ADOPTION OF FARM IMPLEMENTS BY THE RICE FARMERS OF KERALA

BY

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ABSTRACT OF A THESIS

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DECLARATION

I hereby declare that this thesis entitled "ADOPTION OF FARM IMPLEMENTS BY THE RICE FARMERS OF KERALA" is a bonafide record of research work done by me during the course of research ,and that the thesis has not previously formed for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellayani,
30.3.1993.

P. AHAMED

CERTIFICATE

Certified that this thesis entitled "**ADOPTION OF FARM IMPLEMENTS BY THE RICE FARMERS OF KERALA**" is a record of research work done independently by Sri. **P. AHAMED**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

Dr. A.M. TAMPI

Thiruvananthapuram,
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Chairman, Advisory Committee
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CERTIFICATE

We, the undersigned, members of the Advisory Committee of Sri. P. Ahamed, a candidate for the degree **Doctor of Philosophy in Agriculture** with major in Agricultural Extension, agree that the thesis entitled **"ADOPTION OF FARM IMPLEMENTS BY THE RICE FARMERS OF KERALA"** may be submitted by Sri. P. Ahamed, in partial fulfilment of the requirements for the degree.

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to

My Father

(Late) **Janab PATTANI HAMZA HAJI**

who was the sole spirit

behind my academic progress

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INTRODUCTION

1. INTRODUCTION

Technological innovations in the field of agriculture which tend to produce various consequences in society are of three types: biological, chemical, and mechanical. Agricultural development depends largely on technological innovations and its successful transfer. Both are influenced by factor prices, factor scarcity and incentives. Modernised agriculture can contribute substantially to economic growth, but the question is what form of capital investment is the most appropriate. Should the (scarcely) available funds be used for land development (eg., improved drainage and irrigation), high-yielding technology (eg., improved seeds, fertilizers, pesticides), technology to improve labour productivity (mechanization), or for augmenting the knowledge and skills of the farmer through investments in education, training, and extension? Development requires incentives to guide and reward farmers. Once there are investment opportunities and effective incentives, farmers usually respond quickly and apply improved technologies.

Man is said to have made great progress towards civilization when he devised a simple tool from a crooked branch of a tree for tilling his land. When manpower proved insufficient to meet the needs, he pressed animals into service. The use of "iron horses" powered by energy stored in fossil fuels started only in the middle of the last century. All agricultural operations can be done by hand. The other extreme is animalless farming as is observed in some of the western countries.

Owing to their divisibility and favourable cost-benefit ratio, biological and chemical innovations are adopted by farmers of all land size categories, whereas mechanical innovations being relatively costly and indivisible can be adopted mainly by effluent and large farmers.

The potential and desirability of farm mechanization as an agricultural development technique has been widely debated. Mechanization is customarily viewed as a process of substitution of scarce capital for unskilled labour, which is abundant in a country like India. Some apprehend that mechanization would aggravate the problems of rural unemployment and act against optimal utilization of the surplus resources and that because of its capital-intensive character, mechanization of agriculture will be introduced by large farmers which ultimately accentuate the already existing disparities. They argue that about 75 million holdings constituting 77 per cent of the total operational holdings with less than two hectares cannot derive benefits of costly machines like tractors and power threshers. Others, in contrast, hold the view that mechanical relief is necessary for reducing drudgery for deriving the full benefits of high yielding varieties and fertilizers as also for meeting the increased demand for labour.

The human and animal power which was considered to be surplus did not remain so after the green revolution. The absolute demand for labour has rather increased. Moreover, small farmers who cannot afford to maintain a pair of bullocks and whose number is over 20 millions, can have a better access to mechanical power by custom-hiring or joint use of the farm implements and machinery. Further, the machine would perform farm work more efficiently and also undertake jobs which are not feasible by human and animal power. Agricultural mechanization in some of the Asian countries proved that mechanization, if planned and timed properly with other technological inputs, tends to increase productivity of land and man, enhance multiple and intensive cropping, increase labour requirement per unit area, and prevent field losses by harvesting at the optimum time (Bhan, 1987).

1.1 Rationale for mechanization

At the macro level, planners and politicians are interested in mechanization as a means to increase agricultural production. As research reports indicate, mechanization does not always increase production. Yet farmers invest in implements and machinery. Assuming they are rational, there must be reasons why farmers find it attractive to invest in machinery when it does not increase physical output. The reason is that farmer's objective is to increase family income. He chooses the type of technology (or combination) which maximises his income. If (family) labour is cheap and abundant and land is scarce, the farmer will invest in technologies which increase land productivity (eg., irrigation, fertilizer) rather than in mechanization. Therefore, not surprisingly, Indian farmers first emphasized biological and chemical technologies plus irrigation and drainage to increase production (land productivity) and mechanization became important only when the expanding industrial sector forced real labour wages to increase.

When labour and draft animals become more expensive relative to machinery, farmers will mechanize to reduce production costs. High land productivity becomes less important if farmers can supplement income through off-farm activities; they may stop farming altogether, enabling other farmers to take over their land and take advantage of economies of scale. Not surprisingly, cropping intensities declined in India when wage costs increased but investment in mechanization increased rapidly. In areas where there is still a possibility to expand the area while labour become relatively scarce, farmers will first invest in ınization (labour saving) technology rather than land ıctivity - increasing technology.

Relevance of farm mechanization in Indian agriculture

The real break through in Indian agricultural ıction was effected in the mid-sixties through the ıııı.oduction of high yielding dwarf varieties of wheat and rice. Consequently, a new agricultural strategy was evolved in the country, which revolved around the use of package of inputs, namely improved seeds, chemical fertilizers, water, pesticides and improved sources of power and farm equipment. The strategy paid rich dividends in terms of higher production and productivity and ushered in the 'Green Revolution' in certain parts of the country, notably Punjab, Haryana and Western Uttar Pradesh.

Improved farm implements and better sources of power were also recognised, in this process, for the first time, as an important component in the package of inputs vital for increasing agricultural production and productivity. The western concept of mechanization implying large scale use of tractors and large farm machines to make up for the labour shortages, however, was not accepted in India. Farm mechanization in India was adopted as a means of increasing the productivity of land and labour through timeliness of operations, precision placement and efficient utilization of inputs, and reduction of losses at different stages. The Indian model sought to integrate the use of available human labour and animal power with mechanical sources of power.

There have been frequent debate about the desirability of farm mechanization or otherwise in India. It is now widely believed that in an intensive crop husbandry, as being developed in the agriculturally advanced areas of India, selective use of simple and low cost farm machines not only increases the agricultural productivity, but also generates greater employment opportunities. On the basis of extensive studies carried out in different parts of the country, it has been found that use of selective farm mechanization results in 7.5 to 40 per cent increase in agricultural productivity (Table 1.1).

Table 1.1 Agricultural mechanization versus productivity *

Mechanized operations	Percentage increase in productivity	
	range	average
Mechanized seeding and planting	10 - 20	15.0
Weeding	10 - 20	15.0
Plant protection application	10 - 30	20.0
Harvesting and threshing	5 - 10	7.5
Water application	10 - 50	40.0

* Source : Ojah, T.P. (1988). Need for a long term policy. The Hindu Survey of Indian Agriculture - 1988.

1.3 Present status of mechanization in India

The main sources of farm power on the Indian farms include human beings, animals, tractors, power tillers, diesel engines, electric motors, power sprayers, and threshers. The respective contribution on all these sources towards the total power availability is indicated in Table 1.2.

Table 1.2 Existing power availability to Indian agriculture (Singh *et al.* 1984)

Power sources	Numbers (million)	hp per unit	Total hp (million)	hp/ha	Percentage of total
Human : Male	69.70	0.07	4.90	0.0337	7.57
Female	17.70	0.05	0.90	0.0062	1.39
Animal	63.30	0.40	25.30	0.1745	39.17
Tractor	0.65	25.00	16.25	0.1121	25.16
Power tiller	0.02	7.00	0.10	0.0007	0.16
Diesel engine	2.45	7.00	17.15	0.1183	26.55
Total power			64.60	0.4455	100.00

It is evident from the above table that animate power still constitutes to be the main sources of power on the Indian farms.

The horsepower used per hectare for cultivation purposes including that used for lifting water is about 0.45. The quantum of power available per hectare of gross cropped area in the different states of India varies considerably as is evident from Table 1.3. It is high in Punjab, Tamil Nadu and Gujarat. These are the states, where farm production and productivity have been at a faster rate. It is low in Rajasthan, Kerala and Madhya Pradesh, where the rate of increase in production and productivity have been low.

Table 1.3 Total power available for crop production in selected Indian States (Arakeri, 1987)

Sl. No.	State	hp per hectare of cultivated area
1.	Andhra Pradesh	0.36
2.	Assam	0.34
3.	Bihar	0.37
4.	Gujarat	0.43
5.	Haryana	0.33
6.	Himachal Pradesh	0.37
7.	Jammu & Kashmir	0.32
8.	Karnataka	0.29
9.	Kerala	0.22
10.	Maharashtra	0.26
11.	Madhya Pradesh	0.23
12.	Orissa	0.27
13.	Punjab	0.71
14.	Rajasthan	0.19
15.	Tamil Nadu	0.53
16.	Uttar Pradesh	0.39
17.	West Bengal	0.29

World wide analysis carried out by the U.S. President's Science Advisory Committee on World Food Problem indicates that the production has been fairly high in the countries where the power input has been of the order of 0.5

to 0.7 per hectare. If it is intended to reach this optimum level atleast by 2000 AD. in India, the rate of power input will have to be increased at about 5 per cent per annum. This would mean that an additional 60 million horse power of energy will have to be provided by the end of the century. It is obvious that this increase cannot be provided by biological power alone. So there is no way other than the introduction of machine to provide power at the optimum level for farming. Such a situation confirms the relevance of using improved farm implements and machinery in Indian agriculture.

1.4 Priorities in rice farm mechanization

One-third of the total cultivated area of India is under paddy. The extra power required for paddy cultivation alone is estimated to be 21 million hp by the 2000 AD. (Arakeri, 1982). This calls for the enhanced use of improved farm implements and machinery. The cultivation of those modern rice varieties that are short duration non-photoperiod sensitive, demands a balanced use of complementary inputs and related cultural practices.

If we consider the total rice production system, there are seven broad areas where rice production relates to mechanization : (i) land preparation, (ii) sowing/planting, (iii) water management, (iv) inter culture, (v) plant protection, (vi) harvesting and (vii) post harvest processing.

1.5 Present status of rice farm mechanization in Kerala

Kerala is much far behind many Indian states in respect of agricultural mechanization. The average power availability in Kerala is a meagre 0.22 hp per cultivated hectares as against 0.53 hp and 0.71 hp in Tamil Nadu and Punjab respectively. Rice farm mechanization in the state is in its infancy. Human and animal power predominates. The main source of energy is the bullock or buffaloe. The status of farm implements and machinery in the state is shown in Table 1.4.

