, farmers were not adopting them due to practical problems such as transportation, space etc.,

5.2.1.6 Manuring

The results presented in Table 5.7 indicated that the expenditure on machine labour in the form of transportation of manures was Rs.500.10 and it accounted for 29.51 per cent of the costs spent on manuring operation. This indicates that the extent of machine costs in the manuring operation was about 30 per cent.

5.2.1.7 Total expenditure

The results in Table 5.7 (Fig 5.1) indicated that the extent of machine costs in the total costs (Rs.16, 771) was about 25.61 per cent, when the harvesting

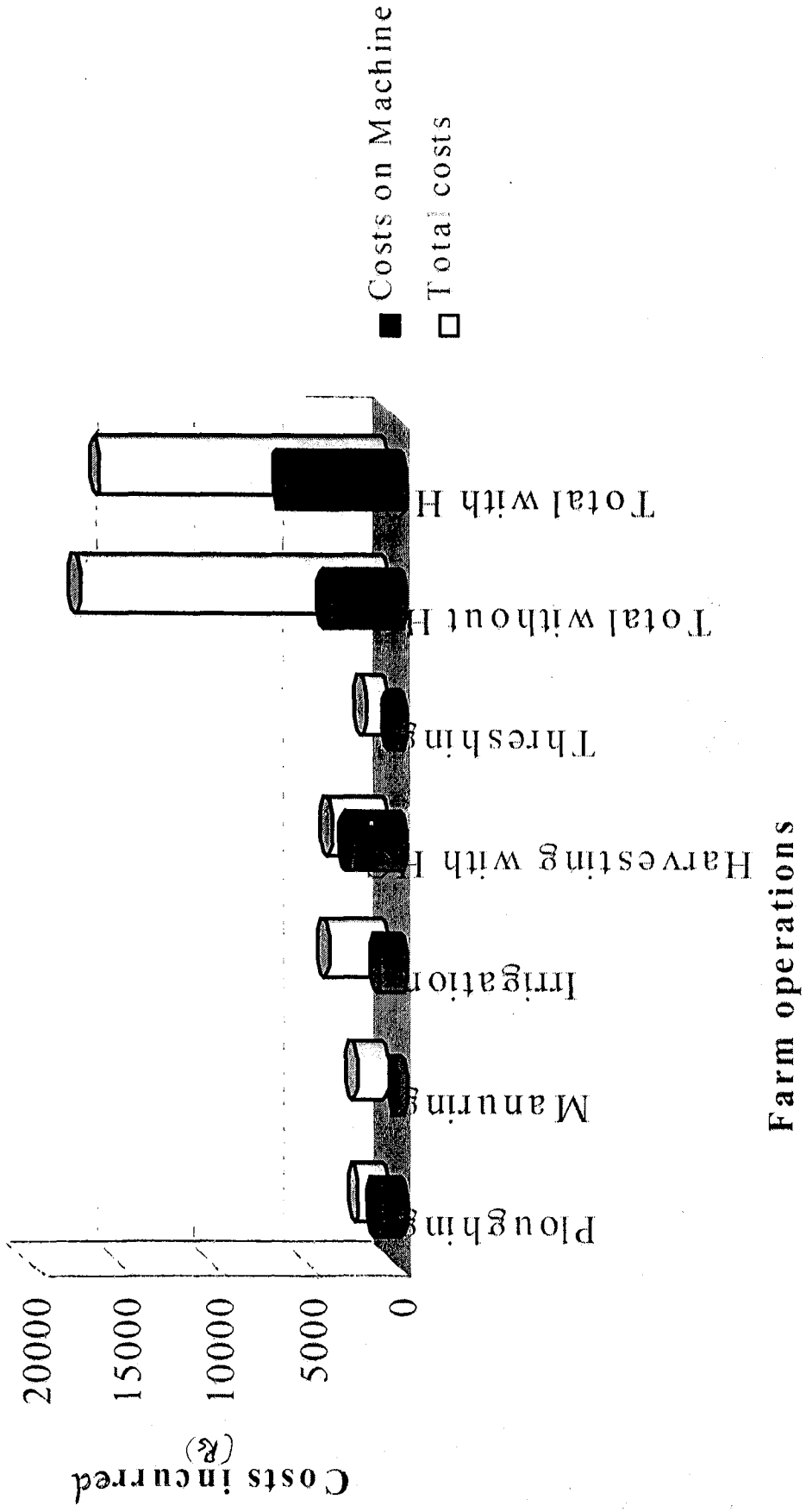

Extent of mechanization in various farm operations
Costs on Machine
Total costs
Costs incurred (Rs)
20000
15000
10000
5000
0
Ploughing
Manuring
Irrigation
Harvesting with H
Threshing
Total without H
Total with H
Farm operations

Fig 5.1

was done by human labour and costs incurred on machine labour accounted for Rs.4,294. If the harvesting was done by harvest-combine the extent of mechanization increased to 42.9 per cent with Rs.6,719 per hectare on machine labour. However, the total costs on mechanized farms decreased from Rs.16,771 to Rs.15,639 with the use of harvest-combine.

While the machine labour extent had gone to 42.9 per cent on the mechanized farms, with the use of harvest-combines. It was also indicated that the remaining operations like sowing, manuring, transplanting etc., were not mechanized on the sample, mechanized farms. Among these operations, transplanting was also a labour intensive operation, as it was the case of harvesting, transplanting also required a lot of human labour simultaneously with the onset of the rains or monsoon. This would cause a lot of demand for human labour and thereby the labour would demand higher wages. Hence, there is every necessity to mechanize this operation in order to save the time and also to avoid high demand for human labour. But the survey identified some problems associated with transplanters, like growing of nursery by a specific method called Dapog method or growing of seedlings in trays, which costs very high. These problems will be discussed in detail in the last section called "Problems and Constraints in using machinery".

From the above discussion it can be concluded that among all the farm operations, ploughing was mechanized to the maximum extent (95.34 %) on all the farms, followed by threshing (56.42 %) and irrigation (46.28 %) operations. However use of harvest combine indicated 100 per cent mechanization of harvesting, threshing and winnowing operations and increased the total extent of

mechanization from 25.61 per cent to 42.9 per cent, besides reducing the total costs on mechanized farms by Rs.505 per hectare.

5.2.2 Comparative economics of mechanization of farm operations with traditional methods

The increased irrigation facilities led to increase in the cropping intensity, thereby increase in the demand for human labour enormously. At this point there is a need to search for alternatives for labour and mechanization seemed to be the best alternative. But in Indian conditions complete mechanization is not advisable, because of surplus labour. Hence partial or selective mechanization is always recommended. In order to find the operations, which can be mechanized profitably the following analysis was carried out by comparing the economics of farm operations on both the categories of farms and presented in Table 5.8.

From the foregoing analysis and discussion operations mechanized on the selected holdings were ploughing, transportation of manures, irrigation, harvesting, threshing and winnowing. Hence inorder to study the comparative economics of farm operations on both categories of farms, only these operations were considered, as important.

5.2.2.1 Ploughing:

The results presented in Table 5.8 and depicted by the Fig 5.2 indicated that the total ploughing costs increased from Rs.1,597 on non-mechanized to Rs.1,664 per hectare on mechanized farms. The difference between these two was Rs.66.97, which was statistically significant at 5 per cent level ($P < 0.05$). Thus

indicating the mechanization had significantly increased the costs incurred on ploughing operation. This may be because of higher per unit operation cost of tractor ploughing than the animal ploughing. Though there was a significant increase in costs on mechanized farms, tractor ploughing has saved a lot of time and gave good tilth. Further it helped for the timely sowing, thereby contributed to increased production. Hence most of the farmers were adopting tractor ploughing.

5.2.2.2 Manuring

Results presented in Table 5.8 indicated that, the expenditure on manures was significantly higher on mechanized farms by Rs.500 per hectare and this is highly significant at 1 per cent level of probability. Thus the costs incurred on manuring operation were increased from mechanized to non-mechanized farms. Further the results indicated that both the cost of manure applied and transportation costs were higher on mechanized farms by Rs.315 and Rs.191 respectively. This may be because the cost of transportation by tractor on the mechanized farms was high when compared to the bullock carts on non-mechanized farms. However another reason for higher costs on mechanized farms may be application of large quantities of manure on mechanized farms, which also increases the total cost of transportation.

5.2.2.3 Harvesting

As mentioned earlier harvesting operation was carried out in two ways on mechanized farms alone, by harvest-combines and by employing human labour. Among 120 mechanized farms, 83 farms used harvest-combines. When it was done by harvest-combines the costs of threshing and winnowing also included.

Hence in order to facilitate the comparison, costs of threshing and winnowing were also added to the harvesting costs on non-mechanized farms, as it is given in Table 5.8. There was a significant decrease in costs by Rs.1,029 when harvest-combine was used (from Rs.4,175 to Rs.3,145), the decrease was found to be statistically significant at 1 per cent level of probability. Thus mechanization had significantly reduced the cost of harvesting operation. When the harvesting was done by human labour, there was no significant difference between the costs incurred by the two categories of farms. Thus from the above analysis it can be said that harvesting operation together with threshing and winnowing, can be mechanized profitably.

5.2.2.4 Threshing

This operation was carried out in two ways and both were mechanized. Firstly by harvest-combines and the other was by tractor. When it was carried out with harvest combine, the costs cannot be compared separately. Hence threshing by tractor (mechanized) and human labour(non-mechanized) were compared. The results indicated that there was a decline in costs from Rs.1,851 per hectare on non-mechanized to Rs.1,278 per hectare on mechanized. This difference Rs.573, was found to be highly significant at one per cent level. Thus mechanization had significantly reduced the cost of threshing operation on mechanized farms. This may be due to less cost of tractor threshing. Further it was observed that the wages of human labour for threshing operation were at the rate of Rs.110 per manday. Thus the above discussion suggests that threshing can also be mechanized profitably.

Table 5.8 Comparative costs of farm operations on mechanized and non-mechanized farms. (per hectare)

S. No	Operation	Mechanized (Rs)	Non-mechanized (Rs)	Difference (Rs)	Standard Error
1	Ploughing *	1664.17	1597.19	66.98*	33.83
2	Sowing	914.58	806.88	107.71**	23.87
3	Manuring*	1696.37	1195.69	500.67**	99.38
	a) Cost on transportation	500.10	309.06	191.04**	48.93
	b) Cost of manure	997.27	681.28	315.99**	102.56
4	Fertilization	3033.12	2777.17	255.96**	75.63
5	Weeding	573.02	531.04	41.98	26.48
6	Transplanting	1179.69	1151.77	27.92	22.48
7	Plant protection	846.35	1003.44	-157.08**	63.04
8	Irrigation *	3211.47	1720.63	1490.85**	76.81
9	Harvesting	1310.71	1243.02	67.69	37.33
10	Threshing *	1278.57	1851.67	-573.10**	39.45
11	Winnowing	1063.57	1080.83	-17.26	33.62
12	Harvesting with HC *	3145.64	4175.52	-1029.88**	186.41
13	Total without HC	16771.63	14959.31	1812.32**	208.34
14	Total with HC	15639.41	14959.31	680.10**	176.93

** Significant at P < 0.01 * Significant at P < 0.05

* Operations mechanized HC: Harvest combine

5.2.2.5 Winnowing

Winnowing was not mechanized on both the categories of farms, except when it was done by harvest-combine. The comparative economics of mechanized and non-mechanized farms with respect to winnowing operation indicated no significant difference. However harvest combines can be profitably

employed, which would simultaneously carry out winnowing operation, in order to save the time and money.

5.2.2.6 Operations, in which no machine was involved

***Sowing*:** It was observed that the expenditure on sowing per hectare was also more on mechanized farms Rs.914 when compared to non-mechanized farms Rs.806 and the difference was found significant statistically at one per cent level. This increase may be because of two reasons. Firstly use of high yielding, good quality or hybrid seed, which costs high and the other was application of seed at higher rates per hectare but not be due to mechanization.

Fertilizer application: In this operation no mechanization was done and it was carried in a similar way on both categories of farms. But still there was a considerable increase in costs on mechanized farms when compared to non-mechanized farms. This may be due to application of high doses of fertilizers by mechanized category of farmers. This is in conformity with the results of Lai *et al* (1976).

Weeding: Weeding operation was also done by human labour on both the farms. It was clear from Table 5.8 there was only a difference of Rs.41and it was not statistically significant. Hence as the results indicated, there was no significant difference between the expenditure spent on weeding by both the categories of the farmers.

Plant protection: The results presented in Table 5.8 (Fig 5.2) indicated that there was decrease of Rs.150 per hectare in costs incurred on plant protection operation

Comparative costs of mechanized and non-mechanized farms

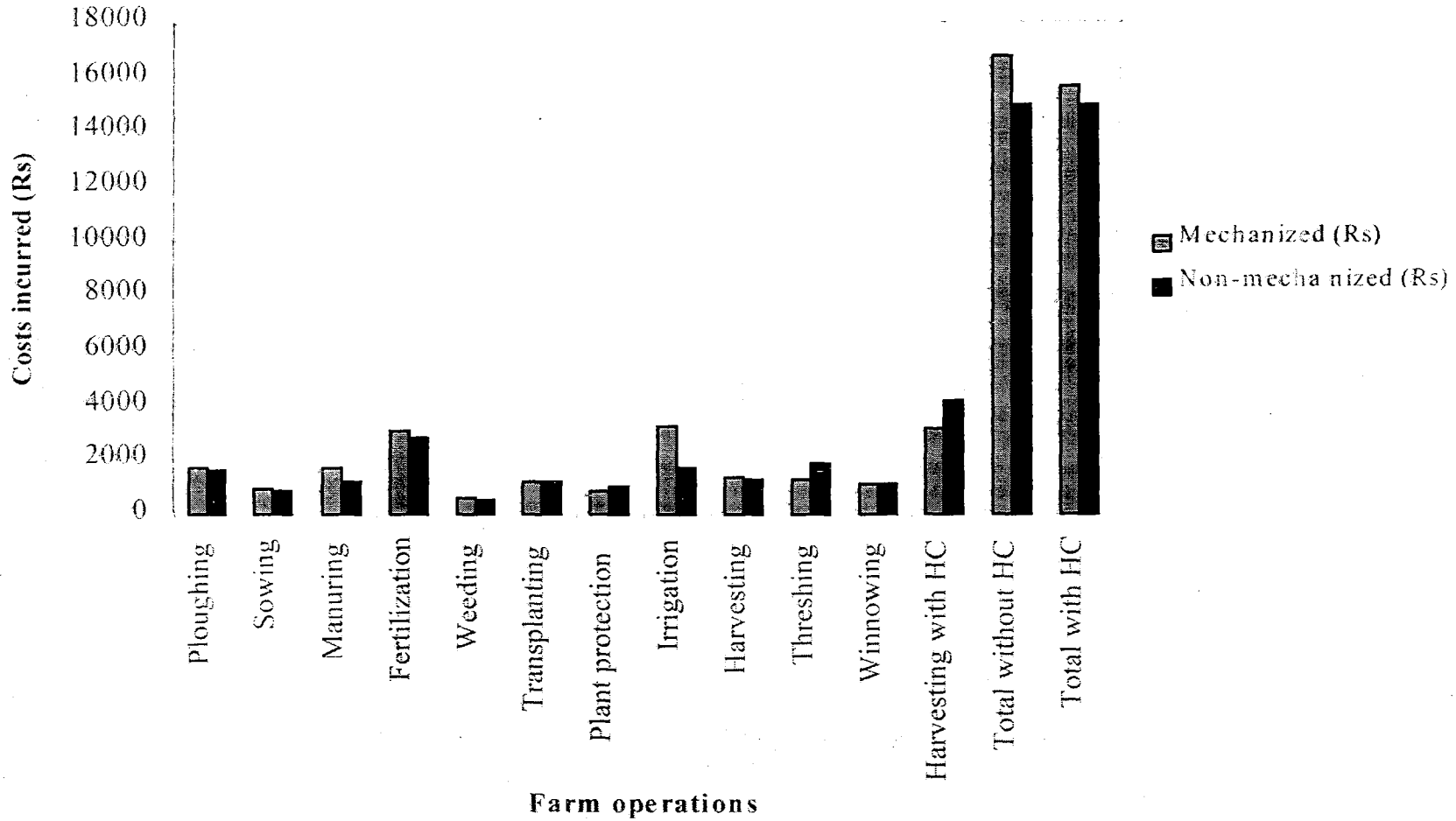


Fig 5.2

from non-mechanized to mechanized farms and this decrease was highly significant at 1 per cent level. However the significant difference observed may not be accounted for mechanization, since the operation was carried out by human labour on both the farms with hand operated sprayers and the decrease in costs may be due to application of less quantities of chemicals per hectare on mechanized farms.