Table 1.4 Number of farm implements and machinery in Kerala (1990-91)*

Sl.No.	Name of implement/machine	Number
A	**Hand operated implements**	
1	Seed drills	1,753
2.	Chaff cutters	4,031
3.	Wheel hoes	5,164
4.	Sprayers	35,406
5.	Dusters	9,501
B	**Animal drawn implements**	
6.	Wooden ploughs	2,28,566
7.	Iron ploughs	47,385
8.	Disc harrows	761
9.	Seed-cum-Fertilizer drills	281
10.	Seed drills	3,186
11.	Wooden levellers	1,08,049
12.	Pedal paddy threshers	1,283
13.	Wetland puddlers	8,085
C	**Power operated machinery**	
14.	Power sprayers/Dusters	2,085
15.	Diesel engine pumpsets	24,475
16.	Electric motor pumpsets	74,456
17.	Power tillers for agricultural purpose	3,925
18.	Tractors for agricultural purpose	1,335
19.	Mould board ploughs (Tractor/Tiller driven)	1,278
20.	Disc harrows (Tractor driven)	84
21.	Tractor drawn seed drills	23
22.	Tractor drawn seed-cum-fertilizer drills	27
23.	Levelling boards (Tractor/Tiller drawn)	3,582
24.	Tractor/Tiller drawn harvesters	60
25.	Self-propelled harvesters	8
26.	Paddy threshers (engine/motor operated)	330
27.	Multi crop threshers	33

* Source : Statistics for planning 1991. Department of Economics and Statistics, Government of Kerala.

1.6 The Problem

The inability to achieve self-sufficiency in the production of a population's staple food is a risk of the highest order. Kerala has never been self-sufficient in the production of rice. The present annual requirement of rice in Kerala is about four million tons. This is likely to grow to about 4.75 million tons by the 2000 AD. The present internal production is hardly sufficient to meet 30 per cent of the requirement. This has necessitated the transfer of resources worth Rs.7,000 million a year to other states to purchase rice. There has been a decreasing trend in the area and production of rice in Kerala for the last few years. During the last 10 years the area under rice has reduced by about 216,000 hectares and the production by about 260,000 tonnes (Farm Guide, 1991)*. The State has to produce annually about 2.8 million tonnes more to attain self sufficiency in rice. The main problems of rice cultivation in Kerala are the high cost of production and low price for the produce.

Labour is the costliest single input in rice cultivation, contributing to about 60 per cent of the total cost of production. Being a purely seasonal crop, it is highly difficult to utilise the hired labour force effectively and continuously all through the year. The human work force, therefore, migrates to towns and cities,

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* Farm Information Bureau, Government of Kerala.

where continuous employment may be possible resulting in labour scarcity in rural areas especially during peak periods of operations like ploughing, sowing, transplanting, weeding, harvesting, threshing and the like. For carrying out these operations efficiently within the season and time, improved implements and machinery are of great value. This could meaningfully reduce the cost of labour, thus leading to reduced cost of production. Labour-intensive farm implements and machinery which could remove the drudgery and increase labour efficiency are appropriate for the socio-economic conditions of Kerala.

Systematic research work on the development and popularisation of farm implements and machinery has not so far been satisfactory in the state. The introduction of improved implements and machinery becomes meaningful only when it reaches the farmers, modifying the farming practices in vogue. Much emphasis is needed on research studies focussed on the present status, extent of use, constraints to adopt and need-based identification of suitable implements and machinery for each crop, locality, and socio-economic conditions of the farmers. Well planned result tests in farmers' fields are essential to corroborate the worth of the farm implements and machinery in use in Kerala.

Since comprehensive and systematic study of this nature has not been done so far in Kerala, the present investigation was designed with the following specific objectives :

1. To conduct a survey of the farm implements and machinery used by the rice farmers of Kerala and to collect basic information on the functions, specifications, costs, availability, and custom service details.

2. To study the extent of adoption of improved farm implements and machinery by the rice farmers of Kerala.

3. To identify the constraints to the use of improved farm implements and machinery as perceived by the rice farmers of Kerala.

4. To conduct result demonstrations with the selected implements and machinery for rice cultivation.

1.7 Scope of the study

The present study is a pioneering and comprehensive one of its kind in Kerala, wherein an attempt has been made to reveal the present status of the use of various conventional and improved farm implements and machinery, their extent of adoption and constraints to their use as perceived by the rice farmers of Kerala.

An investigation on the extent of adoption and constraints as well as farmers' perception will provide valuable data for future research on these lines and thus streamlining the future strategies in the diffusion of innovations related to rice farm mechanization. The knowledge test, attitude scale and Rice Farm Mechanization Quotient specially developed for the study will provide valuable measuring tools to the researchers. The result tests designed for the study will provide guidelines to researchers of Social Sciences and Farm Machinery. The data elicited through the result tests will bring in the real field problems and farmers' reaction to light pertaining to the problems and prospects of rice farm mechanization.

Based on the results of this study appropriate recommendations could be made to overcome the limitations in the diffusion/adoption of technologies pertaining to rice farm mechanization. Such recommendations could also be translated into action with suitable modifications by other rice growing states also in the country.

1.8 Limitations of the study

This being a pioneering study in Kerala the important limitation was the dearth of sufficient literature pertaining to socio-economic aspects related to rice farm mechanization. Available literature in the areas related to the study have been reviewed and presented.

The respondents of the study comprised of the farmers alone. The study could have been more exhaustive with the inclusion of the other sub-systems involved in the transfer of technology, viz. research sub-system, extension sub-system and input sub-system.

Kerala has five NARP regions. The result tests were conducted only in nine locations within the NARP Central Region alone. This was due to limited time, funds and difficulties in transporting the various implements and machinery to far off places in the other regions. However the study being on farm implements and machinery, the generalisation of results would have validity to other rice growing tracts of Kerala.

In a study of this nature, one cannot hope for a comprehensive and exhaustive account of the full range of rice farm mechanization, nor does it attempt to generalise its findings on national basis. The study does not contain an analysis of the consequences of rice farm mechanization.

The present study had the limitation of time, personnel and finance. A study of this nature in much detail would require considerable amount of time, men and material for the researcher. However, all efforts have been taken to make the study as objective as possible. Inspite of the limitations it is expected that the findings of the present study would provide a better insight into the problems of rice farm mechanization whereby, researchers, extension personnel, administrators and policy makers can streamline an appropriate strategy for mechanization of rice cultivation in Kerala.

THEORETICAL ORIENTATION

2 . THEORETICAL ORIENTATION

A review of previous research studies helps in delineating new problem areas and provide a basis for developing a theoretical framework for the present study. This will also help in operationalising the variables and concepts on the basis of which required data could be collected. In accordance with the specific objectives set, the review of literature related to the study is furnished below under the following sub-heads :

2.1 Concept of agricultural mechanization.

2.2 Concept of rice farm mechanization.

2.3 Scope and importance of rice farm mechanization.

2.4 Concept of adoption and its measurement with special emphasis on farm implements and machinery.

2.5 Concept and classification of constraints to adoption of improved farm technology.

2.6 Constraints to rice farm mechanization.

2.7 Concept, importance and methods of result testing of improved farm technology.

2.8 Conceptual model for the study.

2.1 Concept of agricultural mechanization

According to Webster's Dictionary the term 'mechanization' means the act of equipping with machinery, especially to replace human or animal labour.

According to Bhattacharjee (1949) agricultural mechanization is conceived as the application of machine power to work in land usually performed by bullocks, horses and other draft animals or by human labour.

Khan (1978) stated that agricultural mechanization in the broad sense implies the introduction of machines to utilise manual, animal and mechanical power for agriculture. In the developed countries, mechanization has been traditionally considered as a means to improve labour productivity or to minimise labour inputs in farming.

According to Morris (1980) agricultural mechanization, in its broadest sense, is to do with implements, machines and power sources. In economic terms mechanization involves injecting extra capital into the farming system mainly with a view to increasing labour's capacity to do work defined in terms of quantity and/or quality of output per worker. The potential benefits of mechanization to the farmer are reduced drudgery, increased returns and reduced costs.

According to Rijk (1986) agricultural mechanization embraces the utilisation of hand tools, implements for draft animals and mechanically powered machinery for agricultural land development, production, harvesting and on-farm processing. Three major levels of mechanization technology are available : hand tool technology, animal draft technology and mechanical power technology.

The Project Preparation and Monitoring Cell, Government of Kerala (1986) has pointed out that there is a general erroneous impression that agricultural mechanization means large scale introduction of tractors and all that accompanies them in agriculture. Although farm tractor has contributed more than any other factors—to the present day degree of mechanization in many countries, the concept of mechanization is not entirely correct and to some extent misleading. If mechanization is considered synonymous to tractorisation, then there is only limited scope for mechanization in small holdings. Mechanization of agriculture then should mean the use of hand tools, animal drawn implements and machines that use human labour and skill rather than wholly replacing human and animal labour.

Contradictory to the above explanations, Bhan (1987) has defined agricultural mechanization as the use of power driven machines in farming operations in place of human and animal power.

In the light of the above definitions, a simpler expression for agricultural mechanization could be derived :

Use of hand tools for manual operation, implements drawn by draft animals, machines operated by mechanical power for doing various agricultural operations like land preparation, planting, interculture, application of fertilizers and plant protection chemicals, irrigation, harvesting and post harvest operations.

2.1.1 The process of agricultural mechanization

Despite variations in agroclimatic conditions and in cultural and economic systems, similar economic opportunities and constraints lead to similar patterns of agricultural mechanization.

Based on an analysis of mechanization in developed and developing countries, Rijk (1986) concluded that the following stages may be distinguished in the agricultural mechanization process. As the descriptions of these stages suggest, labour productivity increasing technology may be a better term than 'mechanization' because at later stages, the employment of machines also has to be accompanied by changes in other production technology and environment.

Stage I : Power substitution : At the earliest stage of mechanization draft animal power substitutes for human power and mechanical power replaces draft animal power. The mechanization is straight-forward and machinery is simple and inexpensive. Crop production practices are hardly changed and mechanization basically takes advantage of lower costs of the new power sources compared to traditional ones. When a large area can be cultivated (idle land) mechanization often contributes to increased production. Sometimes increased levels of power change the farming systems, mechanization may allow land preparation before the rain starts and may shorten crop turnaround time, thereby increasing land productivity.

Stage II : Mechanization of the human control functions :
Stage II emphasises substitution of human control functions. Depending on the complexity of control and the degree of mechanization, machinery may become increasingly complicated, more sophisticated, and costly : an improved hand-weeding tool is simple but if a paddy harvester replaces manual harvesting, it is complex.

Stage III : Adaptation of the cropping system to the machine :
Even with today's electronics, it is difficult or costly to mechanize certain human control functions. For example, weeds in broadcast paddy cannot be removed with machines, so row seeding and line transplanting with seed drills and transplanters respectively were introduced. Many mixed cropping systems disappeared because of this change even though they were superior to monocultures. Monocropping became financially more attractive since it could be mechanized thereby giving higher returns to labour. Another

example is the change in row distance and its normalisation to accommodate heavier and larger machinery without need to adjust wheel tread when changing to another crop.

Stage IV : Adaptation of the farming system and production environment to facilitate mechanization : At this stage the farming system is usually adapted to increase labour productivity and to benefit from economies of scale. A classic example is the disappearance of mixed farming in Europe when farmers specialised in dairy, poultry, hog or crop production. At this stage, crops (or varieties) which are difficult to be mechanized may rapidly decrease in acreage or even totally disappear, especially if acceptable substitutes become available. Also, new production systems may be developed, eg., minimum and zero-tillage systems which became technically possible with the introduction of herbicides.

At this stage, mechanization also becomes an important justification for investments in land development and land consolidation. The higher the level of mechanization technology, the bigger the investment in land clearing, field layout, drainage, and access roads.

Stage V : Adaptation of crops to the mechanization system : At this stage, an increase in labour productivity requires adapting plant to machines. Breeders increasingly consider suitability of new plant material for mechanized production, eg., resistance to lodging and threshability of paddy crop to facilitate mechanized harvesting and threshing.

Stage VI : Automation of agricultural production : Stage VI is beginning in countries with high labour costs and sophisticated demands on production and quality. In field crop production, this stage is still at the research level.

According to Binswanger (1982), in most Asian countries mechanization is still in stage I, although it may be more advanced in areas such as the Punjab in India, the Central Plain of Thailand, and the Muda Scheme in Malaysia. Exceptions are the Republic of Korea and Republic of China at stages II and III. Further, investments in land development and consolidation projects in some Asian countries suggest that stage IV has begun, but these investments usually were not made for mechanization but to increase land productivity.

2.1.2 Levels and degrees of sophistication of agricultural mechanization

Rijk (1986) has conceptualised three major levels of mechanization : hand tool technology, animal draft technology and mechanical power technology. Each level has different degrees of sophistication (Table 2.1). Each level and degree has different technical, financial, economic and

Table 2.1 Functions and user levels of mechanised farm technology

Function or operation	Level of mechanization technology@		
	Hand tool	Draft animal	Mechanical power
Land preparation	Hoe, spade.	Wooden plough, Iron plough, spike harrow, disc harrow	Power tiller, Tractor with various implements
Planting or seeding	Broadcasting by hand, Planting stick, Jabber, Row marker, Hand-pushed-seeder	Furrow opener, Marker wheel for dibbling, seed drill, seed-cum-fertilizer drill	Power tiller seed drill, Tractor seed drill, Seeding with aircraft
Transplanting	Hand-operated paddy transplanter		Motorised paddy transplanter.
Inter culture	Three-pronged hoe, Rotary weeder	Wooden inter row weeder, Walking type tool carrier, Riding type tool carrier	Inter row weeder
Plant protection operations	Hand sprayer, Atomiser, Knapsack sprayer, Rocker sprayer		Ordinary power sprayer (knapsack), Power tiller boom sprayer, Tractor boom sprayer, Spraying with aircraft
Irrigation	Water can, Irrigation scoop, Water wheel (Chakram), counterpoise-lift	Persian water wheel, Mote	Pumpsets (Diesel/Kerosene/Electric motor). Drip Irrigation system. Sprinkler irrigation system.
Harvesting	Finger-held knife, Sickle, Scythe.	Cutter bar Mower. Reaper-binder.	Engine-mounted reaper, Power tiller-mounted reaper, Tractor-mounted reaper, Power reaper-binder combine harvester
Threshing	Threshing table. Pedal thresher.	Treading (threshing)	Power thresher (engine/electric motor operated), Combine harvester

@ Within each operation, the degree of sophistication increases vertically.

social consequences. Therefore, the mechanization issue is complex and its impact, positive or negative, depends on the type of technology selected for a specific situation in a particular locality.

2.2 Concept of rice farm mechanization

The term rice farm mechanization implies the use of hand tools, animal drawn implements and power machinery to carry out various operations in rice cultivation starting from land preparation to post harvest handling.

Moomaw and Curfs (1971) reported that rice was probably first harvested as a "drop-seed" crop from natural stands along the margins of lakes and rivers in the low lands of south-east Asia. Accordingly many of the hand tools and animal drawn implements must be step by step modifications of the originally devised ones after the settled cultivation of the crop became common.

2.2.1 A generalised sequence of rice farm mechanization

Herdt (1983) reported that as every country/region has different technical and economic conditions, it is unlikely that identical pattern of rice farm mechanization will take place. However, the broad similarities in relative factor abundance and the tasks required for wet-rice, mechanization is likely to emerge. To date, among the Asian rice economies, only Japan has fully mechanized production.

According to Ishikawa (1981), in East Asia investments in land improvements and water control preceded mechanization. Patel and Patel (1971) and Fei and Ranis (1975) reported that with the availability of electricity and internal combustion engines, power pumps have become one of the first machinery investments for many rice producers.

Ishikawa (1981) opined that electric irrigation pumps replaced foot-operated pumps long before power tillers were used. A 1966 study conducted by Lai (1972) in an intensive rice double cropping area of Taiwan noted that one water pump was available for every three farms while there was only one power tiller for every 18 farms.

According to Lee (1972) small manual threshers were among the first widely adopted mechanical devices. They were later introduced into a number of other countries by the Chinese and Japanese, but never became established. Power threshers, however were widely adopted in many places including the Indian Punjab.

Wu (1972) stated that land preparation was the first operation mechanized in countries like Philippines and Thailand.

Herdt (1983) while critically analysing the sequence of mechanization in several countries concluded : "it seems to be more difficult to develop appropriate machines for other rice production tasks such as planting, fertilizing, cultivating and drying. These operations present formidable technical problems".

A critical examination of the reviews highlight the fact that there are substantial divergences from the generalised sequence of mechanization. For example, in India, the old and new technologies coexist. After the initial land preparation with tractor or power tiller, draft animals are used for secondary land preparation. The extent of rice farm mechanization is determined by the degree to which it substitutes for labour or other inputs, the price of labour relative to substitutes, and the price of rice. This argument suggests that rice production in countries like India was not poised for rapid mechanization.

2.3 Scope and importance of rice farm mechanization

Agricultural extension agents and government officials have claimed there is a power shortage for rice farm mechanization in Indian states.

Pande <u>et al.</u> (1983) in their survey report pointed out that only the state of Punjab with its power availability of 0.80 hp per hectare outclassed the all Indian average of 0.54 hp per hectare.

James (1989) has recommended that a threshold power requirement of 0.375 kwh (0.5 hp) per hectare of crop producing area should be available for augmenting crop production in Kerala. The present availability of power in the state is in the range of 0.10 to 0.30 hp per hectare.

The Project Planning and Monitoring Cell, Government of Kerala (1986) has putforth the following suggestions related to rice farm mechanization in Kerala :

i) An estimated power input of 0.50 to 0.80 hp per hectare is essential to produce an average rice yield of three tonnes per hectare. Studies indicate that further increase in rice yield beyond this level will require substantially large increase in power input per unit of increase in yield.

ii) One way of minimising the total power required to obtain high productivity is by providing a high level of irrigation.

iii) Large tractors have not much relevance to the rice farming in Kerala. Small tractors and power tillers are most suitable. Improved hand tools, animal drawn implements, various attachments to power tiller and tractor, use of power sprayers, power harvesters, power threshers and winnowers have to be introduced.

iv) The more power consuming and labour intensive operations are to be mechanized first. As such in rice farm mechanization, the following priority areas are suggested : (a) land development and preparation (b) irrigation (c) seeding and transplanting (d) weeding and interculture (e) harvesting (f) threshing (g) winnowing (h) farm transport.

v) Rice farm mechanization strategies in the state must serve the needs of small farmers through location specific and appropriate equipment that are locally produced.

vi) Indigenous production of farm implements and machinery can effectively reduce capital investment in rice culture and lower mechanization costs. It should suit the agricultural, economic, social and industrial conditions of the state.

vii) A closer analysis reveals an urgent need for suitable equipment for almost every farm operation.

Gopalan (1985) in his comprehensive report submitted to the Government of Kerala has recommended that in order to improve the efficiency of human and animal labour input to rice farming, diversified use of appropriate farm implements and machinery has to be urgently introduced in Kerala.

James and Muhammad (1988) have reported that the various operations related to paddy cultivation are probably the most drudgerous ones. Research findings reveal that a binding body posture similar to that followed in paddy transplanting and hand-harvesting involves an extra energy expenditure of about 2 k cal./minute and a heart beat rate increase of 35 per cent. Hence any simple mechanical aid that enables the farm labourer to do the works like transplanting and harvesting in an erect posture will impart much comfort to the worker. At the same time the machine can bring about a larger area coverage.

According to James (1989) due to the severe unemployment problem in Kerala all rice farm mechanization strategies which are practised in the western world or even in Indian states like Punjab and Haryana are not as such adaptable to Kerala. Selective mecanization which is capable of generating additional employment will be acceptable to Kerala.

While analysing the status of rice production in Kerala, Gopalakrishnan (1990) has opined that about 55 to 60 per cent of the cost of cultivation being accounted for wages to labourers, the practical solution to reduce cost of production is to introduce selective mechanization. About 30 per cent of the cost of cultivation is for preparatory cultivation. If the cattle power is replaced by tiller or tractor power, the cost of preparatory cultivation could be reduced by half. As against 32 pairs of draft cattle required for preparatory cultivation in a hectare of field, only nine hours of tractor ploughing will suffice. Further, the time taken for the operation is reduced substantially and consequently the turn-over period between two rice crops gets shortened atleast by a fortnight. This in turn helps the crop to escape the maladies like drought and incidence of pests and diseases and also to economise the use of irrigation water. As the harvest of the autumn crop (virippu) comes in the rainy season the loss and damage to the produce could be avoided if power threshers, winnowers and power driers are used.

From the aforesaid observations and reports, it could be concluded that the real issue of rice farm mechanization in Kerala is not whether to mechanize or not, but rather the nature of mechanization that would increase production without disturbing the labour force, without creating major socioeconomic imbalance. The rice front of the state cannot be mechanized all on a sudden. It has to be done meaningfully and step-by-step. Low cost hand tools and implements and an appropriate combination of animal draft and mechanical power technologies for specific conditions are suitable for Kerala.