***Transplanting*:** Transplanting operation is very much labour intensive and its mechanization was not yet popularized among farmers. From the results presented in Table 5.8 it is indicated that, there was a slight increase of transplanting costs by Rs.27 per hectare from non-mechanized to mechanized farms. But it was not statistically significant. However due to high demand for human labour and non-availability of labour on time, mechanization of transplanting can profitably be introduced with suitable machinery.

5.2.2.7 Total

The results presented in Table 5.8 (Fig 5.2) indicated that there was an increase in total costs by Rs.1812 per hectare on mechanized farms when compared to non-mechanized farms, when the harvest combine was not used for harvesting. This increase was found to be highly significant at 1 per cent level. However the increase in total costs incurred on mechanized farms had gone down to Rs.680 per hectare, when the harvest combine was used and this difference was also highly significant at 1 per cent level. This may indicate that, the mechanized category of farmers were spending more money on farm operations when compared to non-mechanized farmers, which may be in terms of higher inputs or higher wages to the labour.

From the above discussion it can be concluded that, the costs incurred on all operations were significantly higher on mechanized farms when compared to non-mechanized farms except on plant protection and threshing operations, on which the mechanized farms spent less costs by Rs.187 and Rs.573 per hectare compared to the other farms. Thus the null hypothesis "Farm mechanization does not affect the costs incurred farm operations" is rejected and concluded that mechanization had significant affect on costs incurred on farm operations. This is in conformity with the results of Singh *et al* (1986), they concluded that on mechanized farms the costs incurred were higher on all operations when compared to non-mechanized farms. Further when the harvest combine was used the cost of harvesting, threshing and winnowing operations together reduced by Rs.1,029. However the significant increase in costs incurred on operations like sowing, manuring, fertilizer application etc., on mechanized farms was not due to mechanization, since all these operations were carried out by human labour on both the categories of farms and no machine was involved either partially or completely.

5.2.3 Pattern and extent of labour absorption or displacement due to farm mechanization

Employment of labour can vary significantly even on farms of the same size located in the same area, cultivating the same crop, if the degree of mechanization is different. It is common knowledge that mechanized farms require less labour when compared to non-mechanized. However there has been a controversy of opinion i.e., whether mechanization causes absorption or displacement of labour. In order to arrive at some meaningful conclusions

regarding the pattern of labour employment, an attempt was made to study the employment of labour operation-wise with respect to the two categories of farms.

The results presented in Table 5.9 (Fig 5.3) and the earlier discussion indicated that the operations mechanized were ploughing, irrigation, transportation of manures, harvesting and threshing. Hence these operations were considered as important for comparison.

5.2.3.1 Ploughing

It was clear from Table 5.9 that there was a slight decrease in human labour employment from 4.50 to 4.38 mandays on mechanized farms. However this difference was significant at 5 per cent level of probability. The per cent displacement of human labour was only 4.37 per cent. But in case of bullock labour it was 100 per cent displaced by tractor ploughing. But though there is a significant difference in casual human labour absorption, the difference was only 0.13 mandays as indicated in the Table 5.9, while in case of bullock labour 12.80 Cattle Pair Days were completely displaced by tractor in ploughing operation. However if we consider the human labour, who works with the cattle pair in ploughing the displacement might be about 13 mandays.

5.2.3.2 Manuring

In case of manuring only transportation was mechanized and this was also completely displaced tractor transportation. But with respect to human labour there was no significant difference between mandays worked out on the two farms. This is conformity with the results of Johl (1973). He concluded that tractorisation

5.9 Operation wise pattern of labour employment on selected farms (per hectare)

S. No	Operation	Mecha - nized	Non-mechanized		Difference		
		MDs	MDs	CPDs	MDs	S.E	% change
1	Ploughing	4.38	4.50	12.80	-0.13*	-0.06	-2.78
2	Sowing	2.60	2.50	0.00	0.10**	0.01	4.00
3	Manuring	4.42	4.31	12.35	0.11	0.14	2.55
4	Fertilization	8.44	7.17	0.00	1.27	1.09	17.73
5	Weeding	19.85	19.52	0.00	0.33	0.30	1.71
6	Transplanting	31.88	31.06	0.00	0.81*	0.36	2.62
7	Plant protection	6.40	6.23	0.00	0.17	0.13	2.68
8	Irrigation	32.61	25.58	0.00	7.03**	1.94	27.48
9	Harvesting	33.00	31.75	0.00	1.25	0.92	3.94
10	Threshing	6.45	16.83	0.00	-10.38**	-0.10	-61.65
11	Winnowing	15.85	19.23	0.00	-3.38**	-1.06	-17.57
12	Harvest-Combine	0.00	67.81	0.00	-67.81		100.00
13	Total without HC	165.87	168.68	0.00	-2.80**	0.11	-1.66
14	Total labour with HC	110.57			58.11		34.45
15	Permanent labour	5.50	0.31		5.19**	0.82	
	Per hectare	1.71	0.22		1.49**	0.34	

** Significant at P < 0.01 * Significant at P < 0.05

HC: Harvest combine MDs: Mandays

CPDs: Cattle Pair Days (A pair of cattle with a human labour)

did not have any significant effect on human labour employment. Thus from the above it can be suggested that mechanization did not have any affect on human labour absorption or displacement in case of manuring operation, however it had completely displaced the bullock labour transportation.

5.2.3.3 Irrigation

Mechanization of irrigation has led to assured irrigation throughout the year, thereby providing employment throughout. The results presented in Table 5.9 indicated that the human labour employment increased from 25.58 mandays on non-mechanized farms to 32.61 mandays on mechanized farms. This increase of about 7 mandays per hectare was found to be highly significant at 1 per cent level. This is in conformity with the results of Ahammed and Herdt (1984), Rao and Raju (1987) and ILO (1984). There was about 30 per cent increase in human labour absorption on mechanized farms than on non-mechanized. Mechanization of irrigation created employment for additional human labour through regular and increased number of irrigations, to look after and operate the pumpsets etc., Thus mechanization caused absorption of human labour in irrigation operation.

5.2.3.4 Harvesting

The foregoing results indicated that harvesting on mechanized farms was done in two ways. One with the use of harvest-combines and the other was by human labour. Harvesting by human labour had a positive effect on human labour absorption. There was a marginal increase in human labour absorption of 1.25 mandays. However it was not statistically significant and did not indicate any contribution from mechanization. It may be because of sample error.

But when the operation was carried out by harvest-combine, human labour was completely displaced. Since the harvesting, threshing and winnowing were carried out simultaneously by the harvest combine it has displaced the human labour used for all the three operations i.e. about 67 mandays per hectare. Thus on the farms where the harvest combine was used, 100 per cent displacement of human labour was observed with respect to the three operations mentioned above. This is in conformity with the results indicated by Rao (1972), Balister and Singh (1983) and Lingard *et al* (1994). Out of 120 mechanized farms 85 farms used harvest combine. That means 70 per cent of them used harvest-combines for harvesting. Thus the above results indicated that on mechanized farms, there was a marginal increase in labour absorption when the harvesting was carried out by human labour, while a 100 per cent displacement of labour was observed when it was done by harvest-combines.

5.2.3.5 Threshing

As it was mentioned earlier, threshing operation was carried out in two ways. Threshing with harvest-combine had completely replaced the human labour. Mechanized farms, on which human labour was employed for harvesting adopted tractor threshing. The results indicated that when these farms compared with non-mechanized farms, tractor threshing had also displaced more than 10 mandays per hectare and the difference was statistically significant at 1 per cent level of probability. This is in conformity with the results of Thomas and Kshirsagar (1985). Hence from the above discussion it can be suggested that, tractor threshing caused displacement of human labour.

Operation wise pattern of labour absorption

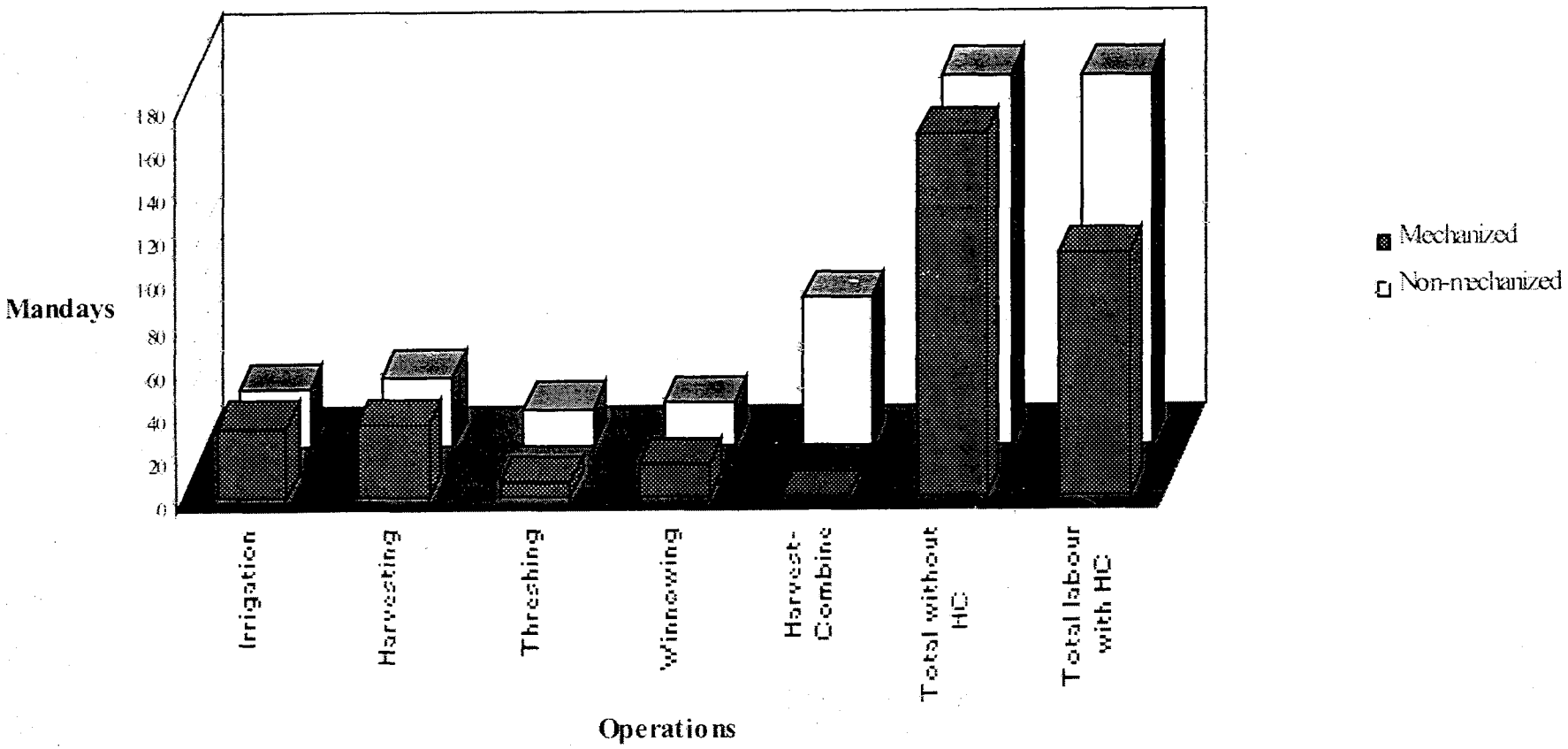


Fig 5.3

5.2.3.6 Operations not mechanized

Operations viz., sowing, fertilizer application, weeding, transplanting, plant protection and winnowing were not mechanized on both the categories of farms. However a slight increase in labour employment on mechanized farms with respect to these operations may be because of application of higher doses of these inputs which require additional labour. But the difference in human labour employment was not significant. Thus it can be suggested that mechanization had no direct effect on human labour employment in these operations.

5.2.3.7 Total

The results presented in Table 5.9 and depicted in the Fig 5.3 indicated that there was a slight decrease in human labour absorption from non-mechanized (168.68 mandays) to mechanized (165.87 mandays). The difference was about 3 mandays, which was found to be highly significant at 1 per cent level. Thus the null hypothesis "no change in the pattern of labour employment due to mechanization" is rejected and concluded that there was a significant displacement of labour due to mechanization. The per cent change in man days from non-mechanized to mechanized indicated that a less than 2 per cent of human labour was displaced on mechanized farms when compared to non-mechanized farms. Thus, though mechanization of agricultural operations had displaced human labour but it was not considerable (< 2%), though there was some displacement on ploughing and threshing operations it was compensated by absorption in case of irrigation these results are in conformity with the study conducted by Rao and Raju (1987) and

Nandal (1988). However this is in the case, where the harvesting was done by human labour.

But when the harvest combines were used, the average mandays on a mechanized farm indicated a large decline. Displacement of nearly 58 mandays per hectare, was observed due to the mechanization of three operations viz., harvesting, threshing and winnowing. When it was taken in per cent terms, about 34 per cent of total human labour was displaced by harvest combine on mechanized farms compared to non-mechanized farms. Thus the above analysis indicated that on mechanized farms considerable labour displacement (34 %) was observed only when the harvest combines were used, otherwise the displacement of labour was only less than 2 per cent. Hence though mechanization is profitable keeping in view of the danger of labour displacement and creation of fresh unemployment, selective mechanization may be more suitable for the labour abundant economies like India. These results are in conformity with the studies conducted by Rao (1972), Basant (1987) and Pariyar *et al* (1995).

5.2.3.8 Permanent labour employment:

The results presented in Table 5.9 indicate that there was a large difference of 5.19 labourers in the employment of permanent labour from mechanized (5.50) to non-mechanized farms (0.31). The permanent labour available per hectare also higher on mechanized farms by 1.49 labourers when compared to non-mechanized farms. This indicated that mechanized farms employed more number of permanent labour and suggested that there was a change in the pattern of labour employment. This might be due to the increased irrigation facilities through

mechanization, which led to the intensification of crops and operations, thereby creating regular and continuous employment opportunities rather than seasonal employment. These results are in conformity with the studies conducted by ILO (1984) and NCAER (1987). From this it may be concluded that mechanization had a positive effect on permanent labour employment.

From the above discussion it can be concluded that the cattle labour was completely displaced by tractors on mechanized farms, but in the case of casual labour, there was only a slight displacement. The displacement of casual labour observed on threshing and ploughing operations due to tractorisation was compensated by the casual labour absorption through irrigation operation. However the use of harvest combines caused a large displacement of casual labour. Further mechanization had a positive affect on permanent labour employment.