2.4 Concept of adoption with special emphasis on adoption of farm implements and machinery

According to Webster's Dictionary the term to 'adopt' means to take up and practice.

Ban and Hawkins (1988) defined adoption of innovations as the decisions to apply an innovation and to continue to use it.

Many research workers have investigated the relationship between an individual's adoption index and a variety of his social characteristics. Some of the results that are summarised by Ban and Hawkins (1990) are presented in Table 2.2.

The 'individual-blame' hypothesis which refers to the socio-psychological factors related to the individual, has, for a long time, been thought to be the principle factor affecting the adoption decision. More recently many researchers have focussed attention on the 'system-blame' hypothesis which states that characteristics of the technology and the access conditions of the farmers affect the adoption decision. (Hooks et al. 1983, Audirac and Beaulieu, 1986., Ban and Hawkins, 1990)

Table 2.2 Percentage of studies showing positive relationship between adoption index and other variables.*

Variable		% of studies	No.of studies
Education	..	74	275
Literacy	..	63	38
Higher Social Status	..	68	402
Larger-size units	..	67	227
Commercial economic orientation	..	71	28
More favourable attitude to credit	..	76	25
More favourable attitude to change	..	75	57
More favourable attitude to education	..	81	31
Intelligence	..	100	5
Social participation	..	73	149
Cosmopoliteness (urban contacts)	..	76	174
Change agent contact	..	87	156
Mass media exposure	..	69	116
Exposure to interpersonal channels	..	77	60
More active information seeking	..	86	14
Knowledge of innovations	..	76	55
Opinion leadership	..	76	55

*Source: Ban, A.W. Vanden and Hawkins, H.S. (1990). Agricultural Extension Longman Scientific & Technical, John Wiley & Sons, New York, pp.107-8 (Based on: Rogers, E.M. (1983) Diffusion of innovations (3rd edn.) (New York: Free Press) pp.260.1)

The classical diffusion model putforth by Rogers and Shoemaker (1971) has been criticised by many researchers due to its main limitations of "insensitivity" to contextual and social structural factors (Beltran, 1976; Goss, 1979; Ashby, 1982; Audirac and Bealieu 1986); and an "individualistic or psychological bias (Bostian, 1974; Havens, 1975; Goss, 1979; Ashby, 1982).

According to Goss (1979) individual-oriented studies are not sufficient for sociological theory-building. In the classical diffusion model there had developed the assumption that individual clients have equal control over their destiny through equal access to the innovation, equal access to the information and other resources needed for adoption. Many case studies have revealed that potential adopters will not be equally predisposed to defining the adoption situation as a desirable or attainable condition themselves.

Ashby (1982) has opined that researches done in the lines of the classical diffusion model have been notably deficient in attention to the diverse physico-biological and social requirements of agricultural technologies, and to variations in farming environments as factors influencing farmers' adoption behaviour. The suitability of agricultural technologies to different farming environments is addressed only in the diffusion literature in terms of the availability of socio-economic resources which facilitate or inhibit farmers' innovation, while the physical and natural parameters of agriculture are largely ignored.

Studies of Perrin and Winkelmann (1976) suggested that agroclimatic zone and topography were the most consistent factors in explaining why some farmers adopt new technologies and others do not.

Mann (1978) reported that farmers have adopted selectively from technological packages, and that this selectivity can be associated for example, the suitability of a technology to soil and rainfall conditions.

Substantial evidence shows that problems of limited diffusion of new rice technology in South Asia are "fundamentally related to insufficiently resolved difficulties in adapting the new technology to certain important local and seasonal environments (Farmer, 1979)".

The importance of location specific constraints to technology transfer points to the need for greater attention in diffusion research to what Prez (1979) has termed "agricultural ecology". This term refers to a long tradition in cultural or human ecology which emphasizes the interdependence between social and physical environment. In an ecological framework a technology or method of farming encapsulates and structures a set of relationships between farmers' social and physical environmental resources (Geertz, 1969).

Gotsch (1972) and De Janvry (1978) have reported that 'intrinsic characteristics' of the technology, relative to the factors it tends to use most intensively, such as capital, labour, information etc. are related to the adoption of technologies.

The 'intrinsic characteristics' of the technology and its 'distributional characteristics' define the 'conditions for access' to the innovation of potential adopters (Diaz Bordenave, 1976; Pearse, 1980; Brown, 1981).

According to Ashby (1982), adoption of innovations is a decision to substitute or adopt a technique or practice presently being used for a newer one. This decision is possible when there is a match between the conditions for access to the innovation, the potential users' ecological (location, natural resource endowment) and structural characteristics (farm size, capital, hired labour, level of management etc.).

Gotsch (1972), Goss (1979), Fliegel and Van ES

(1983) have proved that "consequences" of diffusion of innovations affect adopters and non-adopters of a social system.

Leagans (1985), based on a comprehensive Five - Country study on the adoption of technology by farmers, has listed the following 'disincentives' by the farmers which motivated them not to adopt the recommended technical practices : (a) lack of technical guidance (b) lack of irrigation water (c) more labour required (d) lack of knowledge (e) lack of credit (f) supplies not on time (g) inadequate equipment (h) too expensive technology (i) very complex to adopt (j) neighbours do not use (k) land not adequate (e) labour not available (m) risky to adopt.

Audirac and Bealieu (1986) have listed five groups of factors related to the technology affecting its diffusion/adoption. They are, (a) research and development of the technology, (b) diffusion infrastructure and diffusion agencies' strategies, (c) characteristics of the technology, (d) access conditions for adoption and (e) consequences of adoption.

2.5 Concept of classification of constraints to adoption of improved farm technology

Constraints in the production system constitute the basic point in the development of new technology.

According to Webster's Dictionary, to constrain is to check, especially from free or easy indication or expression or to force by stricture restriction or limitation imposed by nature, oneself or circumstances or exigencies.

The Random House Dictionary of English Language gives the meaning of constraint as something that constraints: the condition of being constrained. Constrain means to repress, to force or to compel.

The Oxford English Dictionary gives the meaning of constraint as confinement, restriction of liberty or compulsion of circumstances or compulsion put upon behaviour.

Nikhade and Bhople (1989) defined constraints as the state or quality of sense of being restricted to a given course of action.

According to Pandya and Trivedi (1988) constraints are "those item of difficulties or problems faced by individuals in the adoption of technology".

Petharam (1985) and Zinyama (1988) called the problems and/or limitations as constraints.

According to Gogoi and Talukadar (1989) constraints are "those factors which have repressive effects on a desired and/or purposive action".

2.5.1 Classification of constraints to adoption of improved farm technology

Classification of constraints helps to get a comprehensive picture of the diverse problems in the way of transfer of technology and its adoption.

Sofranko (1984) called the "obstacles" to agricultural development as constraints and classified them to socio-cultural obstacles and economic obstacles. Socio-cultural obstacles are those within the farmers themselves, contributed by their traditional values and beliefs, illiteracy, lack of achievement motivation, insufficient resources, limited aspirations and low level of skills. Economic obstacles are those caused by limitations in the farm environment, like lack of new technological inputs, inadequate financial incentives, insufficient transportation and marketing facilities, agri-support system and research facilities.

According to Librero (1984) production constraints could be classified into biological and socio-economic constraints. The biological constraints included all farm level problems, while the socio-economic constraints comprised of knowledge, institutions, credit, input availability, economic behaviour, traditions and risk aversion.

Bembridge (1987) grouped the production constraints into biological, socio-economic and institutional. The biological constraints led the farmers either to non-application or poor application of technology, whereas, the socio-economic and institutional constraints prevented them from using the improved technology.

The various constraints to the adoption of new agricultural technology were categorised by Kothicane et al. (1987) into: (a) Technical constraints (b) Economic constraints, (c) Service and supply constraints and (d) Information transfer constraints.

Gomez (1977) classified the constraints to rice production as physical/biological/cultural practices; economic, institutional, social and psychological.

Wagmare and Pandit (1982) classified the various constraints to the adoption of improved technology by the tribal farmers of Madhya Pradesh into educational, economic, sociocultural and practical constraints.

Menon (1983) grouped the various socio-economic, extension and organisational constraints limiting rice production in Kerala into the following three groups : (a) Economic constraints (b) Extension constraints and (c) Organisational constraints.

Swaminathan (1984) classified the constraints causing yield gap in rice into two categories : The first category included biological, chemical and hydrological and pedological constraints. The second category of constraints were economic and social.

Prasad <u>et al.</u> (1987) classified the factors influencing the development of agricultural sector in India into the following five broad categories : (a) Common basic constraints (b) Technological constraints (c) Organisational and administrative constraints (d) Extension constraints (e) Social constraints.

After reviewing the various classifications of constraints to adoption of improved agricultural technology by Indian farmers, Nikhade and Bhople (1989) came out with a classification which they called 'Standardised categorisation of constraints' as given below :

(a) Economic constraints

i) Lack of capital (ii) Non-availability of loans to defaulters.

(b) Input constraints

i) Non-availability of inputs (ii) High cost of inputs (iii) Untimely availability of essential inputs.

(c) Information constraints

i) Lack of technical knowledge (ii) Lack of skill.

(d) Technological constraints

i) Complexity of certain improved technologies

ii) Susceptibility of improved strains to pests and diseases.

(e) Psychological constraints

i) Perception of risk (ii) Perception of low profitability (iii) Non-perception of necessity of technology

(iv) Impact of beliefs and traditions.

(f) Infrastructural constraints

i) Non-availability of draft animals (ii) Non availability of improved implements and machinery.

(g) Situational constraints

i) Non-suitability of soil for a particular crop

ii) Inadequate source of irrigation (iii) Restricted to the use of inputs available in the local co-operatives.

The review of the classification of constraints to the adoption of any improved farm technology indicates that most of the constraints are more or less common to all crop growing tracts of India and elsewhere. The major groups of constraints emerged from the review could be narrowed down to the following categories : (a) Common basic constraints (b) Biological constraints (c) Technological constraints (d) Extension constraints (e) Infrastructure constraints (f) Organisational, administrative and policy constraints (g) Economic constraints (h) Socio-cultural and psychological constraints.

2.6 Constraints to rice farm mechanization

According to Moigne (1979) it is absolutely necessary to determine the constraints faced by a producer before proposing any technological package for adoption.

2.6.1 Constraints to the adoption of improved farm implements and machinery reported from Asian countries other than India

In Pakistan, studies conducted by various researchers like Bose and Clark (1969), Finney (1972), Mc. Inerney and Donaldson (1975), Lockwood et al. (1983) revealed the following constraints : (a) Massive labour displacement (b) Tenant displacement (c) Non-perception of cropping intensity (d) Negligible yield effects due to mechanization.