5. 3. FACTORS DETERMINING MECHANIZATION

Many previous studies have indicated that mechanization has been confined to the irrigated areas. Since irrigation has led to the intensification of crop production which necessitates the quicker completion of farm operations. This inevitably leads to mechanization of agricultural operations. Another important notion among the people is that the farm size restricts mechanization. Likewise there are so many factors that are influencing mechanization of agriculture either positively or negatively. In order to determine the factors that are significantly contributing to mechanization of farm operations in the study area, an attempt is made in this study.

The study used both primary and secondary data to determine the factors. A linear discriminatory function was fitted with the primary data. Functional analysis was carried out with the help of the secondary data. Multiple regression analysis models were tried and the equations which were found as best fit, were taken for the study. The results are presented in subsequent Tables with respect to each district.

5.3.1 Linear Discriminatory Analysis

Discriminatory functions were fitted to the primary data (collected district wise) for the three districts and to the pooled sample data also. Totally four linear discriminatory functions were fitted. In each function all the possible factors were considered. The sample observations were obtained from two groups

(populations) i.e., mechanized and non-mechanized. The empirical results of the analysis were presented district wise and discussed accordingly.

In the present study the factors included in the analysis were

X_1 = Age of the farmer

X_2 = Educational Status

X_3 = Farm size (ha)

X_4 = Area Irrigated (ha)

X_5 = Permanent labour

X_6 = Cropping Intensity (%)

X_7 = Total Casual labour (MDs)

X_8 = Total Wages paid (Rs)

X_9 = Productivity (Kg/ha)

X_{10} = Income (Rs)

Results of each discriminatory function are discussed individually and explicitly.

5.3.1.1 Prakasam district:

The discriminatory function for the district was

$$Z = 0.3705 X_1 + 2.16 X_2 + 2.93 X_3 + 0.54 X_4 + 3.8 X_5 + 0.28 X_6 + 1.32 X_7 - 0.02 X_8 + 0.03 X_9 - 0.002 X_{10}$$

$Z_1 = 144.625$ $Z_2 = 98.726$ $Z = 121.675$

The value of D^2 was found to be highly significant at 1 per cent level. This indicates the fitted function is valid to draw conclusions and the factors included have effective discriminating power. The mean Z score was 121.675

Table: 5.10 Results of discriminatory analysis for Prakasam district

S. No	Factors	Coefficient (li)	Mean difference (di)	Li * di	Percentage
1	Age	0.3705	-0.80	-0.2964	-0.6457
2	Educational Status	2.1625	1.60	3.4599	7.5381
3	Farm size	2.9367	1.85	5.4329	11.8366
4	Area Irrigated	0.5474	2.58	1.4095	3.0709
5	Permanent labour	3.8076	2.05	7.8057	17.0060
6	Cropping Intensity	0.285	74.34	21.1877	46.1612
7	Total Casual labour (MDs)	1.3259	-11.32	-15.0153	-32.7136
8	Total Wages paid	-0.0200	-968.48	19.3792	42.2211
9	Productivity	0.0307	137.50	4.2162	9.1857
10	Income	-0.0022	774.88	-1.6801	-3.6603
	D^2	45.89**			
	Z	121.675			

** Significant at $P < 0.01$

The relative importance of variables in discrimination can be obtained from the criterion $(Lidi)x100/D^2$. These results along with those of discriminatory analysis are presented in Table 5.10. Of all the factors, *cropping intensity* had relatively maximum weightage of 46.16 per cent of the total distance between the groups, followed by *wages paid to labour* (42.22 %) and *total number of casual labour (MDs) for crop production* (32.71%). The variable which had the

least weightage was *age of the farmer* (0.0645%) and the *area irrigated* and *income* were contributed about three per cent. *Permanent labour* and *farm size* contributed 17 and 11 per cent respectively.

The results presented in Table 5.11 indicated the mean differences and their significance between the two groups, corresponding to the variables included in the function. The difference is from mechanized to non-mechanized and the mean differences of all the variables were statistically significant. The mean difference with respect to *cropping intensity* was positive and significant suggesting that the *cropping intensity*, which had relatively maximum weightage in discrimination, is higher (73.34%) on mechanized farms. However the difference with respect to the variables *total casual labour (MDs) used in crop production* (11.3MDs) and *total labour wages paid* (Rs.968.48) were negative and significant at one per cent level ($P < 0.01$). With this it can be suggested that, *the casual labour employed* and *wages paid to the casual labour* were significantly reduced with mechanization. However unlike the casual labour, *permanent labour employed* had a positive affect on farm mechanization. This may be because of two reasons, firstly it may be due to the maintenance of machinery, secondly through mechanization (of irrigation especially) cropping intensity has been increased tremendously. This has resulted into a continuous requirement of labour throughout the year, leading to more employment of permanent labour rather than casual hired labour. Like wise the other variables like *irrigated area, farm size*, etc., were found to have positive affect on mechanization.

Table 5.11 Mean differences with respect to the factors included in the functions, (district wise)

S. No	Factors	Prakasam Dt (di)	Nellore Dt (di)	West Godavari Dt (di)	Pooled (di)
1	Age	-0.80** (-0.18)	-1.05** (-0.16)	-0.83** (-0.17)	0.892** (-0.10)
2	Educational Status	1.60** (0.18)	1.37** (0.19)	1.28** (0.20)	1.416** (0.11)
3	Farm size	1.85** (0.19)	1.68** (0.21)	1.83** (0.21)	1.783** (0.12)
4	Area Irrigated	2.58** (0.16)	2.27** (0.22)	2.75** (0.15)	2.5** (0.11)
5	Permanent labour	2.05** (0.14)	2.15** (0.16)	2.02** (0.15)	2.083** (0.09)
6	Cropping Intensity	74.34** (4.46)	71.84** (5.15)	76.07** (3.99)	73.416** (2.71)
7	Total Casual labour (MDs)	-11.32** (-2.11)	-19.55** (-2.35)	-18.92** (-1.75)	-16.567** (1.24)
8	Total Wages paid	-968.48** (-131.59)	-1956.25** (-127.19)	-1601.75** (-104.01)	-1512.13** (77.51)
9	Productivity	137.50** (29.13)	236.52** (54.50)	189.38** (34.31)	188.13** (28.42)
10	Income	774.88** (195.68)	1178.38** (296.82)	953.38** (175.90)	972.175** (140.08)

** Significant at $P < 0.01$

Thus of all the factors included, *cropping intensity, wages paid to labour and total casual labour (MDs) for crop production* were found to be important as they occupied first three places respectively to discriminate between the two groups, followed by *permanent labour employed, farm size and productivity*. Hence from this it can be concluded that these factors had influenced the mechanization of farm operations significantly in Prakasam district.

The critical scores for the two groups were 144.625 (Z_1) and 98.726 (Z_2) for the first (mechanized) and second (non-mechanized) groups respectively.. Based on this score individual observations can be classified or determined to which group they belong to. If the score of a particular observation falls above 121.675

then it would belong to the mechanized (first) group, otherwise to the non-mechanized group.

5.3.1.1 Nellore district:

The discriminatory function for the district was

$$Z = -1.737\ X_1 - 0.5603\ X_2 + 5.5728\ X_3 - 8.3232\ X_4 + 6.6578\ X_5 + 0.3471\ X_6 + 0.1846\ X_7 - 0.0069\ X_8 - 0.007\ X_9 + 0.0012\ X_{10}$$

$Z_1 = 65.0222$ $Z_2 = 24.611$ $Z = 44.816$

The D^2 was tested with F test and was found to be highly significant at 1 per cent ($P < 0.01$), indicating the validity of the fitted discriminant function between the two groups. The mean score (Z) was found to be 44.816.

The relative weightages of the variables obtained from the criterion Lidi x 100/ D^2 are presented in Table 5.12. Among them *cropping intensity* occupied the first place with 61.706 per cent of the total distance between the groups, indicating its importance in discrimination of the mechanized farms from non-mechanized farms. Followed by *area irrigated* with 46.85 per cent and *permanent labour*, *wages paid to labour for crop production*, *farm size* and *total casual labour (MDs) for crop production* had 35.42 per cent, 33.609 per cent, 23.098 per cent and 8.928 per cent respectively to the total distance (D^2). Unlike in the case of Prakasam district *age group* was contributing 4.5 per cent to the total distance in Nellore and the *educational status* of the farmer (1.91%) had the least weightage among all. Further the *productivity* (4.18%) and *income* (3.53%) had a small weightage.

Table: 5.12 Results of discriminatory analysis for Nellore district

S. No	Factors	Coefficient (Li)	Mean difference(di)	Li * di	Percentage
1	Age	-1.7370	-1.05	1.8239	4.5133
2	Educational Status	-0.5603	1.37	-0.7704	-1.9063
3	Farm size	5.5728	1.68	9.3345	23.0988
4	Area Irrigated	-8.3232	2.27	-18.9353	-46.4568
5	Permanent labour	6.6578	2.15	14.3143	35.4218
6	Cropping Intensity	0.3471	71.84	24.9361	61.7062
7	Total Casual labour (MDs)	0.1846	-19.55	-3.6082	-8.9287
8	Total Wages paid	-0.0069	-1956.25	13.5821	33.6099
9	Productivity	-0.0072	236.52	-1.6927	-4.1888
10	Income	0.0012	1178.38	1.4268	3.5307
	D^2	40.411**			

** Significant at $P < 0.01$

The results presented in Table 5.11 indicated the mean differences and their significance between the two groups corresponding to the variables included in the function. The mean differences of all the variables were statistically significant. The mean difference with respect to variables *cropping intensity, area irrigated, permanent labour and farm size*, which had relatively more weightage in discrimination, was positive and highly significant at one per cent ($P < 0.01$) suggesting that they had a positive affect on mechanization. However the difference with respect to the *total labour wages paid* (Rs.968.48) were negatively significant at one per cent level ($P < 0.01$). This suggests that the *cropping intensity, area*

irrigated, permanent labour and farm size had a positive affect on mechanization while *wages paid to casual labour* reduced with mechanization. Like wise the other variables, *age and education status*, *productivity, income* etc., were found to have positive affect on mechanization.

Thus among all the variables included, *cropping intensity, area irrigated, permanent labour employed, wages paid to labour for crop production, farm size and total casual labour (MDs)* used for crop production were the important factors contributing to mechanization in Nellore district. Further to some extent *age* and agricultural *productivity* were also contributed.

5.3.1.3 West-Godavari District:

The discriminatory function for the district was

$$Z = 2.368\ X_1 + 1.604\ X_2 + 3.156\ X_3 + 2.459\ X_4 + 3.518\ X_5 + 0.337\ X_6 + 0.289\ X_7 - 0.013\ X_8 + 0.008\ X_9 - 0.004\ X_{10}$$

$Z_1 = 60.34$ $Z = 30.66$ $Z_2 = 0.987$

The D^2 was tested with F test and was found to be highly significant at one per cent level ($P < 0.01$) indicating the fitted function was valid, and the variables included were effective in discrimination between two groups. The mean Z score was 30.66.

The details of relative importance of factors included in the function, between the two groups are presented in Table 5.13. *Cropping intensity* and *wages paid to labour for crop production* had maximum relative weightages 43.246 per cent and 36.672 per cent respectively, followed by *permanent labour employed* and

area irrigated with 12 per cent and 11.39 per cent respectively. The factors that had the least weightage were agricultural *productivity, age and educational status* of the farmer each contributed about 3 per cent.

Thus from the above analysis, it is clear that mechanization of farm operations in West Godavari district was mainly influenced by *cropping intensity, wages paid to labour for crop production, area irrigated, permanent labour employed and farm size*

Table: 5.13 Results of discriminatory analysis for West Godavari district

S. No	Factors	Coefficient (Li)	Mean difference (di)	Li * di	Percentage
1	Age	2.3682	-0.83	-1.9537	-3.2916
2	Educational Status	1.6047	1.28	2.0460	3.4470
3	Farm size	3.1560	1.83	5.7598	9.7038
4	Area Irrigated	2.4591	2.75	6.7626	11.3934
5	Permanent labour	3.5187	2.02	7.1254	12.0046
6	Cropping Intensity	0.3374	76.07	25.6690	43.2461
7	Total Casual labour(MDs)	0.2894	-18.92	-5.4775	-9.2282
8	Total Wages paid	-0.0136	-1601.75	21.7674	36.6728
9	Productivity	0.0087	189.38	1.6509	2.7814
10	Income	-0.0042	953.38	-3.9943	-6.7294
	D^2	59.355**			

**Significant at $P < 0.01$

The mean differences corresponding to all the variables as presented in Table 5.11 indicated that the relative important factor *cropping intensity* had a positive affect on mechanization with its positively significant mean

difference. However the *wages paid to the casual labour* was negative indicating its reduced use with mechanization.

5.3.1.4 Pooled sample

Total sample was pooled and that was considered to represent the coastal A.P., since these three districts were taken as representation for the entire coastal A.P. Thus the following function was fitted for coastal A.P.

The function fitted for the pooled sample was

$$Z = -0.024\ X_1 + 0.92\ X_2 + 2.13\ X_3 - 0.62\ X_4 + 3.53\ X_5 + 0.19\ X_6 + 0.17\ X_7 - 0.0063\ X_8 - 0.0073\ X_9 + 0.001\ X_{10}.$$

$Z_1 = 42.42$ $Z = 27.072$ $Z_2 = 11.724.$

From the results of fitted function it can be said, the D square was highly significant at one per cent ($P < 0.01$). . The mean Z score was 11.724

Table 5.14 indicates that, *cropping intensity* had maximum relative weightage of 46.33 per cent, among all the variables. Followed by *wages paid to labour for crop production, permanent labour* and *farm size* with 30.19 per cent, 23.97 per cent and 12.42 per cent respectively. Other factors like *productivity* and *educational status* had about 4 per cent each and the *age* of the farmer contributed the least. However the mean differences indicated that the *cropping intensity, permanent labour* and *farm size* had a positive effect on mechanization with their highly significant and positive mean differences, where as the *total wages paid to labour* had a negatively significant mean difference.

Table: 5.14 Results of discriminatory analysis for pooled sample.

S. No	Factors	Coefficient (li)	Mean difference(di)	Li * di	Percentage
1	Age	-0.024	0.892	0.0216	0.07
2	Educational Status	0.92	1.416	1.31	4.26
3	Farm size	2.13	1.783	3.81	12.42
4	Area Irrigated	-0.62	2.500	-1.54	-5.02
5	Permanent labour	3.53	2.083	7.35	23.97
6	Cropping Intensity	0.19	73.416	14.22	46.33
7	Total Casual labour(MDs)	0.17	-16.567	-2.85	-9.31
8	Total Wages paid	-0.0063	-1512.13	9.26	30.19
9	Productivity	-0.0073	188.13	1.36	-4.45
10	Income	0.001	972.175	1.003	3.27
	D^2	30.695**			

** Significant at P <0.01

From the above discussion, it can be revealed that among various factors that were considered, *cropping intensity* was found to be relatively more important factor to discriminate mechanization. Though all the other variables included were found to be important, its contribution was about 50 per cent in all the functions fitted, followed by *total wages paid to casual labour* for crop production and *permanent labour employmed.* However, in case of Nellore, *per cent area irrigated* occupied the second place followed by *permanent labour employed* and *total wages paid to casual labour* (for crop production). Though the other factors were found to be significant in discriminating the two groups, their contribution was not much, except for one or two cases like *farm size* in case of Nellore district and *casual labour (MDs)* used for crop production in case of Prakasam district. Thus it

can be concluded that the important factors that are determining or influencing the mechanization of agriculture in coastal Andhra Pradesh were found to be *cropping intensity, total wages paid to casual labour, permanent labour employmed, total casual labour(MD*s) used for crop production, *area irrigated and farm size.* To some extent *productivity* and *farm income* also helped in enhancing the machine use.