Qureshi (1978) while reporting the status of agricultural mechanization in Pakistan indicated that small and fragmented holdings, availability of cheap labour, opposition from labourers, lack of desired spare parts, absence of repair and service facilities in the rural areas, non-availability of financing for farmers, paucity of technical services, high prices of farm machinery, and lack of research for standardisation of implements and machinery were the major problems in agricultural mechanization.

In Srilanka, Kathirkamathamby (1978) studied the major constraints to adoption of rice mechanization equipment and found that small fragmented holdings, lack of capital and credit, nonavailability of specific equipment for specific work situation and unsuitability of improved machines to the local crop conditions were the difficulties perceived by the rice farmers.

Kishida (1978) reported that despite Japan being the leader in rice farm mechanization, it has the problems like small and separated fields and rapid decrease of young farmers to operate the machines and to take up rice farming.

Shrestha (1978) while analysing the status of farm mechanization in Nepal reported that most of the rice farm operations were still carried out manually or by animal power with indigenous tools and implements. Small and fragmented holdings, undulating topography, high initial cost of the machines, shortage of spare parts, lack of repair and maintenance facilities, and a low level of technical know-how were the explanations given for the slow pace of rice mechanization in Nepal.

Findings of Tarmana (1978) and Hafsah and Bernsten (1983) in Indonesia revealed that fragmented and tiny rice fields, high initial cost of implements and machines, inadequate credit, insufficient technological development, shortage of trained man power, limited demand of domestic markets, low custom-hire services, low availability of spare parts and low propaganda were the limiting factors in the diffusion of mechanization.

Tin (1978) reported that constraints to the use of farm implements and machinery for rice cultivation in Burma were (a) small farms (b) soil and water problems (c) lack of credit facilities (d) lack of custom-hire services (e) lack of conveyance accessibility to tractors and (f) limited supply of irrigation water.

Jabbar et al. (1983) found that lack of attitude, knowledge and conviction on the advantages of improved farm machinery, non-availability of suitable equipment, lack of capital, high priced spare parts and fuel and inadequate repair and maintenance facilities were the major constraints to the adoption of farm implements and machinery in Bangladesh.

Constraints to rice mechanization in Philippines as reported by Juarez and Pathnopas (1983) were small farms, unavailability of custom services, poor performance of certain machines and plentiful availability of human labour.

Research findings of Wattanutchariya (1983) revealed that financial constraints, technological difficulties, lack of skilled labour, low price for rice, high cost of production, high initial cost of machinery and unsuitability of available equipment to specific situations were the important obstacles to large scale adoption of rice mechanization technology in Thailand.

Analysing the various research findings, Rijk (1986) summarised the major constraints to the use of improved farm implements and machinery in developing Asian countries. They were : (a) Small and fragmented holdings (b) Low price for paddy (c) Insufficient credit facilities (d) Lack of farm machinery subsidies (e) Seasonal nature of operations (f) Farmers' lack of awareness and knowledge on farm equipment (g) Low level of entrepreneurship of rice farmers (h) Inefficient public hire services and co-operative ownership of farm machinery (i) Insufficiency of private custom hire services (j) Lack of farm machinery policy.

2.6.2 Constraints to the adoption of rice farm mechanization technology reported from the Indian states other than Kerala

Rao (1972) while discussing the problems encountered in farm mechanization in Tamil Nadu stated that high cost of machines, small size of holdings and limited scope to small farmers were the perceived reasons for not using power machines like power sprayer.

Singh (1978) studied the status of agricultural mechanization in Southeast and East India and reported the following constraints to the diffusion/adoption of improved farm machinery for rice cultivation : (a) Small holdings (b) Less recognition to the contribution of mechanical power to rice farming (c) Low availability of tractors (d) High cost of farm implements and machinery (e) Heavy import duty and taxes on machines (f) Inadequate custom hire services (g) Lack of joint ownership (g) Lack of awareness and knowledge of farmers on improved farm machinery (h) Lack of propaganda on the advantages of farm equipment (i) Less remunerative price of paddy in relation to investment on farm machinery.

Suri (1978) opined that small and fragmented holdings, low resource capacity of rice farmers, lack of appropriate mechanization technology for the small rice farms and lack of co-operation among farmers for joint and/or co-operative ownership were the main constraints to the use of farm implements and machinery for rice cultivation in India.

The National Council of Applied Economic Research (1980) in its report on the implications of tractorisation in India remarked that inadequate irrigation facilities and low cropping intensity stood in the way of large scale use of power machines like tractors and power tillers. The status of Punjab was quoted as an example. Punjab, with its 75 per cent of the area being irrigated and having very high cropping intensity, has more than 12 tractors per 1000 cultivated hectares. The corresponding figures reported were 2.8 tractors/1000 hectares for Uttar Pradesh and 1.0/1000 hectares for Kerala.

Saikia and Gogoi (1982) in a case study on improved agricultural implements in Assam stated that particularly the small farmers were discouraged to use the improved implements due to high initial cost and high repair and maintenance costs.

Gupta and Ram (1989) opined that the problems associated with the adoption of mechanical power inputs in rice farming in Northern Bihar were small and fragmented holdings, poor economic conditions of the farmers, low level of attitude, awareness and knowledge, high cost of machines, high cost of operation of power machinery, low level of modernity and entrepreneurship of the farmers and low level of extension orientation.

Prakash (1989) while analysing the problems and prospects of farm mechanization in Bihar identified the following constraints : (a) Predominance of small and marginal farmers (b) Small and fragmented holdings (c) Lack of resources available with the farmers (d) Lack of credit facilities (e) Absence of clearly defined tenancy and share cropping arrangements (f) Ineffective extension service (g) Traditional nature of the farmers.

Singh et al. (1989) in a study to find the effect of modern equipment on productivity identified that small size of holdings, lack of awareness and technical knowledge of the farmers, lack of sufficient availability of attachable implements for the power machines and poor level of literacy were the important reasons for the low level of adoption of improved farm equipment.

According to Singh and Kumar (1989) following were the important constraints to the large scale adoption of rice mechanization equipment : (a) Lack of economic resources (b) Costly equipment (c) Undulating terrain of the field (d) Sloppy and terrace lands (e) Lack of extension and propaganda (f) Low level of entrepreneurship.

Sinha (1989) opined that the important factors that militated against the rapid use of improved farm machinery were lack of proper type of power units best suited for developed implements and machines, low mechanical aptitude and skill of the farmer and lack of suitable and efficient units for multipurpose use suitable for diverse conditions.

Alagesan and Padbanaban (1990) in a study on the use of improved agricultural implements by the farmers of Tamil Nadu identified the constraints specific to 12 selected implements/appliances. The constraints enlisted were mostly in the order of costliness, very limited scope to use and no means to purchase.

According to Philip and Subramanyan (1990) lack of awareness on improved farm implements and machinery were the most important constraints to their adoption as perceived by the farmers of Tirunelveli district of Tamil Nadu.

2.6.3 Constraints to the adoption of rice farm mechanization technology reported from Kerala

Kerala does not have a commendable history of agricultural mechanization. Mechanization, especially rice mechanization, is in its infancy. Only very limited research reports related to the socio-economic aspects of mechanization have emerged. The available literature are reviewed hereunder :

According to a report of the Project Planning and Monitoring Cell, Government of Kerala (1986) "Since small sized farm holdings constitute a large segment of the arable land in Kerala, it is ironic that with all technological and new farm machinery developments, the small farmers of Kerala have little access to appropriate farm equipment, especially power machines". The report has identified the following constraints also : economic and socio-cultural limitations, lack of foreign exchange to import equipment, low level of local manufacturing, lesser number of rural artisans to supply tools and implements and the lesser compatibility of imported machines with the resource endowments of the State.

The report has further stated that the use of machinery imported from western countries have the constraints of huge capital investment and massive human and animal labour displacement. At the same time, machinery imported from Japan have the problems like high sophistication and complexity and high initial cost. They are not economically accessible to the small rice farmers of Kerala.

James (1988) and James and Muhammed (1988) have identified the following constraints to rice farm mechanization in Kerala : (a) Small size of holdings (b) Fragmented holdings (c) Economic backwardness of farmers (d)

Lack of sufficient credit facilities (e) Lack of promotional subsidies (f) Unemployment problem (g) Inadequacy of research and field trials (h) Lack of location specific and production oriented research on farm power machinery (i) Lack of appropriate equipment to suit the regional requirements of the State (j) Scanty infrastructural facilities for extension activities in the field of farm machinery (k) Lack of facilities to train farmers in the use of improved farm equipment (l) Absence of village artisans to supply hand tools and animal drawn implements.

Prakash (1989) in a study entitled "Sequential analysis of constraints in increasing production of rice and coconut in Kerala" found that barring the central region, low use of farm machinery was an important production constraint in rice farming in the other four NARP regions of Kerala. The reasons attributed to this limitation were : (a) small farm size, (b) fragmentation of holdings, (c) absentee landlordism, (d) nonavailability of suitable equipment, (e) lack of facilities to train operators, (f) insufficiency of private and public hire services, (g) lack of freedom given to farmers to select farm equipment of their choice while granting hire purchase facility and (h) inadequacy of repair and service facilities.

The review of the constraints to the adoption of improved implements and machinery indicates that some of the major problems like small and fragmented holdings, uneven terrain, low cropping intensity, lack of attitude, awareness and knowledge of the farmers, lack of funds available with the farmers, lack of credit facilities and subsidies, high initial cost of the farm equipment, inadequacy of repair and service facilities are common to all regions of Kerala. In the light of these observations, it would be desirable to find out the major constraints as perceived by Kerala rice farmers.

2.7 Concept, importance and methods of result testing of improved farm technology

Karajgi (1969) has stressed the importance of on-farm testing of the recommendations by saying, "the extension agent has to make sure recommendations to farmers are relevant, beneficial and appropriate. Given the gap between researchers and farmers, recommendations must be tested in the farmers' fields. Due to the time and location specificity of farm operations, practices/equipment developed by researchers for one region need not always be suited to other local settings until they are tested thoroughly. Such result tests initiate the process of learning and motivates the farmer to change his old habits, customs, traditions and practices and thereby help to build a progressive attitude in him. Once the full process of result testing and/or result demonstration is thoroughly grasped, there is no reason why a technology tested in advance at the research station be adopted by the farmers".

The concept of result testing of agricultural technologies has been given by Gibbons and Schroeder (1983). According to them, unless a farmer sees a practice work well in his own locale, caution holds him back from employing the practice. Local testing of recommendations helps arouse farmers' interest in new practices and enables farmers themselves to take part in the process of testing and formulating new practices. Testing of practices in the field involves a combination of adaptive research and extension work. Quite often these steps overlap as depicted below in fig. 2.1.

Fig. 2.1 Diagrammatic representation of overlapping phases of adaptive research and extension

a. Small-plot experiments at research stations.
b. Farm (field) experiments on local farms.
c. Result tests (field trials) on local farms.
d. Result demonstrations (demonstration plots).
e. Mass application (promotion).
Adjustment of recommendations by individual farmers, feedback and suggestions, advisory services.

Adaptive Research

Extension Work

Kellogg (1977b) has opined that once the research directives are chosen and preliminary results of experiments obtained, on-farm field testing and verification can be begun. In general, this involves planning on-farm trails, choosing method(s) for implementing these trials and adjusting trials as results occur. Certain trials will yield results that indicate that technological options can be managed by farmers and are significant improvement over current farming practices.

The simplicity-complexity aspects related to the items to be included in a result test have been recommended by Harwood (1979). In designing trials, it is best to work towards technically viable designs rather than towards optional designs. Optimality usually does not have much operational meaning within the complexity of farmers' circumstances, while technical viability implies designs that are responsive to conditions likely to prevail when the technologies are introduced to farmers.

According to Kirkby <u>et al.</u> (1981) before finalising result trial design, it is necessary to determine the characteristics of farmers who are to be chosen as co-operators. It is important to decide whether to select more progressive farmers or farmers who are representative of the areas' average farmers. More progressive farmers are usually easier to work with and ensure a higher degree of success with trials. However, the results from such trials are probably not representative and may provide biased answers to the question of the appropriateness of the technology.

Zandstra *et al.* (1981) in their book on methodology for on-farm cropping system have opined that the level of complexity of on-farm trials is critical. If trials are very complex and involve a large number of treatments, they are difficult to manage under actual farm conditions. It is better to have less complex trials in order to meet the limited resources of co-operating farmers.

Shaner *et al.* (1982) have putforth the following recommendations on establishing standards for result testing trials which included (a) setting up trials that will yield useful results, (b) avoid unnecessary detail and complexity and (c) gaining uniformity among trials across areas and over time. These standards are related to types of farmers, location and number of trials, design complexity and methods of evaluating results.

Tripp (1982) has stressed the importance of collecting data on the perception, of co-operating farmers, of the various technological, socio-economic and psychological aspects involved in the mode and results of the result tests. According to him, some of the most valuable information obtained by on-farm research are the observations, perceptions and opinions of the farmer. Collecting data from the fields fulfills only a part of the goals of on-farm trials.

According to Limpinutana et al. (1982) the trials on farmers' fields have to be managed by the researcher. Researchers often pay farmers for their labour and the use of their land, so that farmers do not suffer losses from poor experimental results. Small plots are generally chosen, although larger plots may be needed to study constraints on farm equipment and machinery. The necessity of researcher to visit the trials atleast on a weekly basis severely restricts the number of trials managed by any individual researcher.

Johnson and Kellogg (1984) have highlighted the invaluable role of the participating farmers in the result tests. The farmers reveal their reactions to the improved technologies included in the trials. These reactions have to be systematically recorded by the researcher.

The result testing of the three "packages" of implements and machinery envisaged in the present study was undertaken following the criteria and recommendations elicited from review of literature cited in the preceding paragraphs.

2.7.1 Review of research findings related to result tests done with package of farm implements and machinery for rice cultivation in India

Shanmugham (1981) stressed the importance of conducting result tests with the improved farm implements and machinery in comparison with the conventional ones so as to recommend "packages" of implements for specific regions and specific crops. After these trials, they could be popularised among the farmers through result demonstrations.

Bansal and Jain (1986) conducted result tests with various packages of farm equipment and reported the comparative advantage of using the improved packages over the conventional ones. They observed increase in the yields to the tune of 15.35 per cent. The cost of operation was less with the improved implements. The net saving in the cost of cultivation recorded was Rs.830/- per hectare. The total investment of Rs.2525/- for the "improved implement package" could be recovered in one year.

Rao (1986) conducted result trials in farmers' fields in Andhra Pradesh and identified a set of eight implements. He reported increased yields and lesser cost of cultivation ranging from Rs.200/- to Rs.320/- per hectare.

Shanmugham (1986) identified a package of nine implements and machinery and popularised them in four villages near Coimbatore. The farmers appreciated the usefulness and were convinced of the economic advantages over the conventional ones.

Gupta and Ram (1989) studied the economics of power tiller farming system in comparison with the traditional methods for important operations like puddling, harvesting and threshing of rice crop. For land preparation, rototilling by Kubota power tiller recorded the least cost and highest yield (20.98 per cent higher than ploughing with "Desi" plough). Harvesting with vertical conveyer reaper required only 6.25 hours per hectare as against manual harvesting which required 18 - 20 man days per hectare. Cost of harvesting was reduced by half when reaper harvesting was done (Rs.126/ha and Rs.288/ha for reaper harvesting and manual harvesting respectively). In addition to economic benefits, timeliness in completion of harvesting by reaper gave advantages by facilitating timely sowing of the rabi crop.

Threshing with a wireloop type paddy thresher operated by Kubota power tiller resulted in 50 per cent saving in the cost of threshing (Rs.12.70/quintal and Rs.27.00/quintal for machine threshing and manual threshing respectively).

Panday et al. (1989) identified an improved package of agricultural implements and result tested them in Bhopal and came up with the following results : (a) The use of improved agricultural implements/tools resulted in a saving of 25 to 30 per cent time and in reducing drudgery

(b) The increase in labour productivity was perceived by the farmers (c) The participating farmers showed keen interest in the improved implement package as it contributed to saving in time, quality of work and reduced cost of cultivation (d) The improved package had positive impact on the neighbouring farmers. This was reflected by their willingness/approach for including them in their cultivation programme during the succeeding year.

Sinha et al. (1989) in a study conducted at Ranchi observed that considerable increase in net returns could be achieved from paddy cultivation by the use of package of improved implements. They used a package of six implements : Mould Board plough (10 cm), Ridger plough, Seed-cum-Fertilizer drill, Grubber, Dutch hoe and line sowing behind the plough. Ploughing, seeding and weeding produced highly significant difference in net profit from the rice crop. The treatment, Mould Board Plough + Ridger Plough gave the highest net return of Rs.1500/- per hectare as against that from Desi plough (Rs.1271/- per ha). Amongst the weeders, Grubber proved to be the best with Rs.1538/- per hectare net return against the least with the conventional *khurpi* (Rs.1240/- per ha).

They recommended two sets of packages :

(a) Most profitable package : Mould Board plough + Ridger plough + Birsa Seed-cum-Fertilizer drill +

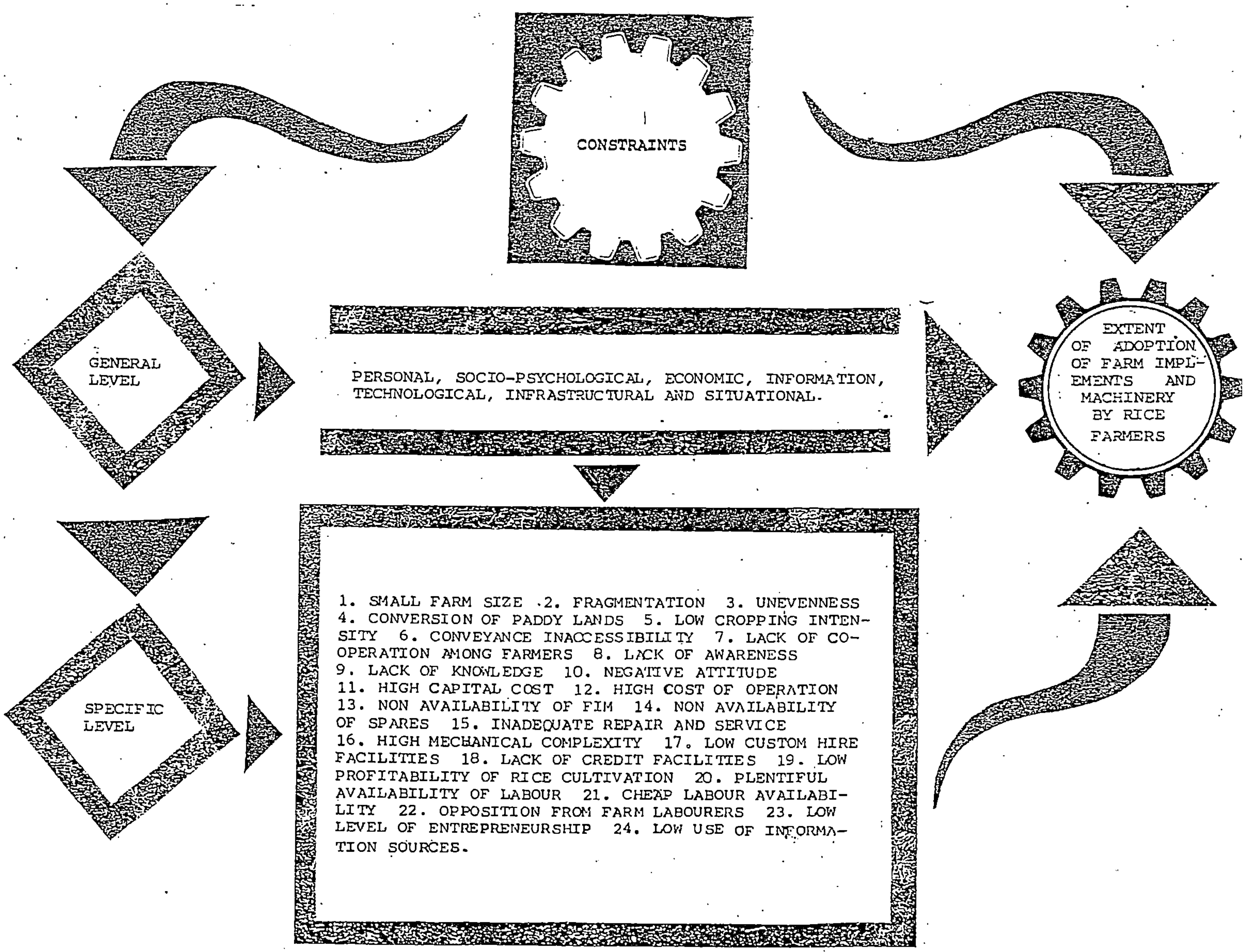
Grubber weeder. The price of the package worked out was Rs.405/- with an increased net return of Rs.919/- per ha over and above the local methods and implements.

(b) Intermediate technology package : Ridger plough + Seeding behind the plough + Weeding with Dutch hoe with a package cost of Rs.130/- and a net additional return of Rs.484/- per ha when compared to conventional practices.