5.3.2 Results of multiple regression analysis

In order to find the determinants that have been contributing to the increased mechanization of agriculture, time series data was used. The stock of various components of machinery was fitted in the model as dependent variable and the possible independent factors too were included which were agricultural productivity, irrigated area, *long term credit,* and *price* of the corresponding machinery. Labour density was also considered but it was felt that it could not represent the actual involvement of labour in agricultural operations and hence its inclusion may not lead to any meaningful conclusions. Thus it was dropped out from the equation.

For the sake of convenience the results of the analysis are presented in the following sub-heads.

5.3.2.1 Tillage machinery

5.3.2.2 Irrigation equipment

5.3.2.3 Harvesting machinery

5.3.2.4 Plant protection equipment.

Each type of machinery was further analysed with respect to the selected districts. The stocks of machinery were used as dependent variables. The independent or predictor variables considered were agricultural *productivity*, *long term credit*, irrigated area as per cent of net area sown and the *prices* of the corresponding machinery.

When the number of machinery (tractors/power tillers) were considered, owing to the differences in the size of districts, the absolute number may not be felt appropriate for comparison. Hence the density of (tractors) machinery was taken, by dividing the number of machinery with net area sown in thousand hectares. Accordingly the density was expressed as number of machinery per thousand hectares of net area sown. The predictor variable area irrigated was also expressed in percentage terms to net area sown. The general equations used were:

$$Yi = a + b_1\ pdty + b_2\ Ir + b_3\ ltc + b_4\ P_{yi} + e$$

$$lnyi = a + b_1\ pdty + b_2\ Ir + b_3\ ltc + b_4\ P_{yi} + e$$

Where Yi = Density of machinery

ltc = Long term credit

Ir = Per cent area irrigated

P_{yi} = Price of corresponding machinery

pdty = Productivity: refers to Agricultural productivity

When both the above models were tried, semi-log model gave good fit with greater R^2 and increased significance of coefficients. Thus finally the semi-log fit was considered the better option.

5.3.2.1 Tillage machinery:

Under this both tractors and power tillers were considered. The results of semi-log functions fitted are presented and discussed below

Tractors:

West Godavari district:

While fitting the regression equation problem of multicollinearity was observed and to minimize the effect of this problem stepwise regression analysis was carried out. Among various equations tried the following equation gave the best fit with three variables *long term credit*, *per cent area irrigated* and *price* of the tractors.

$$\ln Td = -5.986 + 0.0867^{**} \ln c + 0.0354^{*} \ln r - 3.209 X10^{-7} {}^{*}P_t$$
$$(0.005) \qquad (0.012) \qquad (1.519x10^{-7})$$
$$R^2 = 0.988 \qquad F = 221.52^{**} \text{ with } (2, 11)df$$

Where lnTd = Natural log of tractor density

** Significant at $P < 0.01$ * Significant at $P < 0.05$

Figures in the parentheses indicate Standard Errors.

The above results indicated that the coefficients of *long term credit,* per *cent area irrigated* and *price* of tractors were found to be statistically significant at 1, 5 and 5 per cent level of probability respectively.

Highly significant coefficient *long term credit,* indicates its positive effect on the mechanization. Coefficient of the variable *per cent area irrigated* was also significant and positive emphasizing the fact that with increased irrigation and credit facilities mechanization has also been increased over time. However, *price* of tractors had a negative influence on the density of the tractors, thus reinforcing its theoretical relationship.

Nellore district:

Similar to the case of West Godavari district, regression was fitted through stepwise regression, due to the multicollinearity. Of all the equations tried the following equation gave the best fit with high R^2. The results are given below.

$$\ln Td = -3.0073 + 8.265 \times 10^{-4}{}^{**}\ pdty + 0.017^{*}\ Ir$$
$$(1.875 \times 10^{-4}) \qquad (0.0082)$$
$$R^2 = 0.901 \qquad F = 41.35^{**} \text{ with } (1,11)df$$

Where ** Significant at $P < 0.01$ * Significant at $P < 0.05$

Figures in the parentheses indicate Standard Errors.

Thus of all the four variables considered two variables, *productivity* and *per cent area irrigated* remained in the final equation and the other two were dropped out. Coefficients of *productivity* and percent area irrigated were found statistically significant at 1 per cent level and 5 per cent level respectively.

Hence with the above results it can be said that the agricultural *productivity* and *per cent area irrigated* were the two important determinants of tractorisation in Nellore district.

Prakasam district:

The final regression function fitted was

$$\text{InTd} = -4.4702 + 0.1244\ \text{lc}^{**} + 0.0231\ \text{Ir}^{*}$$
$$(0.036) \qquad (0.008)$$

$R^2 = 0.984$ $\qquad F = 276.96^{**}$ with (1,11) df

Where ** Significant at $P < 0.01$ * Significant at $P < 0.05$

Figures in the parentheses indicate Standard Errors.

The above equation fitted through stepwise regression analysis for Prakasam district had a high R^2 (98%) and the coefficients of the *long term credit* and *per cent area irrigated* were positive and significant at 1 per cent and 5 per cent level respectively. The positive sign of coefficients indicated that, both these variables might have enhanced the tractorisation in the district.

Thus from the foregoing analysis it is clear that the important determinants of tractorisation in case of West Godavari are *long term credit, tractor price* and *percent irrigated area.* However, the coefficient of *tractor price* was negative, indicating its negative effect. While in case of Nellore district only *agricultural productivity* and *percent area irrigated* were found to be influencing significantly. In case of Prakasam district also only *percent area irrigated and long term credit* were found to be the significant factors.

Power tillers

Functions fitted for ***West Godavari***

$$InPTd = -5.83 + 0.0313^{*}\ Ir + 6.17 \times 10^{-5}{}^{**}\ Ppt$$
$$(0.0102) \qquad (1.904 \times 10^{-6})$$

$R^2 = 0.993$ $\quad F = 655.035^{**}$ with (1,11)df

Nellore distract

$$InPTd = -4.53 - 8.602 \times 10^{-4} Pdty^{*} + 0.0289\ Ir + 4.61 \times 10^{-5} Ppt$$
$$(3.68 \times 10^{-4}) \qquad (0.025) \qquad (3.38 \times 10^{-5})$$

$R^2 = 0.60$ $\quad F = 4.034^{**}$ with (1,11) df

Prakasam distrct

$$InPTd = -9.36 + 2.7677 \times 10^{-4}{}^{*}\ Pdty + 0.1588^{**}\ Ic - 0.0389^{**}\ Ir$$
$$(1.327 \times 10^{-4}) \qquad (0.037) \qquad (0.009)$$
$$+ 5.6174^{**} \times 10^{-5} Ppt$$
$$(1.178 \times 10^{-5})$$

$R^2 = 0.985$ $\quad F = 169.58^{**}$ with (1,11) df

Where $\quad ^{**}$ Significant at $P < 0.01$ $\quad ^{*}$ Significant at $P < 0.05$

Figures in the parentheses indicate Standard Errors.

The above results indicated that all the functions fitted were good with high R^2 values i.e., more than 90 per cent, in case of West Godavari and Prakasam districts, while 60 per cent in case of Nellore district.

In case of west Godavari district coefficients of *percent area irrigated* and *price* of tractors were found to be statistically significant and positive

at 5 per cent and 1 per cent level respectively. While in the case of Prakasam district coefficients of all the four variables were found to be statistically significant but the coefficient of *per cent area irrigated* was negative even after conducting stepwise regression analysis. Hence the negative sign of the coefficient may be because of the influence of other variables and is inexplicable. However in Nellore district the coefficient of productivity was found significant at 5 per cent level but negative.

Thus in case of West Godavari *per cent area irrigated* and *price* of tractors were significantly contributing to the increase of power tiller use. In case of Prakasam district all the four explanatory variables were significantly influencing the power tiller density but the coefficient of *per cent area irrigated* was found to be negative. Whereas in case of Nellore district the variables included in the function explained only 60 per cent of the variation in density of power tillers and only one variable, *productivity* was significant but negative.

5.3.2.2 Irrigation Equipment:

The irrigation equipment included oil engines and electric motors. Densities of them (irrigation equipment) were taken into function as dependent variables and the function was fitted with selected independent variables or determinants. The results are presented district wise.

West Godavari:

Oil engines

$$\text{In OEd} = 1.5073 - \underset{(1.096\times10^{-4})}{6.109 \times 10^{-4}}{}^{**}\,\text{Pdty} + \underset{(0.011)}{0.0218}{}^{*}\,\text{Ir} + \underset{(5.326\times10^{-6})}{4.0218 \times 10^{-5}}{}^{**}\,\text{Poe}$$

$R^2 = 0.93$ $F = 49.44^{**}$ (1,11) df

Where lnOEd = Natural log of Oil Engine density

Electric motors:

In Emd = -2.381 + 0.1104** lc
(0.0141)

$R^2 = 0.889$ $F = 61.306^{**}$(1,11) df

Where lnEMd = Natural log of Electric motor density

** Significant at P < 0.01 * Significant at P < 0.05

Figures in the parentheses indicate Standard Errors.

The above results indicated that in case of oil engines, the final equation fitted was best with high R^2 and the coefficients of variables *per cent area irrigated, Price* and *productivity* were found to be significant at 1 per cent, 1 per cent and 5 per cent respectively. But the coefficient of *productivity* was negatively significant. The negative sign of the coefficient of *productivity* may be due to the effect of some other factors that is inexplicable. Thus the *per cent area irrigated, price* of oil engines and *agricultural productivity* were the significant factors that are determining the use of oil engines in West Godavari district.

In the case of electric motors only the coefficient of *long term credit* in the district was found to be statistically significant at 1 per cent level and the fit was good with high R^2 (85.9%). Thus it can be said that the density of electric motors in the district was increased with increase in the *long term credit.*

Prakasam district:

Oil engines:

$\ln OEd = 2.8769 + 2.42 \times 10^{-4}$ Pdty - 0.0264* Ir

(1.325×10^{-4}) (0.0099)

$R^2 = 0.6195$ F = 7.189* (1,11) df

Electric motors:

$\ln EMd = -1.8557 + 0.1378^{**}$ lc - 0.0241** Ir + $5.6753^{*} \times 10^{-5}$ Pem

(0.036) (0.008) (2.51×10^{-5})

$R^2 = 0.994$ F 516.322** (1,11) df

Where ** Significant at $P < 0.01$ * Significant at $P < 0.05$

Figures in the parentheses indicate Standard Errors.

Similar to other cases, stepwise regression results indicated the fit was good with R^2 99% . The variables included were *productivity* and *per cent area irrigated*, but only the coefficient of *per cent area irrigated* was found to be statistically significant at 5 per cent level and negative. Thus the density of oil engines in Prakasam district over a period was significantly influenced by *per cent area irrigated* negatively.

The final equation fitted through stepwise regression indicated that coefficients of predictor variables *long term credit* and *per cent area irrigated* were significant at 1 per cent level, while the coefficient *price* of electric motor was significant at 5 per cent level. However, the coefficient of *per cent area irrigated* was negatively significant this may be because of the influence of other variables. Hence the negative sign of the coefficient of *per cent area irrigated* is inexplicable.

Finally factors that are significantly determining the density of electric motors in the Prakasam district were *per cent area irrigated*, *long term credit* and *price*. The *long term credit* in the districts had a significant and positive influence over the electric motor density. Similarly though the coefficient of *percent area irrigated* had negative sign it may not necessarily mean its negative effect on the density of electric motors, since it was found that it had positive association with the density in correlation analysis. The *price* increase also could not affect its use significantly, which may be due to their increased demand for irrigation through bore wells.

Thus the important determinants of irrigation equipment were found to be *per cent area irrigated* in case of oil engines and *long term credit*, *per cent area irrigated* and *price* in case of electric motors.

5.3.2.3 Harvesting machinery

Mechanization of harvesting in the study area was with harvest-combine. The determinants for the density of harvesters in the study area were analysed and presented district wise.

West Godavari:

The final function fitted was

$$\ln Hd = -0.452 + \underset{(1.11\times10^{-6})}{2.5196^{**} \times 10^{-6}} P_H$$

$R^2 = 0.757$ $\quad F = 31.153^{**}$ with(1,11) df

Where ** Significant at $P < 0.01$ * Significant at $P < 0.05$

lnHd = Natural log of Harvester density

Figures in the parentheses indicate Standard Errors.

The density of harvesters in the district was considered to be influenced by agricultural *productivity*, *per cent area irrigated, long term credit* and *price*. However the final function fitted through stepwise regression analysis had only one explanatory variable i.e., *price*.

The results indicated that only *price* of harvesters was found to be statistically significant at one per cent level of probability and positive. This indicates that the *price* of harvesters had a positive influence on its density in the district. This suggests that, though there was an increase in *price*, the use of harvesters increased due to their efficient use in agriculture.

Prakasam district:

The final function fitted was

$$\ln Hd = -3.805 - 0.015134\ ^{**}pdty + 1.14 \times 10^{-5}\ ^{**}Ph$$
$$(0.0024) \qquad (5.23 \times 10^{-6})$$

$R^2 = 0.945 \quad F = 78.73.^{**}$ (1,11) df

Where ** Significant at $P < 0.01$ * Significant at $P < 0.05$

Figures in the parentheses indicate Standard Errors.

The density of harvesters in Prakasam district was significantly determined by *productivity* in the district and *price* of harvesters, as their corresponding coefficients were found statistically significant at 1 per cent level. However, the coefficient of *productivity* was negative, indicating its negative impact or influence on density of harvesters in this district. This may be because of the reason that being most of the area under rain fed conditions, the *productivity* of

crops Prakasam district is not increasing in tune with the number of harvesters in the districts. There was a considerable increase in the number of harvesters in the district during the study period i.e. from 14 in 1981to 147 in 1993. However the coefficient of *price* of harvesters was positive and significant at 1 per cent indicating that in spite of increase in their *price* the harvesters use was increased

Nellore district:

Function fitted was

$$\ln Hd = -3.9529 + 1.143^{*} \times 10^{-5}\ pdty + 2.96^{**} \times 10^{-6}\ P_h$$
$$(0.487\times10^{-5}) \qquad (1.41\times10^{-7})$$

$R^2 = 0.978$ $F = 459.60.^{**}$ with(1,11) df

Where ** Significant at $P < 0.01$ * Significant at $P < 0.05$

Figures in the parentheses indicate Standard Errors.

Similar to West Godavari district here also coefficient of *productivity* and *price* of harvesters were found to be positive and statistically significant at 5 per cent and 1 per cent respectively. R^2 was also high and fit was good. Thus in case of Nellore district the density of harvesters was significantly influenced by *productivity* and *price* of harvesters. Inspite of increase in its *price*, farmers are going for harvesters.

5.3.2.4 Plant Protection Equipment

Similar to the analysis other machinery, density of plant protection equipment in the district per thousand hectares of net area sown was considered as dependent variable and the predictor variables viz., *productivity*, *per cent area*

irrigated, price and *long term credit* of the machinery etc were considered. The functions were fitted individually for each district.

West Godavari:

Function fitted was

$$\ln PPEd = -1.913 + 0.0523^{**}\ Ir + 0.0017^{**}\ Pppe$$
$$(0.013) \qquad (1.346 \times 10^{-4})$$

$R^2 = 0.962$ $\quad F = 114.02^{**}$ (1,11) df

Where ** Significant at $P < 0.01$ * Significant at $P < 0.05$

lnPPEd = Density of Plant protection equipment

Figures in the parentheses indicate Standard Errors.

The results of stepwise regression analysis presented above indicate that the density of plant protection equipment in the district was significantly determined by *per cent area irrigated* and *price* of the equipment. With the high R^2 (0.96) the fit was found to be good. The positive sign of the coefficients indicated that though the *price* of the equipment was increased the demand (density) for them also increased because of increased use of pesticides and other plant protection chemicals along with the area irrigated.

Thus the important determinants of density of plant protection equipment found to be *per cent area irrigated* and *price* of the equipment.

Nellore district

The final equation fitted was

$$\ln PPEd = -0.1423 + 0.0026^{**}\ Pppe$$
$$(1.319 \times 10^{-4})$$

$R^2 = 0.975 \quad F = 394.90^{**}$ (1,11) df

Where ** Significant at P < 0.01 * Significant at P < 0.05

Figures in the parentheses indicate Standard Errors.

In case of Nellore district the density of plant protection equipment was significantly influenced by only its *price* at 1 per cent level. The R^2 was 97.5% and the fit was found to be good. Thus in case of Nellore district the density or stock of plant protection equipment was significantly determined by its *price* and the effect was found to be positive.

Prakasam district:

The final euqation fitted was

$$\ln PPEd = 3.217 + 0.0011^{**}\ Pppe$$
$$(9.188x10^{-5})$$

$R^2 = 0.935 \quad F = 144.70^{**}$ with (1,11) df

Where ** Significant at P < 0.01 * Significant at P < 0.05

Figures in theparentheses indicate Standard Errors.

The results o' regression analysis indicated that the coefficient of *price* of plant protection equpment was statistically significant at 1 per cent level and positive. The R^2 (93.5% was also found to be high and the fit was good with significant F value. Thus important determinant of density of plant protection equipment in the district was is *price.*

Results indicaed that in West Godavari district *per cent area irrigated* and *price* of plant rotection equipment were found to be statistically significant and positive indicaing their positive influence on the density of plant

protection equipment (PPE). Just as in the case of harvesters the use of plant protection equipment also increased in spite of the increase in their *price*. However, in case of Nellore and Prakasam districts the density of PPE was significant and positively influenced by its *price* only.

From the above discussion it be can summarized that, among the factors considered to influence the tractor density in the study area, *per cent area irrigated* was found significant. This is in conformity with the results obtained by Singh and Singh (1983). However *long term credit* was also a significant factor in West Godavari and Nellore districts. Density of power tillers was determined by *price* and *per cent area irrigated* in West Godavari, agricultural *productivity* in Nellore district and all the four factors (*long term credit*, *per cent area irrigated*, *price* and agricultural *productivity*).

Factors influencing oil engine density were agricultural *productivity*, *per cent area irrigated* and *price* in west Godavari, agricultural *productivity* in Nellore and *per cent area irrigated* in Prakasam districts. Density of electric motors was influenced by their *price* in all three districts. Further it was influenced by *long term credit* and *per cent area irrigated* in Prakasam district.

Important factor influencing the density of harvesters in the study area was their *price* in all the three districts. However agricultural *productivity* was also found significant in Nellore and Prakasam districts. Similarly the density of plant protection equipment in the study area was determined mainly by their *price* and in West Godavari district *per cent area irrigated* was also found significant.

5.4 IMPACT OF FARM MECHANIZATION ON CROPPING INTENSITY, PRODUCTION, PRODUCTIVITY AND INCOME ON THE SELECTED FARMS

Apart from human labour employment, mechanization also influences the factors like cropping intensity, production, productivity and income. Displacement or absorption of human labour alone does not decide whether to go for the mechanization or not. Though there may be some labour displacement with mechanization, if it has positive impact on the above mentioned aspects it is always profitable and advisable to go for such a kind of mechanization. To illustrate, in the case of paddy harvest combine, though it displaces about 42 per cent of human labour, it saves 5 to 10 per cent of grain loss. Further it reduces costs by replacing the highly paid human labour, thus giving high net returns. Hence in order to know whether mechanization is profitable or not there is every necessity to study its impact on cropping intensity, production, productivity and income of farms.

Impact was studied with respect to the factors like cropping intensity, production, productivity and income. Differences were calculated and tested for their statistical significance and the results are presented in Table 5.15.

5.4.1 Impact of mechanization on the Cropping intensity of the farm

The results presented in Table 5.15 indicated that there was a significant increase in cropping intensity from 105 per cent on non-mechanized farms to 180 per cent on mechanized farms. An increase of about 75 per cent was observed and it is depicted in the Fig 5.4. This increase was found to be

statistically significant at 1 per cent level of significance. Thus the null hypothesis "mechanization has no significant impact on cropping intensity" is rejected and concluded that mechanization had increased the cropping intensity by 75 per cent. This is in conformity with the results obtained by Rao (1972), Motilal (1973), Jayasuriya *et al.* (1986) and Balister *et al.* (1993). However this increase in cropping intensity was due to the extended irrigation facilities and conserving time in carrying out various operations.

Table 5.15 Impact of mechanization on various aspects

S. No	Particular	Mechanized	Non-mechanized	Difference	S.E
1	Cropping Intensity (%)	179.52	105.44	74.08**	28.20
2	Production (Q)	274.99	85.68	189.30**	18.02
3	Productivity (Q)	54.71	52.75	1.96**	0.28
4	Gross Income (Rs.)	26,675.00	24,253.13	2421.88**	349.80
5	Net Income (Rs.)	12,352.50	11,437.73	914.78**	179.36

** Significant at 1 % level (P<0.01)

5.4.2 Impact of mechanization on the Productivity of the farm

Results presented in Table 5.15 and depicted in the Fig 5.4 indicated that there was an yield increase of 196 Kg per hectare on an average on mechanized farm when compared to non-mechanized farms. This increase was found to be statistically significant at 1 $P < 0.01$. Thus the null hypothesis "mechanization has no significant impact on productivity" is rejected and concluded that mechanization had increased the productivity by 196 Kg per hectare. This is in conformity with the results of *Singh et al.* (1986). Important

reasons for this may be the extended irrigation facilities due to mechanization, use of high yielding variety seeds, etc. The average size of irrigated area on mechanized farms was about 3 hectares, whereas in case of non-mechanized farms it was only one hectare. Since it is a known fact that productivity on irrigated land is considerably higher than the non-irrigated area. Further the use of HYV, high fertilizer and manure application on average, on a mechanized farm was higher when compared to non-mechanized farm. Thus mechanization had increased the irrigated area thereby increasing the productivity.

5.4.3 Impact of mechanization on the Production of the farm

As it was seen earlier, increased productivity indicates increased production per farm on mechanized farms. The results presented in Table 5.15 indicated that production per farm on a mechanized farm (27 tonnes) was higher by nearly 19 tonnes per farm, when compared to non-mechanized farms (8 tonnes). This was found statistically significant. Thus the null hypothesis "mechanization has no significant impact on production" is rejected and concluded that mechanization had increased the production by 18 tonnes. This large difference was accounted for bigger size of mechanized farms. Frequency of farmers in various farm sizes, presented in Table 5.4 indicated that, about 95 per cent of the non-mechanized farms had less than or equal to 2 hectares, while more than 72.50 per cent of the mechanized farms had more than 2 hectares. Thus mechanized farms being large, produced much higher output when compared to non-mechanized, thereby creating a large increase in production due to mechanization.

Impact of mechanization on various aspects

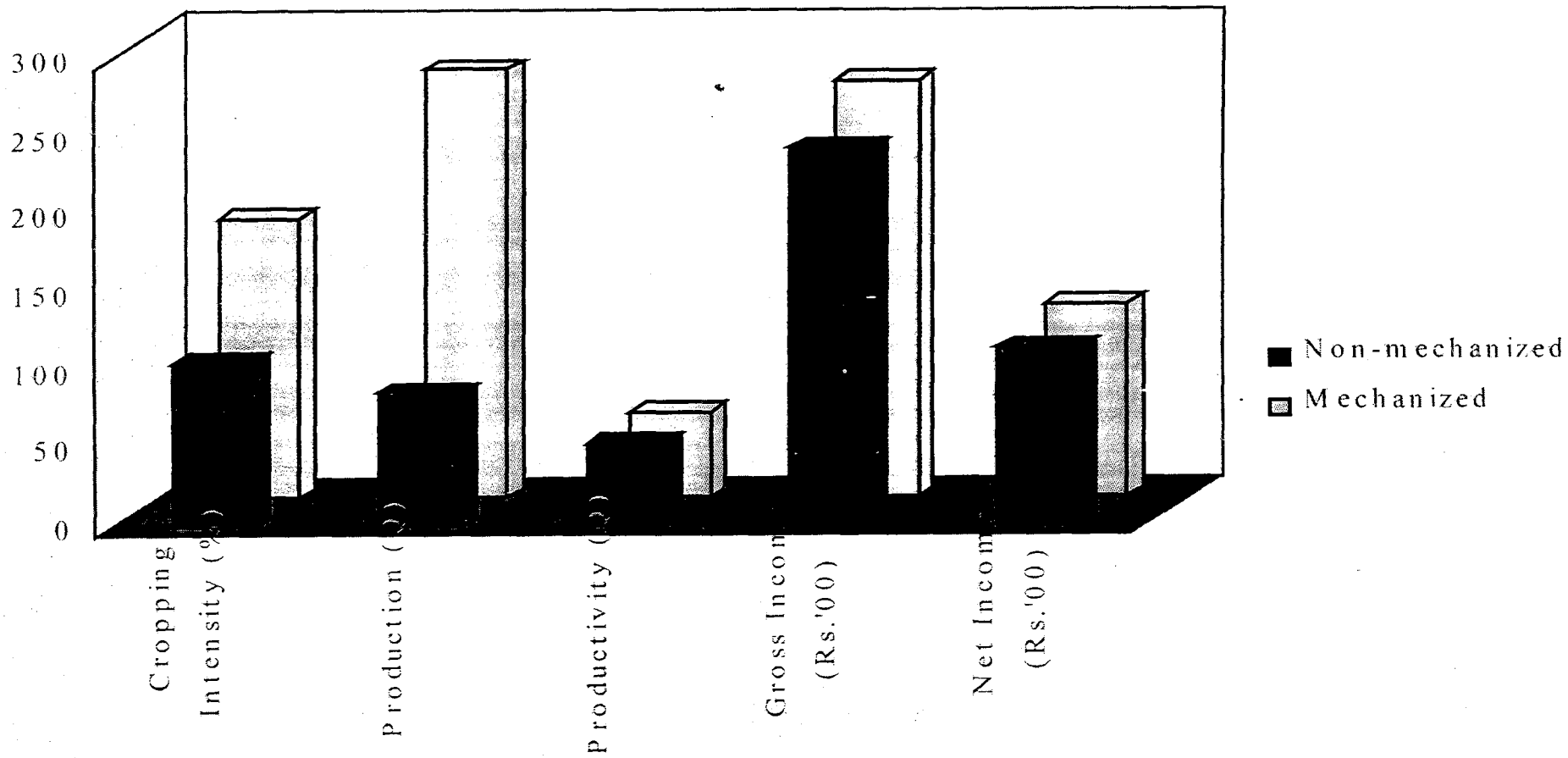


Fig 5.4

5.4.4 Impact of mechanization on the income of the farm

Gross income: The results presented in Table 5.15 indicated that gross income per hectare was also found to be higher on mechanized farms. It is a known fact that when there is high productivity on mechanized farms, there will definitely be high gross income. There was an increase in gross income of Rs.2,421 per hectare from non-mechanized (Rs.24,253.13) to mechanized farms (Rs.26675). This increase was found to be statistically significant at 1 per cent ($P < 0.01$). Thus the null hypothesis "mechanization has no significant impact on income" is rejected and concluded that mechanization had positive impact on gross income. This is in conformity with the study conducted by Kahlon (1976).

Net income: Information on operational costs was collected to study the impact of mechanization on net farm income. The results are presented in Table 5.15 and depicted in the Fig 5.4. The average net income from a mechanized farm per hectare exceeded the net income from non-mechanized from by Rs.914 and it was found statistically significant at 1 per cent level of probability. This is in conformity with the study conducted by Reddy *et al.* (1984) and Balister *et al.* (1993). Compared to non-mechanized farms the per hectare cultivation expenses of mechanized farms were higher by 7.93 per cent. The additional expenditure on mechanized farms may be accounted for the extra expenditure on material inputs, more number of irrigations, human labour etc., Thus a mechanized category of farmer in spite of spending more, derived higher net income per hectare compared to a non-mechanized category of farmer. However, this may not to be attributed

entirely to machine usage since the other factors such as high yielding varieties, fertilizers and irrigation have also contributed to it.

From the above discussion it can be concluded that mechanization had positive impact on all the aspects considered viz., cropping intensity, production, productivity and income.

5. 5. DEMAND PROJECTIONS FOR FARM MACHINERY IN THE SELECTED DISTRICTS

All the machinery, whether agricultural or manufacturing are supposed to be productive agents. Their services are inputs in production of output. With a given level of demand for an output, the demand for a durable input is a demand for stock, and not of a flow. Thus in order to project various types of farm machinery, a semi-log model was fitted with stock of machinery as dependent variable and *price* of machinery and other variables influencing the production process were considered as predictor variables. Stock of machinery was taken as number of particular machinery per thousand hectares of net area sown i.e. in terms of density per thousand hectares. The *prices* of machinery used in the models were relative prices. Other variables were average agricultural *productivity* in the district, *per cent area irrigated* and *long term credit* in the district.

However the study used the data of machinery stocks between 1981 to 1992, for a period of 12 years. The data pertaining to farm machinery were available only upto 1992, after that no survey relating to that has been conducted. Hence the latest data available was for the year 1992. With this data, models were fitted individually for various types of machinery district wise (the results are being presented and discussed subsequently). Growth rates of the predictor variables were calculated and then the predicted values for the corresponding variables were calculated. Finally these predicted values were substituted in the fitted model and thereby the demand for machinery was projected in the selected districts.

5.5.1 Demand projections for tillage machinery

Tillage machinery includes tractors and power tillers. These are the most important and widely used machinery in agriculture. Demand for this machinery was projected district wise for the years 2005 & 2010. The results are presented in Table 5.16.

Table: 5.16 District wise demand projections for various types of farm machinery

Machinery & District	2005		2010	
	Density	Stock	Density	Stock
Tractors				
West Godavari	20.754	12003.836	36.077	20658.748
Nellore	14.400	7234.447	33.523	17595.548
Prakasam	16.305	6063.583	33.528	12789.854
Power tillers				
West Godavari	0.797	456.415	1.370	792.658
Nellore	0.083	41.678	0.102	51.356
Prakasam	1.401	521.008	3.708	1414.330
Irrigation equipment - Diesel engines				
West Godavari	6.658	3804.582	7.150	4137.657
Nellore	0.609	306.269	0.555	279.277
Prakasam	11.806	4390.491	10.983	4189.752
Electric motors				
West Godavari	256.551	146589.983	539.921	312416.364
Nellore	132.097	66428.562	654.096	328928.663
Prakasam	130.915	48684.1984	319.205	121765.176
Harvesters				
West Godavari	15.221	8697.419	20.477	11848.701
Nellore	14.517	7300.688	20.701	10410.298
Prakasam	6.015	2237.032	19.107	7288.691
Plant Protection Equipment				
West Godavari	162.383	92783.559	437.767	253306.647
Nellore	52.555	26429.065	229.212	115265.060
Prakasam	141.681	52687.882	264.192	100779.663

Tractors:

Use of tractors has become inevitable and has been growing continuously. The demand for the tractors was projected individually for the selected districts of coastal A.P. Results presented in Table 5.16 indicated the projected demand for tractors in the years 2005 and 2010. In case of West Godavari district, there would be 12,003 tractors in 2005 and 20,658 tractors in 2010. While in case of Nellore district there would be 7,234 and 17,595 tractors in 2005 and 2010 years respectively, whereas in the case of Prakasam district it would be 6,063 in 2005 and 12,789 in 2010. The results indicated that though the number of tractors would be highest in case of West Godavari district, it was found that a considerable (growth) increase was observed in case of Nellore and Prakasam districts. Thus the use of tractors would be increased in near future owing to their multipurpose uses.