Sivaswami et al. (1990) result tested a package of five paddy equipment comprising of Bose plough, Helical blade puddler, Manual weeder, Fertilizer spreader and improved sickles in an adopted village of Malappuram district of Kerala. The economic advantages and the relative perception of the farmers on various aspects of the individual equipment and the "package" were analysed. The improved implements had significantly higher savings in terms of cost of cultivation, labour input, time of operations, higher field coverage and quality of work. The implements won the appreciation of the participating farmers.

In the light of the reports briefed in the previous paragraphs, it was envisaged in this study to conduct nine result tests with three packages of farm implements and machinery.

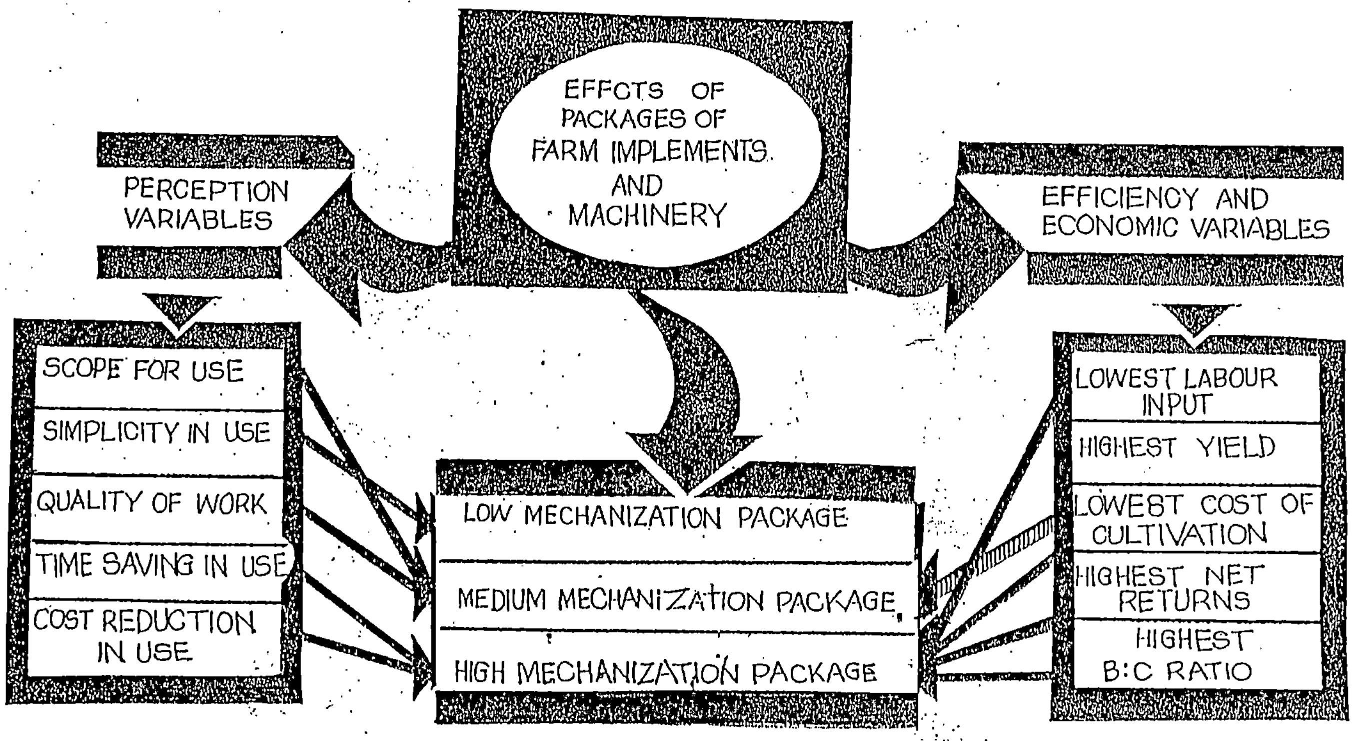
Fig. 2. 2 CONCEPTUAL MODEL DEPICTING THE CONSTRAINTS TO RICE FARM MECHANIZATION



The review on the extent of adoption of farm implements and machinery and constraints to their adoption brought out an information gap in these aspects. Though there were several studies highlighting the influence of socio-personal and socio-psychological variables on adoption behaviour in general, studies focussed on farm implements and machinery were limitted in number. This underlines the need for intensification of research in this field.

In general the review indicated that not much work has been done on adoption and constraints to rice farm mechanization per se in India. The situation is more bleak in Kerala as the review brought out the paucity of information on the status of rice farm mechanization, studies on its problems and prospects, extent of adoption, constraints to adoption, actual performance data of farm implements and machinery in farmers' field, and farmers' perception on the worth of rice farm mechanization. The present study is undertaken to throw more light on these aspects.

Fig. 4.9 EMPIRICAL MODEL OF RESULT TESTS WITH SELECTED PACKAGES OF FARM IMPLEMENTS AND MACHINERY.



SIGNIFICANT EFFECT NON SIGNIFICANT EFFECT

METHODOLOGY

3. METHOD

In accordance with the specific objectives, the methodology followed in the study is summarised under the following heads :

3.1 Phased programme chalked out for the study.

3.2 Locale of the study.

3.3 Sampling design.

3.4 Survey of the implements and machinery used by the rice farmers.

3.5 Extent of adoption of implements and machinery for rice farm mechanization.

3.6 Identification of constraints to rice farm mechanization.

3.7 Measurement of identified constraints.

3.8 Result tests with the selected packages of farm implements and machinery.

3.9 Procedure adopted for data collection.

3.10 Statistical tools used.

3.11 Operationalisation of concepts.

3.12 General hypotheses set for the study.

3.1 Phased programme chalked out for the study

The study was conducted as a phased programme commencing from the virippu (Autumn) crop season of 1990 in two stages as described below :

Stage I

The first three objectives listed below envisaged in the study were accomplished by the Stage I.

1. To conduct a survey of the farm implements and machinery used by the rice farmers of Kerala and to collect basic information on the functions, specifications, costs, availability and custom-service details.
2. To study the extent of adoption of improved farm implements and machinery by the rice farmers of Kerala.
3. To identify the constraints to the use of improved farm implements and machinery as perceived by the rice farmers of Kerala.

Stage II

The fourth objective of the study viz. 'to conduct result tests with the selected farm implements and machinery for rice cultivation was accomplished by Stage II.

3.2 Locale of the study

3.2.1 Selection of the study area for Stage I

Kerala is divided into five agro-climatic regions based on its physiography, climate, soil characteristics, sea water intrusion, irrigation facilities and land use pattern. The regions are : (i) Northern, (ii) Central, (iii) Southern, (iv) Highrange and (v) Special zone of problem areas. Five NARP centres are functioning to represent these five regions. The first stage of the study was conducted in all these five regions (Fig. 3.1).

3.2.2 Profile of the study area

3.2.2.1 General agricultural characteristics of Kerala State

Kerala state lies in the South-West corner of the Indian Peninsula between 8°/18" and 12°/48" north latitudes and 74° 52" and 77° 22" east longitudes as a long narrow strip of land, 32 to 133 km wide, between the Western Ghats in the east and the Arabian Sea in the west with a 580 km long coastal line. In the south, the state is bounded by Tamil Nadu and in the north by Karnataka. With a geographical area of 38863 km , Kerala supports a population of 29,098,518 (1991 census)*.

Kerala is administratively divided into 14 districts spread over 61 taluks covering 1362 revenue villages. There are 987 panchayats, three corporations, 56 municipalities and one township. There are 151 development blocks in the State.

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* Report of the Directorate of Census, Government of India (January 19, 1993).

3.2.2.2 Physiography

Kerala is a land highly diversed in its physical features and agro-ecological conditions. The undulating topography ranges in altitude from below mean sea level to 2694 m above MSL. Topographically the state can be divided into four well defined natural divisions, viz. the high ranges (750 m above MSL), the highland (75 - 750 m above MSL), the midland (75. - 75 m above MSL) and the lowland (upto 7.5 m above MSL). All these natural divisions run almost parallel in north-south orientation.

3.2.2.3 Climate and rainfall

The state has a fairly salubrious climate. In the high ranges and highland regions there is bracing cold climate for most part of the year whereas the other regions have tropical climate. The most important rainy season in the state is during the south-west monsoon commencing from June and ending in September. The other rainy season is the north-east monsoon which generally lasts from October to November. The average annual rainfall in the state is 3125 mm (1992). The annual rainfall ranges from 1479 mm at Parassala in the south to 3562 mm at Hosdurg in the north.

The mean annual temperature varies from 25.4°C to 31.0°C in the central part of Kerala. The daily maximum temperature may shoot upto 40°C in summer and the minimum may come down to 16°C in winter.

The mean monthly relative humidity over different parts of Kerala varies between 85 per cent and 95 per cent during June - September and is about 70 per cent in January.

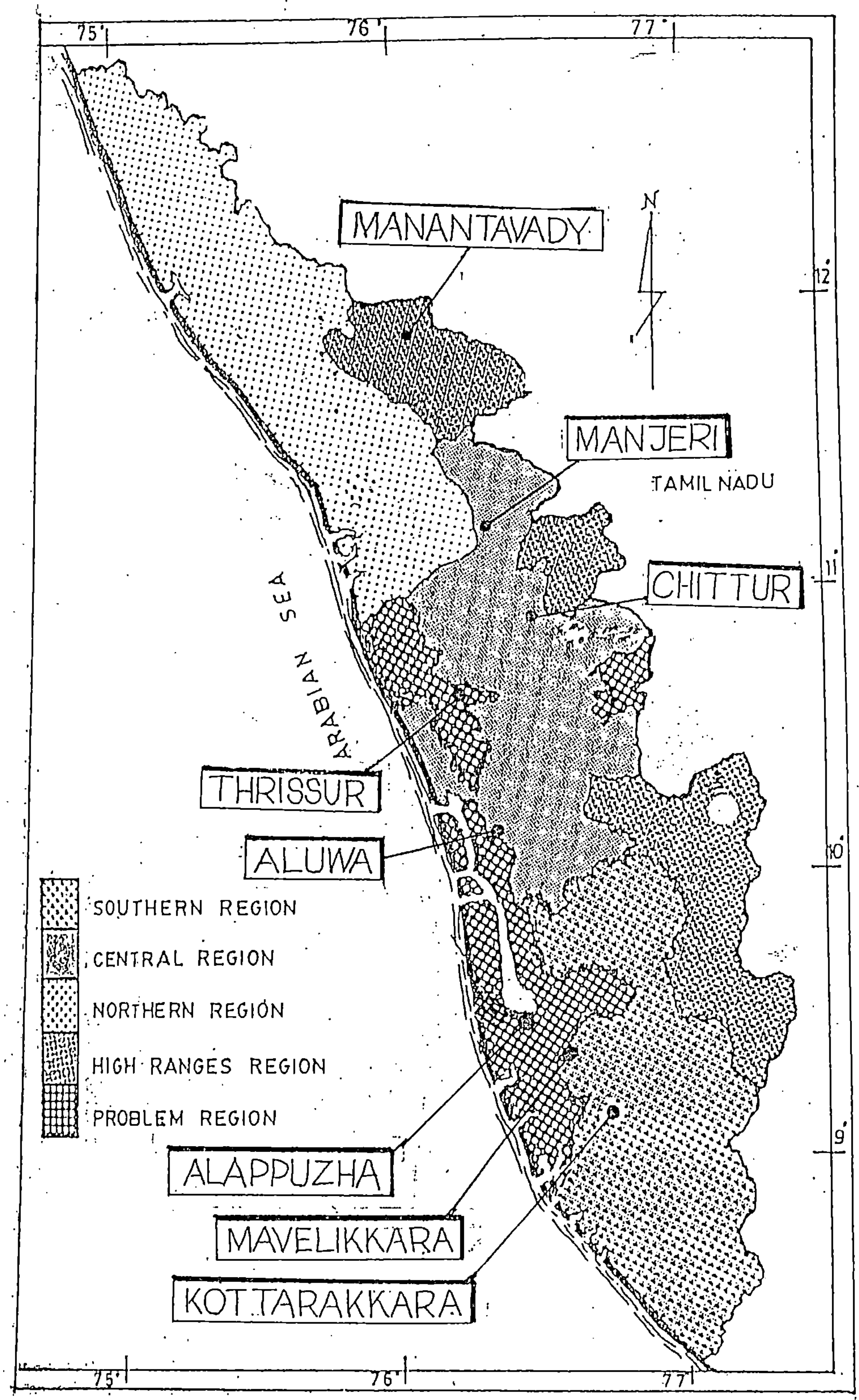
3.2.3 Brief description of the NARP regions