Power tillers:

The number of power tillers in the selected districts projected would be 456, 41 and 521 in West Godavari, Nellore and Prakasam districts respectively in 2005. Whereas in 2010 the number of power tillers would be 792 in West Godavari, 51 in Nellore district and 1414 in Prakasam district.

The above mentioned results indicated that though there seemed to be an increase in number of power tillers in all the districts, the increase was felt more in case of Prakasam district, where the number projected was 621 in 2005 and 1,414 in 2010 year. A conspicuous growth was observed. This indicates that the use of

power tillers would be more in Prakasam district in future when compared to the other districts.

5.5.2 Demand projections for Irrigation equipment

Machines under this category are oil engines and electric motors. The projected demands are presented in Table 5.16.

Oil Engines: In case of oil engines the demand would be numbering 3,804, 306 and 4,390 in West Godavari, Nellore and Prakasam districts respectively for the year 2005. While the number of oil engines in 2010 would be 4,137, 279 and 4,189 in West Godavari, Nellore and Prakasam respectively.

The results indicate that in case of West Godavari there was a continuous increase in their number, whereas in case of Nellore and Prakasam districts the number of oil engines would decrease by 2010, especially in case of Nellore district there was a continuous decrease in their use. However the results indicated that the use of oil engines would be higher in Prakasam district when compared to other two districts in future. On the whole the situation indicates that the demand for oil engines would go down in future, due to increase in use of electric pumpsets.

Electric motors:

Number of electric pumpsets in West Godavari would increase to (1,46,590 by 2005 and 3,12,416 by 2010) 256 per thousand hectares of net area sown by 2005 and 539 per thousand hectares of net area sown by 2010.

In case of Nellore district it would be 132 per thousand hectares of net area sown by 2005 and it would be 654 by 2010. While in the case of Prakasam district the number of electric pumpsets per thousand hectares would be 130 by 2005 and 319 by 2010 year. Thus the number of electric pumpsets is being projected to increase continuously in all the three districts. The projected increase is more in case of Nellore district and least in Prakasam district. This clearly indicates that the use of electric pumpsets would increase in Nellore district where the use of oil engines would go down and in case of Prakasam district where the increase of electric pumpsets is projected to be more than the oil engines. But in West Godavari district a continuous increase can be seen in both the cases. However care should be taken in acknowledging the projected figures that the scenario of irrigation, water technology management may alter the projected demand.

5.5.3 Demand projections for Harvesting machinery

Harvesters:

Results presented in Table 5. 16 indicated that the number of harvesters in West Godavari would be 8,803 in 2005 and 11,725 in 2010.. While in Nellore district the number would be 7,289 in 2005 and 10,850 in 2010 and in Prakasam district the number of harvesters would be 2,189 in 2005 and 7,297 in 2010. Thus the results indicate an unusual increase in number of harvesters over a period. Especially in case of Prakasam district there is likely to be a many fold increase, however the increase observed may be because of two reasons. Firstly there was a drastic increase in the number of tractors in the Prakasam district from 14 harvesters in 1981 to 147 in 1993, nearly a 10 fold increase. The other reason

might be the variables included in the model might have positive influence on the increase of harvesters. Keeping this in mind though the increase may not be very intensified as it was observed, from the projections there would be a definite and considerable increase in demand for harvesters in coastal Anadhra Pradesh. It is obvious that their use has been increasing dramatically in recent years. It is observed that within the last two years the use of harvesters, which may be hired or purchased increased nearly by 20-30 per cent in the selected districts and many of them were hired from other states. However this is subjected to the changes in the cropping pattern, where the demand for harvesters may be affected.

5.5.4 Demand projections for Plant protection equipment

The results indicated that, the projected number of plant protection equipment per thousand hectares of net area sown would be 162 in West Godavari, 141 in Prakasam district and 52 in Nellore district by 2005. While they would increase to 437, 229 and 264 in West Godavari, Nellore and Prakasam districts respectively per thousand hectares of net area sown, by the year 2010. Thus West Godavari tops in possessing plant protection equipment both in density and stock. Prakasam district would have more (number of) density of equipment than Nellore district, whereas Nellore district would have equipment more in number when compared to Prakasam district. However, there would be a considerable increase in demand for plant protection equipment in all the districts as they are inevitable for crop production.

From the above discussion, it can be concluded that there would be a considerable increase in the projected number of tractors, electric motors, harvesters

and plant protection equipment in future in all the three districts. However the projected number of power tillers and oil engines suggested that there may be a decline in their use in all the selected districts except in Prakasam district where it indicated a slight increase in their projected number in future.

5.6 PROBLEMS AND CONSTRAINTS ASSOCIATED WITH FARM MECHANIZATION

The slow process of mechanization of farm operations in India is because of several reasons including small size of the farm holding and poor economic status of the farmer.

It is well known fact that, even in this machine age the Indian farmer mostly relies on primitive tools and implements. The result ofcourse is low productivity in agriculture. It is mainly through mechanization that an agricultural revolution has been brought about in the countries of the west. Though it is true that farm mechanization has shown good results as of raising the agricultural production and improving the standard of living within very short period, the mechanization of farm operations in India is very slow. There are several arguments against farm mechanization. An attempt was made to find out the possible reasons for this slow adoption and/or non-adoption of mechanization at farm level in Andhra Pradesh. To elicit the information from the farmers, regarding the problems associated with casual human labour, the whole sample (240) was considered and the remaining problems were discussed with and obtained the opinions of mechanized category of farmers.

5.6.1 Problems with hired human labour

Before going into the detailed analysis of the problems associated with farm mechanization, it is important to know whether farm mechanization is

needed or not. For that both the mechanized and non-mechanized categories of farmers were enquired and their responses are presented in Table 5.17.

The results indicated that about 95 per cent of farmers (228) expressed that *non-availability of human labour* during the peak season is a severe problem i.e., at the time of transplanting and harvesting in case of paddy, planting and cutting of sugarcane etc.,. These operations require a large number of human labour to carryout them. The problem of *high wages* demanded by the hired human labour (90.83 %) during those peak periods as mentioned above was the next important problem associated with it. Further it was observed that some times though the farmer gets the labour but it would be very expensive for him. Since the harvesting operation cannot be delayed and most of the varieties are synchronous in maturity, hence all the farmers would try to carry out the operation at the same time. With this the demand for labour would be more and the labour increase their wages depending on the demand. *Delay in carrying out the farm operations* was the other important problem. About 45 per cent of sample farmers expressed this problem. Thus in the case of coastal districts where the harvesting of paddy coincides with cyclones, mechanization of harvesting operation not only saves time but also helps in safe reach of grain to house (farmer). Thus with increased cropping intensity and farm efficiency there is every need to mechanize farm operations.

Table 5.17 Problems with casual human labour

S. No	Problem	Frequency	%
1.	Problem of non-availability of human labour during the peak season	228	95.00
2.	Demand for high wages during peak season	218	90.83
3.	Delay in carrying out the operation	108	45.00

5.6.2 Problems associated with the use of farm machinery

The results presented in Table 5.18 indicated the most important problems or the reasons that restrict the use of farm machinery. The most important problem was *small size of farm holding* as expressed by 197 farmers who accounted for 82.08 per cent of the sample. This is in conformity with the study conducted by Kamble and Kurpakar (1999). Followed by the problem of *high cost of machinery*, which was expressed by 47.58 per cent of the farmers. Of the total farmers (240), 42.92 per cent of the farmers faced the problems of *non-availability of the machinery*. Likewise 40.83 per cent of the total farmers encountered *difficulties in transportation of the machinery* to the farm. This was mostly in case of harvest combine whose transportation was felt difficult with its bulk and also it is not possible to reach the farm, unless the fields on its way were cleared or harvested.

Table 5.18 Problems of using farm machinery

S. No	Problem	Frequency	Per cent
1.	Small size of the farm holding	197	82.08
2.	High cost of using machinery	114	47.50
3.	Non-availability of the machinery	103	42.92
4.	Difficulties in transportation of machinery to the farm	98	40.8

Thus most of the farmers were not going for mechanization of the farm operations because of their restricted farm size and high cost of using the machinery. Some of them could not get the machinery into their farms.

5.6.3 Problems associated with purchase of machinery

Study of the problems associated with farm mechanization, starts with the problems associated with purchasing of farm machinery. Though agriculture sector is considered to be the most subsidised sector in the economy, farm mechanization has not been subsidised as in the case of other inputs. Hence it is very difficult for the farmers to acquire the machinery. Results presented in Table 5.19 indicated that the first and foremost problem in acquiring farm machinery was *seasonal and uneconomical use*. About 90 per cent of the mechanized farms expressed this problem.

Table 5.19 Problems associated with purchase of farm machinery

	Problem	Frequency	%
1.	High initial investment on machinery	96	80.0
2.	Uneconomical to buy if the use is seasonal	109	90.83
3.	Non-availability of loans for purchasing second hand machinery	106	88.33
4.	Method of existing purchase is not suitable	48	40.60
5.	Non-availability of suitable machinery	43	35.83
6.	Inadequate knowledge of the farmer about the machinery	32	26.66

Most of the agricultural operations were seasonal hence the machinery like harvest-combines etc., cannot be used regularly and thereby the investment on such machinery may not be recovered soon and some times it may not be economical too. Hence 109 mechanized farmers felt that it was not economical to buy farm machinery, unless there is a continuous work for it. This is in

conformity with the results of Chatta and Grover (1995). This was followed by the problem *of non-availability of loans for purchasing second hand machinery* and it was indicated by 88 per cent of farmers. Farmers are habituated to buy second hand machinery, in case of tractors it is a very common practice adopted by medium size farmers. But they cannot get loan with their insufficient size of holdings. This is in conformity with the studies conducted by Chatta and Grewal (1991) and Singh and Tewari (1994). The problem of *high initial investment on the machinery* was expressed by 80 per cent of the mechanized category of farmers. Due to the high cost of machinery like harvest-combine, which costs in lakhs, farmers were not able to buy the machinery. Other problems like *non-availability of machinery*, *inadequate knowledge of the buyer* about the machinery and *method of purchase was not suitable*, were expressed by 35, 40 and 26 per cent of the mechanized category of farmers respectively.

Table 5.20 Problems of obtaining loan for the purchase of farm machinery

S. No	Problem	Frequency	Percentage
1.	Possession of small farm holding	112	93.30
2.	Complicated procedure in the sanction of loan	87	72.50
3.	Terms of repayment are not convenient	69	57.50
4.	Required amount of loan is not sanctioned	63	52.50
5.	High interest rate	54	45.00

It is observed from the above Table 5.20 that, the most important problem felt by the farmers was *small farm size,* which not sufficient to attain loan and it was expressed by about 93 per cent of mechanized category of farmers. That

indicated, only large farmers with more acreage were able to get loan than small farmers. For example when a farmer wants to get a tractor loan he should have minimum 10 acres of land on his own. But in India most of the farmers are small and marginal, and hence they cannot dream of purchasing such machinery through institutional loan. Even in the case of medium size farmers, some of them may be interested in purchasing second hand machinery (from large farmers), for which there is no institutional credit facility. This mainly restricts the purchase of machinery.

Farmers were suffering from the *complicated loan sanction procedures*. About 72 per cent of the sampled farmers expressed this problem. Sanction of a loan requires, producing of different forms along with loan application, which may be a difficult task for the farmers, most of them being uneducated. Further the *terms of repayment* were also not convenient for the farmers as it was expressed by 57 per cent of the mechanized category of farmers. Sometimes the *loan amount sanctioned by the financial institute is not sufficient* for the purchase of machinery and the farmer had to add the remaining money by borrowing from other sources. This problem was expressed by 52 per cent of the mechanized category farmers. Among them about 45 per cent felt the loan provided for the purchase of machinery was of *high interest rate*.

5.6.4 Problems associated with repair and after sale services

Once the machine is bought, it requires some regular maintenance and upkeeping, for which there must be some after sale services. Keeping this in

view, the survey was also undertaken to study the problems and constraints associated with repairs and maintenance.

Table 5.21 Problems with repairs and after sale services

S. No.	Particulars	Farmers	
		Frequency	%
1.	Inefficient repairing facilities	108	90
2.	Inadequate/no after sale services	101	84.17
3.	High cost of repairs and maintenance	90	75
4.	Lack of availability of spare parts	47	39.17
5.	Lack of skill/knowledge to use the machinery	33	27.5

Important problems faced by the farmers were identified and presented in Table 5.21. In majority of the cases the *repairing facilities available were not efficient and insufficient too.* About 90 per cent of the mechanized category farmers indicated that they were not satisfied with the repairing facilities available, while 84 per cent of the farmers indicated that there were *no after sale services*. This is in conformity with the results of the study conducted by Kamble and Kurpakar (1999). Another important problem that makes mechanization costly was *high costs of repairing and maintenance.* Seventy five per cent of the mechanized category of farmers, said the process of repairing is costly. *Lack of availability of spare parts* was another important problem expressed by 38 per cent of the farmers and the problem of *lack of skill in the use of machinery* was found to be minor as it was indicated by only 27 per cent of farmers.

5.6.5 Problems associated with hiring of machinery

Due to high cost of machinery such as harvesters, transplanters etc., all the farmers may not afford to purchase and even if purchased, it is not economical if the farmer's holding is small and if it cannot be used on the other farmers' fields. Hence a convenient and profitable way of acquiring farm machinery is "hiring". But there were some problems even with hiring also and the study tried to focus on these problems. Important problems identified were presented in Table 5.22. On perusal of data it is evident that the problem of *transportation* of heavy machinery like harvest-combine, oil engines etc., was the important problem. The results of the survey supported it with 73 per cent of the respondent farmers indicated the above problem. Even if a vehicle was arranged to carry the machine, the fields on the way should be cleared or there should be a direct road to the field.

This problem was followed by *the non-availability of machinery to hire* and *high cost of hiring* as expressed by 55 per cent and 50 per cent of the mechanized category of farmers respectively. During the peak season, like harvesting of paddy the machine hirers increased the costs with the increased demand. This resulted in high cost of machinery to hire. Like wise during the peak season, due to limited labour availability, farmers would go for mechanization of particular operation (like paddy harvesting), which facilitated transition from manual operation to mechanization. But due to limited number of machines there may be more demand for machinery. Another important problem associated with the above situation is *delay in carrying out of the operations* due to insufficient number of machines available. When the demand is high and limited number of machinery

then in such situation, those farmers who can pay more can carryout the operation soon and those who cannot afford get delayed. Hence this resulted into a problem and it was encountered by 40 per cent of the mechanized category farmers.

Table 5.22 Problems with hiring of machinery

S.No.	Particulars	Farmers	
		Frequency	%
1.	Non-availability of machinery to hire	67	55.83
2.	High cost of hiring	54	45.00
3.	Difficulty in transportation of the machinery to the fields	88	73.33
4.	Delay in carrying out of operations	48	40.00

5.6.6 Problems with particular machinery

All the problems explained and discussed above were faced by the farmers in general with any type of farm machinery. But there were some specific problems with certain machinery such as the harvesters and transplanters. Those problems were presented in the following Table 5.23.

Transplanters: It was found from the study that none of the respondent farmers was adopting paddy transplanters. Important reasons behind this were growing of *special type of nursery* called Dapog and it was expressed by 98 per cent of the farmer. However as explained by experts in the department of Agricultural Engineering, ANGRAU, this problem of special type of nursery is associated with imported transplanters from Korea, Japan and China and whose efficiency is about 90 per cent. Though there are some indigenously developed transplanters, which do not require special type of nursery, they need the operations such as root wash,

separation and arrangement of seedlings etc., and to carryout these operations additional labour will be required. In addition to this their efficiency is also very less i.e., about 40 to 50 per cent only. This problem was followed by *high cost or uneconomical to purchase* the machinery and *not suitable for all types of soils*. About 84.17 per cent and 82.50 per cent of mechanized category of farmers respectively indicated these problems. Some of the farmers (42.5%) had no proper knowledge about the transplanters. Hence these may be the reasons for not popularizing the transplanters among the farmers.

Harvest combine: As it was mentioned in the earlier results that transplanting and harvesting of paddy are the most important and labour intensive operations (important in the sense that they should be carried out on time). They require large number of labour at the same time and should be carried out on time, any delay in carrying out of these operations may lead to reduction in the yields. Hence all the farmers prefer to carry out within the time and this attitude of the farmers intensifies the demand for labour during the sowing season and harvesting periods. The possible solution for this may be mechanization of these operations.

Unlike the transplanters the harvesters are getting popularized now a days. But still they are not used widely. Most of the farmers were not using it, *for the sake of straw*, which was used as feed for cattle and about 98 per cent of the farmers expressed this as an important problem. Harvesting of paddy with harvest-combine resulted into *chopping of straw*, which might not be preferred as cattle feed. With this problem small farmers and those who grow paddy on small area of land, were not going for harvest combines. While large farmers and those farmers, who

grow large area under paddy, were practicing machine harvesting. However these large farmers also employing human labour to harvest a part of the paddy, to obtain the quality straw for cattle feed purpose.

Table 5.23 Problems with the use of particular machinery

S.No.	Particulars	Farmers	
		Frequency	Per cent
	Harvesters		
1.	Wastage of straw due to chopping by harvester	115	95.83
2.	Requirement of large farm size	104	86.67
3.	Paddy-fallow-pulse pattern is not suitable	92	76.67
4.	Not suitable for all type of soils	76	63.33
5.	Difficult to transport	86	71.67
	Transplanters		
6.	Special type of nursery required	118	98.33
7.	Plant population and spacing in between may not be maintained	101	84.17
8.	Not suitable for all types of soils	99	82.50
9.	Lack of knowledge	51	42.50

Another important problem was that *paddy-fallow-pulse* type of cropping pattern can not be practiced and this problem was expressed by 76.67 per cent of the farmers. Normally farmers sow, pulse seed while paddy crop is on the field and just before it is harvested. But with the heavy machinery like harvest combine there will be a lot of damage to pulse seedlings. Thus it is not advisable for paddy fallow pulse conditions. About 63 per cent of the farmers expressed that *not suitable for all types of soils*. If the soil is black then the machinery with its bulk

cannot move and it may get struck in the field. Hence the type of soil or soil conditions also restrict the use of machinery.

From Table 5.23, it is evident that 71 per cent of farmers encountered the problem of *difficulty in transportation of the machinery*. The harvest-combine is heavy and with its bulk it is difficult to carry it to remote fields. It needs to be carried by a vehicle. Thus this problem has given rise to another problem

From the above discussion it can be concluded that *the non-availability* and *demand for higher wages during the peak season* were the two important problems associated with casual human labour. While *small farm holding, high cost* and *non-availability of machinery* were the major constraints associated with use of machinery. *Uneconomical and seasonal use, non-availability of credit facilities for purchase of second hand machinery* and *high initial investment* were the problems associated with purchase of machinery. To obtain loan *possession of small farm holding* and *complicated loan procedures* were the problems identified. *Repair and after sale services were inefficient and inadequate* in the study area, even if available, they were found *costly*. *Requirement of large farm, difficult to transport* and *the wastage of straw* were the important constraints restricting the harvester use in the study area. Preparation of *special type of nursery and unsuitability for all types of soils* may be the important reasons for not using the transplanters by the farmers.

SUMMARY AND CONCLUSIONS

CHAPTER VI

SUMMARY AND CONCLUSIONS

It is a known fact that Indian agriculture is highly dependent on labour. In spite of abundant labour in the country farmers are facing problems during peak seasons. Use of machinery to carryout the farm operations can solve some of these problems. Further farm machinery helps in saving the time. However, in spite of its usefulness and need in carrying out the farm operations, mechanization has not received the required importance. There may be several reasons behind this. In order to probe into the present situation of mechanization and the future demand for farm machinery in the state, the study was undertaken to evaluate the economics of farm mechanization in coastal Andhra Pradesh, with the following specific objectives.

Specific objectives

1. To study the benefits of mechanization vis-à-vis traditional methods

    a) To assess the extent of mechanization in various farm operations

    b) To estimate comparative economics of farm operations with traditional methods

    c) To study the pattern and extent of labour absorption or labour displacement due to farm mechanization

2. To identify the determinants of farm mechanization

3. To analyse the impact of farm mechanization on cropping intensity, production, productivity and income on selected farms.

4. To estimate the demand for farm machinery in the selected districts of coastal Andhra Pradesh.

5. To study the problems and constraints associated with farm mechanization.

The study was undertaken in the coastal districts of Andhra Pradesh where labour problem was acute during the peak seasons. Three districts West Godavri, Prakasam and Nellore, were selected, based on their first three positions in the state with their farm machinery. A random sample of 240 farmers was selected from 12 villages of the three districts. Entire sample was divided into two categories viz., mechanized and non-mechanized farms.

Interview method was adopted to collect the primary data through well structured and pretested schedules, while the secondary data were obtained from the Directorate of Economics and Statistics, State, District, Mandal and Village official records.

Collected data were analysed with a combination of simple tabular analysis, linear discriminant and regression analysis to achieve the specified objectives of the study.

Major findings of the study are summarised below.

General particulars of the selected farm holdings

The average family size (5.38) was less on mechanized farms when compared to non-mechanized farms (5.64). Family composition of both mechanized (2.03) and non-mechanized (2.08) farm families was dominated by children.

The average number of family labour on mechanized farms, was very less (1.59) when compared to non-mechanized farms (3.07). However the composition was similar on both the families, male workers contributed 89.31 per cent and 55.05 per cent followed by female workers 6.92 per cent and 28.34 per cent on mechanized and non-mechanized farms respectively. Female and child labour was 3.77 per cent and 16.61 per cent on mechanized and non-mechanized farms respectively. This suggests that involvement of farm families in their work is more in case of non-mechanized farms. This may be due to their small size of the farms.

The literacy levels of mechanized farm families were found higher when compared to non-mechanized farms. Of all the mechanized farmers only 3.33 per cent were illiterates, while 22.50 per cent of non-mechanized farmers were illiterates. Among the mechanized farmers, 48.33 per cent were educated upto college and above whereas 73.33 per cent of non-mechanized farmers were educated only below high school level.

Pattern of land holdings indicated that 72.50 per cent of mechanized farms had more than 2 hectares of land of which about 40 per cent had more than 4 hectares whereas 95.00 per cent of non-mechanized farms had less than 2 hectares of land. This suggested that 70 per cent of mechanized farmers were large while most

(95 per cent) of the non-mechanized farms were small. Further it is indicated that the small farm size may be one of the factors, which were not facilitating the farmers to go for mechanization of farm operations.

Average animal holdings of a mechanized farm (16.41) was more when compared to non-mechanized farm (8.22). Further average number of all categories of animals were also less on non-mechanized farms when compared to mechanized farms. However, on both mechanized and non-mechanized farms average number of milch animals was more when compared to draught purpose animals (19.74%, 13.02%).

As it is known, farm machinery was more on mechanized farms, indicating their readiness for mechanization of operations. Average number of electric motors possessed by mechanized farmers was 3.21 and by non-mechanized farmers was 0.016. Similarly the average number of bullock carts was 0.78 and 0.22 on mechanized and non-mechanized farms respectively. Among mechanized farms, 87 farmers possessed tractors.

Extent of mechanization in various farm operations

Mechanization may be either partial or complete depending on the extent of its use in carrying out of various operations. Ploughing and irrigation operations were mechanized on all the mechanized farms (100%). Among all, ploughing operation was mechanized to the maximum extent of 95.34 per cent, followed by threshing (56.42%) and irrigation (46.28%) operations. However, when the harvest-combine was used, harvesting, threshing and winnowing operations were

carried out simultaneously and the extent of mechanization of the three operations was 100 per cent. Finally the extent of mechanization on an average was 25.61 per cent when the harvesting was done by human labour whereas 42.96 per cent when the harvest-combine was used. This suggests that even with the use of harvest-combine the extent of mechanization was (below 50%) not complete.

Comparative economics of mechanized and non-mechanized farms

Comparative costs of operations on both the farms suggested that the expenses incurred on all the operations were more on mechanized farms when compared to non-mechanized farms, except costs of plant protection, threshing and winnowing, which were estimated at Rs.187.08, Rs.573.10 and Rs.17.26 respectively higher on non-mechanized farms. Further the total costs were also higher by Rs.1,812.32 on mechanized farms when compared to the other. However, when the harvest-combine was used the difference between the total costs of mechanized farms to non-mechanized farms was only Rs.680 per hectare.

Labour use pattern on mechanized and non-mechanized farm

Labour use pattern on both the farms indicated that the average total mandays on mechanized farms was 168.87 and on non-mechanized farms it was 166.00 mandays. Labour displaced with mechanization was only 2.88 MDs per hectare (1.66% less than non-mechanized farms). Operations, in which farm labour displaced were threshing (10.38 MDs), winnowing (3.38 MDs) and ploughing (0.13 MDs). In the remaining operations there was no displacement of labour, instead there was absorption of labour. Major absorption was by mechanization of irrigation

operation and it resulted in increase of labour employment by 27.48 per cent over non-mechanized farms. This suggests that though there was a slight displacement of labour due to the mechanization of farm operations like threshing, winnowing and ploughing, sufficient absorption of labour was observed through mechanization of other operations especially irrigation. Further employment of permanent labour was also higher on mechanized farms.

Factors determining mechanization

The results of discriminant analysis indicated that, major factors influencing the mechanization in Prakasam district were cropping intensity, wages paid to labour and total casual labour employed for crop production, which contributed 46.16 per cent, 42.22 per cent and 32.71 per cent respectively for the total distance (D^2) between the two groups. Further permanent labour, farm size, productivity and educational status of the farmer contributed 17.01 per cent, 11.84 per cent, 9.79 per cent and 2.54 per cent respectively to the total (D^2) distance. The mean Z score was found to be 121.65.

Results of discriminatory analysis carried out for Nellore district indicated that *cropping intensity*, *per cent area irrigated*, *permanent labour employed*, *wages paid to hired labour* and *farm size* had relatively large weightages of 61.71 per cent, 46.46 per cent, 35.42 per cent, 36.61 per cent and 23.09 per cent respectively to the total distance (D^2) between the two groups.

The remaining factors such as the *total casual labour employed (MDS)* (8.93%), *age of farmer* (4.51%), *productivity* (4.18%), *income* (3.53%) etc.,

had a negligible weightage. Thus the major factors discriminating the two groups were *cropping intensity, per cent area irrigated, permanent labour employed, wages paid to hired labour* and *farm size.*

Results of discriminatory function fitted for West Godavari district indicated that *cropping intensity* (43.25%), *total wages paid to labour* (36.67%), *permanent labour employed* (12.00%) and *per cent area irrigated* (11.39%) had relatively higher weightages in the discrimination between the two groups. Further, factors like *farm size* (99.70%), *total casual labour employed (MDs)* (9.23%) and *income* of farmers (6.73%) also helped in discriminating the mechanized group from non-mechanized group.

Factors that had relatively more weightages in discrimination as indicated by the results of discriminatory function fitted for the pooled sample were *cropping intensity* (46.33%), *total wages paid to casual labour* (30.19%), *permanent labour employed* (23.97) and *farm size* (12.42%). The other factors in the function, such as *total casual labour (MDs) employed* (9.31%), *per cent area irrigated* (5.02%), *productivity* (4.45%), *educational status* (4.26%) and *income* (3.27%) had relatively less contribution in the total distance. Similar pattern was also observed in all the three districts except in Nellore district where *per cent area irrigated* occupied the second place followed by *permanent labour employed* and *total wages paid to hired labour.* The contribution of other variables was not much except the *farm size* in Nellore district and *casual labour(MDs) employed* in case of Prakasam district, which had considerable weightage.

In order to find out the factors determining mechanization functional analysis was done with a semi-log regression model. The models were fitted to time series secondary data, machinery wise for each district.

Tractors: Results indicated that important factors determining tractorisation in West Godavari district were *long term credit*, *per cent area irrigated* and *price* of tractors. The first two factors had positive influence, while the latter had a negative effect on tractorisation. In case of Nellore district coefficients of agricultural *productivity* and *per cent area irrigated* were found to be positive and statistically significant. This suggests that *agricultural productivity* and *area irrigated* were the important factors enhancing tractorisation in the district. Similarly results of the semi-log regression function fitted for Prakasam district indicated that the coefficients of *long term credit* and *per cent area irrigated* were found to be statistically significant. This indicates that *long term credit* and *per cent area irrigated* were the factors determining the tractorisation in the district.

Power tillers: Results of semi-log regression functions fitted for power tillers with respect to three districts indicated that in case of West Godavari *price* of power tillers and *per cent area irrigated* were found to be statistically significant and positive. Thus suggest their positive effect on power tiller use in the district. While in the case of Prakasam district all the four variables included in the function were found to be statistically significant and except the coefficient *of per cent area irrigated*, all other coefficients were positive. However this negative sign might due to the influence of other variables, which is inexplicable. Function fitted for Nellore had only one statistically significant variable and which was agricultural

productivity indicating its significant positive influence on power tiller density in the district.

Irrigation equipment: Similar to the tillage machinery densities of irrigation equipment (oil engines and electric pumpsets) were also fitted in the function as dependent variables and the independent variables were agricultural *productivity*, *per cent area irrigated, long term credit* and *price*. In case of West Godavari, the factors that were significantly influencing the density of oil engines were *agricultural productivity, per cent area irrigated* and *price* but the coefficient of *productivity* was negatively significant. Thus important factors influencing the density of oil engines were *productivity*, *per cent area irrigated* and *price*. While the factor determining the electric motor density in the district was only the *long term credit*, whose coefficient was statistically significant.

Results of function fitted for Nellore district indicated that the factor influencing oil engine density in the district was *agricultural productivity* and it was found to be negatively significant. This indicated the decrease in oil engine density with increased *agricultural productivity*. Whereas the determinants of electric motor density was found to be its *price* only. The coefficient of the *price* was significant and positive, suggesting increased density of electric motors even with their increased *price*.

In case of Prakasam district the results of function fitted for oil engines indicated that only the *per cent area irrigated* was found to be statistically significant but negative. This suggests that with increased *per cent area irrigated* the oil engine density declined. Whereas the factors determining the density of

electric motors in the district were *per cent area irrigated, long term credit* and *price.*

Harvesting machinery: Density of harvesting machines with respect to the three districts was fitted in the semi-log model as dependent variable along with the explanatory variables mentioned above. Results indicated that the *price* of harvesters was found to be positive and statistically significant in West Godavari district, suggesting the increased use of harvesters in spite of their increased *price.*

In case of Nellore district also the important determinants of density of harvesting machinery were *price* and *agricultural productivity.* Similar to the case of West Godavari the number of harvesters also increased in spite of increase in *price* in Nellore district. While in case of Prakasam district the density of harvesters was influenced by *price* and *agricultural productivity.* However, the coefficient of *agricultural productivity* was found to be negatively significant, indicating its negative effect on the density of harvesters.

Plant protection equipment: Similar to the earlier functions fitted, here the density of plant protection equipment was used as dependent variable and the independent variables were *price, agricultural productivity, per cent area irrigated* and *long term credit.*

Results obtained from the semi-log functions fitted for the study area, indicated that *per cent area irrigated* and *price* of plant protection equipment were found to be statistically significant and positive in West Godavari district, thus revealing their positive influence on the density of plant protection equipment

(PPE). Just as in the case of harvesters the use of plant protection equipment also increased in spite of the increase in their price. However, in case of Nellore and Prakasam districts the density of PPE was significant and positively influenced by its price only.

Impact of mechanization on cropping intensity, production, productivity and income

Apart from labour employment, mechanization also significantly influenced the factors like cropping intensity, production, productivity and income.

Cropping intensity

There was a significant increase of about 75 per cent of cropping intensity on mechanized farms (179.5%) from non-mechanized farms (105%). The increase was statistically significant rejecting the null hypothesis that, mechanization does not have any impact on cropping intensity. Further it was suggested that mechanization had a positive impact on cropping intensity through extended irrigation facilities.

Productivity

Productivity of mechanized farms (5,471 kg) was about 196 kg per hectare more than non-mechanized farms (5,275 kg) and the difference was found statistically significant at one per cent level. Thus the null hypothesis "no impact of mechanization on productivity" was rejected and concluded that productivity was increased by mechanization.

Production

Similar to the productivity, the average production was also higher by 19 t per farm on mechanized farms (27.49 t per farm) than non-mechanized farm (8.568 t per farm) and was statistically significant thereby the null hypothesis of no impact of mechanization on production was rejected. However this large difference in the production was due to larger farm sizes of mechanized farms. The frequencies of farmers indicated that 95 per cent of non-mechanized farmers were small farmers with 2 or less than 2 hectares of farm size. While 72.50 per cent of mechanized farmers were large farmers with more than 2 hectares of farm holding. This suggests mechanization had a positive impact on production, however this was mostly accounted to the large farm size of mechanized farmers.

Income

The gross income of mechanized farms (Rs.26,675) was higher by Rs.2,421 when compared to non-mechanized farms (Rs.24,253) and it was statistically significant rejecting the null hypothesis of no impact of mechanization on income. Average net income on a mechanized farm was also higher by Rs.914.78 when compared to non-mechanized farms and the difference was found statistically significant. This suggests that mechanization had significantly contributed to the increase of both gross income and net income.

Demand projections for farm machinery in the selected districts of coastal A.P

Tillage machinery: Based on the semi-log models fitted, demand for various types of farm machinery were projected. Firstly demand for independent or

explanatory variables was projected. Based on that the demand for farm machinery was projected for the years 2005 and 2010. Projections for tillage machinery indicated that in case of West Godvari district there would be 12,000 and 20,658 tractors by the year 2005 and 2010 respectively. In Nellore district the number of tractors in 2005 would be 7,234 and 17,595 in 2010, while in case of Prakasam district it would be 6,063 and 12,789 by 2005 and 2010 respectively. Overall the indications are for considerable increase in the use of tractors in future in the study area.

However the demand projections for power tillers indicated that the number of power tillers by 2005 would be 456, 41 and 521 in West Godavari, Nellore and Prakasam districts respectively, while it would be 792 in West Godavari, 51 in Nellore and 1414 in Prakasam district by 2010. Suggesting that there may not be much use of power tillers in future in Nellore and West Godavari districts. However, there seemed to be a considerable increase in number in case of Prakasam district, which may be due to rainfed agriculture where preference would be for power tillers.

Irrigation equipment: Irrigation equipment included oil engines and electric motors. Demand projections for oil engines indicated that the number of oil engines would be 3,804, 306 and 4,390 in West Godavari, Nellore and Prakasam districts respectively by 2005 and it would be 4,137, 279 and 4,189 in West Godavari, Nellore and Prakasam districts respectively by 2010. This suggests a decline in use of oil engines in future in two districts and a marginal increase in one district.

Demand projections for electric motors suggested that there would be a considerable increase in their number in future. Number of electric motors by 2005 in West Godavari, Nellore and Prakasam would be (1,46,590) 256 per thousand hectares of net area sown (NAS), (66,428) 132 per thousand hectares of NAS and (48,684) 130 per thousand hectares of NAS respectively. Further it would increase to 539 per thousand hectares of NAS in West Godavari, 654 per thousand hectares of NAS in Nellore district and 319 per thousand hectares of NAS in Prakasam district. This suggested that there would be a sharp increase in electric motor use in future. However this unusual increase may be due to two reasons. Firstly, there was drastic increase in electric motor number during the study period (from 1981 to 1992), secondly as it was mentioned earlier there would be a decline in the use of oil engines in the study area in future.

Harvesting machinery: Similar to the case of electric motors, demand projections for harvesters also indicated a sharp increase in their number by the year 2010. The number of harvesters by 2005 would be 8,697, 7,300 and 2,237 in West Godavari, Nellore and Prakasam districts respectively and it is expected to increase to 11,848, 10,410 and 7,288 in West Godavari, Nellore and Prakasam districts respectively by the year 2010. There would be a many fold increase in their number and this may be because of the drastic increase in their number during the study period.

Plant protection equipment: Demand projections for plant protection equipment indicated that the projected number would be 162 per thousand hectares of NAS (92,793), 52 per thousand hectares of NAS (26,429) and 141 per thousand hectares of NAS (52,687) in West Godavari, Nellore and Prakasam districts respectively by

2005. The projected number by the year 2010 would be 437, 229 and 264 per thousand hectares of NAS in West Godavari, Nellore and Prakasam districts respectively. This indicates a considerable growth in the number of plant protection equipment in future in all the three districts.

From the above it can be concluded that there would be a considerable increase in the projected number of tractors, electric motors, harvesters and plant protection equipment in future in all the three districts. However the projected number of power tillers and oil engines suggested that there may be a decline in their use in all the selected districts except in Prakasam district where it was indicated a slight increase in their projected number in future.

Problems and constraints associated with farm mechanization

In spite of all the advantages from mechanization, there are still several arguments against it. In order to know the important constraints that are associated with the mechanization an opinion survey was conducted among the farmers. The results of the survey were grouped under some specific categories of problems.

Problems associated with hired human labour

Important problems in hiring casual human labour were problem of non-availability during the peak season, demand for high wages during the season and delay in carrying out of operation as expressed by 95 per cent, 90 per cent and 45 per cent of the sample farmers.

Problems associated with use of machinery

Important problems that were associated with the use of farm machinery were small size of the holdings (82.08%), high cost of using machinery (47.50%), non- availability of the machinery to hire (42.92%) and difficulties in transporting the machinery to the farm (40.8%) as expressed by 197, 114, 103 and 98 farmers.

Problems associated with purchase of machinery

Major problems associated with purchase were uneconomical and seasonal use of machinery, non-availability of loans to buy second hand machinery, high cost of machinery and method of purchase is not suitable as expressed by 90.83 per cent, 88.33 per cent, 80.00 per cent and 40.60 per cent of mechanized category of farmers respectively. Further non-availability of suitable machinery (35.83%) and inadequate knowledge of the farmer (26.66%) were also restricting the purchase of machinery to some extent.

Problems associated with loans for the purchase of machinery

Major problems identified under this category were possession of small farm holding, complicated procedures in the sanction of loan, terms of repayment are not convenient, required amount of loan is not sanctioned and high rate of interest as they were pointed out by 93.30 per cent, 72.50 per cent, 57.50 per cent, 52.50 per cent and 45.00 per cent of farmers respectively.

Problems associated with repairs and after sale services

Important problems under this category were inefficient repairing facilities, inadequate or no after sale services, repair and maintenance also costly and lack of availability of spare parts as expressed by 90 per cent, 84 per cent, 75 per cent and 38 per cent of mechanized category of farmers.

Problems associated with hiring of machinery

The important problems associated with hiring of machinery were non-availability of machinery on time, difficulty in transportation of machinery to fields, high cost of hiring and delay in carrying out of operations due to insufficient number to hire as encountered by 55.83 per cent, 73.33 per cent, 45.00 per cent and 40.00 per cent of mechanized category of farmers respectively.

Problems associated with particular machinery

Apart from the general problems mentioned above there were certain problems which are associated with particular machinery as indicated by the sample farmers.

Harvesters: Harvest combines are being popularised now a days but not widely because of certain problems associated with it. As the survey indicated the problems were chopping of straw, which would not be preferred as a cattle feed, restriction of farm size, paddy-fallow-pulse cannot be possible as expressed by 96 per cent, 87 per cent and 77 per cent of mechanized category of farmers respectively.

Transplanters: Transplanters have not yet adopted by the farmers, though they were developed and made suitable for field conditions. The survey brought out some of the problems and constraints behind the non-adoption of transplanters. They include requirement of special type of nursery, required spacing and population may not be achieved, not suitable for all kinds of soil as indicated by 98 per cent, 84 per cent and 83 per cent of mechanized category of farmers respectively. The department of Agricultural Engineering, ANGRAU, had developed some transplanters, which do not require special type of nursery. But these transplanters need, separation and root wash of seedlings, which would require additional labour thereby it becomes laborious and costly than traditional method and the efficiency was also very less i.e., about 50 per cent.

CONCLUSIONS

1. Among all farm operations, ploughing operation was mechanized to the maximum extent followed by threshing and irrigation. However on the farms where harvest combine was used, the extent of mechanization of harvesting, threshing and winnowing was 100 per cent. Further the extent of mechanization in the total costs was less than 50 per cent (even with the use of harvester).

2. Expenditure incurred on all the farm operations was high on mechanized farms when compared to non-mechanized farms.

3. Pattern and extent of labour employment indicated that on the whole there was no considerable displacement of human labour but complete displacement of cattle labour was observed on mechanized farms due to mechanization through tractorisation and use of pumpsets. However the use of harvest combine was resulted into a large displacement of human labour.

4. Among the important factors discriminating the mechanized farms from non-mechanized farms in the study area was *cropping intensity* followed by total *wages paid to the casual labour* and total *mandays* for crop production.

5. Among the factors considered, to influence the tractor density in the study area, *per cent area irrigated* was found significant. However *long term credit* was also a significant factor in West Godavari and Nellore districts.

6. Density of power tillers was determined by *price* and *per cent area irrigated* in West Godavari district, agricultural *productivity* in Nellore district and all the

four factors (*price, per cent area irrigated, long term credit* and *agricultural productivity*) in Prakasam district.

7. Factors influencing oil engine density were agricultural *productivity, per cent area irrigated* and *price* in West Godavari, *agricultural productivity* in Nellore and *per cent area irrigated* in Prakasam districts. Density of electric motors was influenced by their *price* in all the three districts. It was further influenced by *long term credit* and *per cent area irrigated* in Prakasam district.

8. Important factor influencing the density of harvesters in the study area was their *price* in all the three districts. However agricultural *productivity* was also found to be significant in Nellore and Prakasam districts. Similarly the density of plant protection equipment in the study area was determined mainly by their *price* and in West Godavari district *per cent area irrigated* was also found significant.

9. Mechanization had positive impact on cropping intensity, production, productivity and income of the selected farms.

10. Projected demand for farm machinery indicated that there would be a considerable increase in the number of tractors, electric motors, harvesters and plant protection equipment in the selected districts of AP. However the projected demand for oil engines and power tillers had shown a decrease suggesting a decline in their use in future in the study area.

11. *Non-availability* and *demand for higher wages* during the peak season were the two important problems associated with hired human labour, while *small size* of

farm holding, *high cost* and *non-availability* were the major constraints associated with use of machinery.

12. *Uneconomical and seasonal use, non-availability of credit facilities* for purchase of second hand machinery and *high initial investment* were the problems associated with purchase of machinery. However to obtain loan *possession of small farm and complicated loan procedures* were the problems identified.

13. *Repair and after sale services were inefficient* and *inadequate* in the study area, if present, they were *costly. Insufficient number of machinery* to hire and the *wastage of straw* was the important constraint restricting the harvester use in the study area.

14. *Preparation of special type of nursery* and *unsuitability for all types of soils* may be the important reasons for not using the transplanters by the farmers.

POLICY IMPLICATIONS

Based on the above findings the following policy implications emerged

1. Providing incentives in the form of subsidies to encourage to buy farm machinery could be a possibility to offset the high initial investments for farmers.

2. Keeping in view of the growing utilization of farm machinery, government can acquire them and make available to the farmers for hiring through the state department agriculture and Agro Industries Corporations. This would solve the problems associated with hiring from the open market and to some extent purchase of farm machinery.

3. There is need for one mobile repairing unit for field repairs attached to each agricultural division office in the state. Further one agricultural repairing work shop may be situated at each mandal or at least for each agricultural division and one principal agricultural repairing work shop at state head quarters under the state Department of Agriculture and Agro Industries Corporations.

4. There is scope for on-farm research on farm machinery to develop and modify them to suit the present agricultural situation and cropping pattern.

5. There is a potential for more investments in farm machinery manufacturing through appropriate policy incentives.

6. Extension agencies should play a key role in popularising various types of farm machinery among the farmers and in providing feed back to the research and development units.

7. State Agricultural Universities should take initiative in developing and modifying farm machinery based on the requirements of the farmers to suit the existing field conditions, especially keeping in view of the needs of small and marginal farmers.

8. Keeping in view of the danger of labour displacement and creation of fresh unemployment, extension agencies should focus on educating and encouraging the farmers to go for selective mechanization.

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APPENDICES

Appendix I

Projected values of independent variables

Particular	Growth rate	Projected Values	
Prices	**(%)**	**2005Y**	**2010Y**
Tractors	7.118659	401826.23	566713.97
Power Tillers	3.252783	48922.52	57413.97
Harvesters	5.953698	6220706.23	8306542.37
Electric Motors	7.945685	20486.23	30025.37
Oil Engines	6.63163	27400.35	37773.42
Plant Protection Equipment	6.324654	1578.53	2144.98
Nellore district			
Productivity	3.133079	4107.64	4792.72
Long term credit	1.757567	67.97	74.15
Per cent area irrigated	2.333715	115.13	129.21
NAS	0.862095	502122.80	524143.09
Prakasam district			
Productivity	3.276534	4036.97	4743.12
Long term credit	1.621506	49.58	53.73
Per cent area irrigated	3.285726	52.47	61.68
NAS	0.481154	372875.55	381932.82
West Godavari district			
Productivity	2.697542	4115.00	4700.78
Long term credit	1.80968	71.82	78.56
Per cent area irrigated	0.132788	82.59	83.14
NAS	-0.1998	578387.88	572632.83