3.2.3.1 Central Region

The Central Region consists of the central districts of Kerala, viz. Palakkad, Thrissur and Ernakulam excluding the highranges, central saline tracts and other isolated areas like kole lands with special soil and physiographic conditions. Geographical area of the zone is 973,689 hectares, forming 25 per cent of the area of the state. The soil type is mainly laterite. This zone is the major rice growing tract of the state which accounts for about 50 per cent of the area under rice and 52 per cent of production of rice in Kerala. Coconut, arecanut, groundnut, sesamum, pulses, banana and pineapple are the important crops of the zone.

Palakkad district which accounts for about one-fourth of the total area under rice of the state is under the Central Region. There are three crop seasons for rice - virippu, mundakan and punja. Mechanised farming, especially rice farm mechanization, has made a significant contribution in revolutionising the agricultural scene of the zone.

Fig. 3.1 MAP OF KERALA SHOWING THE STUDY AREA



* Agricultural Subdivisions selected for the study.

Central Region is the forerunner in the use of tractors, power tillers, power sprayers, pumpsets, improved implements and even power threshers.

From the Central Region, Chittur agricultural sub division by virtue of its highest area and production of rice during 1989-90 was selected for the study.

3.2.3.2 Southern Region

The Southern Region comprises the districts of Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha and Kottayam with a total geographical area of 726,200 hectares, forming 18.68 per cent of the area of the state. The soils are lateritic, the texture ranging from sand to sandy loam and clay loam. The major crops of the region are rice, coconut, tapioca, pepper, cashew, rubber, arecanut, sugarcane, pulses and banana.

There are three crop seasons for rice - virippu, mundakan and punja. Rice farm mechanization has not shown much head-way in the Southern Region. Though animal ploughing is predominant, in certain areas power tillers and tractors have become common. From the Southern Region, Kottarakkara Agricultural Subdivision due to its highest area and production of rice during 1989-90 was selected for the study.

3.2.3.3 Northern Region

Northern Region consists of the four northern districts of Kerala viz. Kasaragode, Kannur, Kozhikode and Malappuram. The total geographical area of the region is 1.094,600 ha covering 28.2 per cent of the area of the State. Agriculture is the main occupation of the people. Nearly 88 per cent of the population is engaged in farming and allied activities. Rice, coconut, arecanut, pepper, banana, cashew and rubber are the important crops of the region. The major types of soils in the region are coastal alluvium, laterite and forest loam.

There are three crop seasons for rice - viripu, mundakan and punja. The Northern Region does not have a commendable status with respect to rice farm mechanization. For the past few years, farmers have been experiencing acute shortage of farm labourers during peak periods of operations. As a consequence, tractor ploughing has become common in all the districts of the region.

Manjeri Agricultural Subdivision by virtue of its highest area and production of rice during 1989-90 was selected for the study.

3.2.3.4 Highrange Region

This region comprises the districts of Wynad and Idukki, Nelliampathy and Attappady hill ranges of Palakkad district, Tanithode and Seethathode Panchayats of Pathanamthitta district, Ariyankavu, Kulathupuzha and Thenmala panchayats of Kollam district and Peringamala, Aryanad, Vithura, Kallikad and Amboori panchayats of Thiruvananthapuram district. The total geographical area of the region is 2,177,280 ha which is 56.55 per cent of the area of the State.

The Wynad Range occupies the first position both in area and production of rice in the Highrange Region. It is situated at an elevation ranging from 700 to 2100 m above MSL. The geographical area of the region is 213,200 ha. Agriculture is the main occupation of the region. The soil type is forest loam. Wynad region is famous for plantation crops and spices. Coffee, the most widely cultivated crop, is the main source of income to the vast majority of small farmers. Pepper, cardamom, ginger, tea and rice are the other important crops of this region.

Mananthawady Subdivision ranks first in area and production of rice in the Wynad Range. Despite being a plantation based farming system, rice based farming system is prevalent in paddy fields. Rice fields are mostly in the valleys formed by hillocks and therefore gently or steeply sloping from one end to the other. Flat land are found only on the river banks. In a majority of paddy lands only a single crop of paddy is taken with very long duration local varieties. The cropping season extends from May to December. The land is left fallow from January to April due to lack of irrigation facilities. A second crop of paddy with short duration varieties is taken in a small area in some parts of the subdivision where irrigation facilities are available. In some areas a two year rotation is followed with rice-banana, rice-ginger and rice-tapioca.

Due to the undulating topography and small plot size, tractor operation is very difficult. In some areas, especially in the flat lands on the river banks, power tillers are used for farm operations.

Mananthawady agricultural subdivision was selected for the present study.

3.2.3.5 Special zone of problem areas

The region comprises of five subregions viz. Onattukara, Kuttanad, Pokkali, Kole and Sugarcane lands spread over the six districts of Kerala, viz. Alappuzha, Kollam, Kottayam, Ernakulam, Thrissur and Malappuram. One subdivision each was selected from each of these sub regions.

<u>Onattukara</u>

The Onattukara region, which falls into Kollam and Alappuzha districts and characterised by a purely rainfed sandy loam belt is now a problem area of low level of production and productivity. Two rice crops are raised viz. <u>virippu</u> <u>and</u> <u>mundakan</u> and followed by a third crop of sesamum during summer season. The soil being sandy loam in nature, Bose ploughs and power tillers are largely used for land preparation.

Mavelikkara which is the single subdivision representing the Onattukara subregion was selected for the study.

<u>Kuttanad</u>

Kuttanad area comprises of the low lying lands and the backwater system found in the districts of Alappuzha and Kottayam. The paddy fields are mostly lands reclaimed from the backwaters. The soil types are peat or kari soils with a pH ranging from 4.5 to 5.5. The fields are lying at a level of 1.0 to 2.5 metres below Mean Sea Level and are subject to inundation of salt water. One or two crops of paddy are raised with punja being the dominant crop. A second crop is raised depending upon the location of <u>padasekharam</u> and the weather. The area of each <u>padasekharam</u> ranges from a few hectares to above 1000 hectares owned by several cultivators.

The vast nature of the paddy fields allow farm mechanization to a great extent. Tractors and power tillers are commonly used even though there are traditional ploughmen. Power sprayers are used for application of pesticides. Chemical weedicides are extensively applied.

The Agricultural subdivision selected for the study was Alappuzha.

Pokkali

This area comprises the marshy lands of Ernakulam district where intrusion of salt water is the problem. The total area of the region is 8903 hectares. The soils are acid saline. The main crops grown are rice, coconut and banana. Rice, the most important crop of this region is cultivated under saline conditions as pokkali paddy. Only one rice crop is raised. After November, the lands are used for prawn culture.

The rice farm mechanization in this region is characterised by the use of power tillers for land preparation.

Aluwa, being the single Agricultural subdivision representing the pokkali area, was selected for the study.

Kole lands

The kole area lies continuously along the coastal strip of Thrissur and Malappuram districts with an area of 11,000 hectares. Acidity, salinity, poor drainage and presence of toxic salts are the characteristics of the region. Generally only one paddy crop is taken which is known as kole punja. During the rest of the year the fields are under submergence. Besides paddy, coconut, tapioca, banana and vegetables are the other important crops of these areas.

The commonest feature of the paddy cultivation in the kole lands is a type of group farming under the leadership of a 'Kole Padavu' committee which has been prevailing from long time back. This group action facilitates the use of tractors, power tillers, power sprayers and even power threshers. Similarly the inputs are also arranged on a joint basis.

The Thrissur Agricultural subdivision which represents the largest kole area was selected for the study.

3.3 Sampling design

A multistage sampling procedure was followed for the purpose of drawing sample for the present study (Fig. 3.2).

The representative area under each of the five NARP regions was selected following a three stage sampling based on the net cropped area and production of rice in the year 1989-90. In the first stage, one Agricultural subdivision was selected from each of the NARP regions except the special zone of Problem Region, where one Agricultural subdivision each was selected from each of the sub-regions namely, Onattukara, Kuttanad, Pokkali and Kole lands. The Agricultural Subdivisions which had both the highest net cropped area under rice and recorded the highest production during the year 1989-90 were selected. Thus there were eight Agricultural Subdivisions selected for the study. In the second stage, two Krishibhavans (Panchayat level agricultural extension unit) each were selected, based on the same criteria of net cropped area and production of rice, from the four Agricultural Subdivisions selected from the four NARP regions. In the special zone of Problem Region, one Krishibhavan was selected from each of the four Agricultural Subdivisions. Thus there were 12 Krishibhavans selected for the study.

In the third stage, from each Krishibhavan, two padasekharams (group of paddy fields in a village) each were selected, again based on the criteria of area and production of rice as was done in earlier stages. Thus there were 24 padasekharams selected for the study.

3.3.1 Selection of respondents

The ultimate unit of sample for the study was individual farmer. The list of rice farmers in the selected padasekharams was prepared with the help of the Agricultural Assistants in charge of the padasekharams and the

Agricultural Officer of the <u>Krishibhavan</u>.

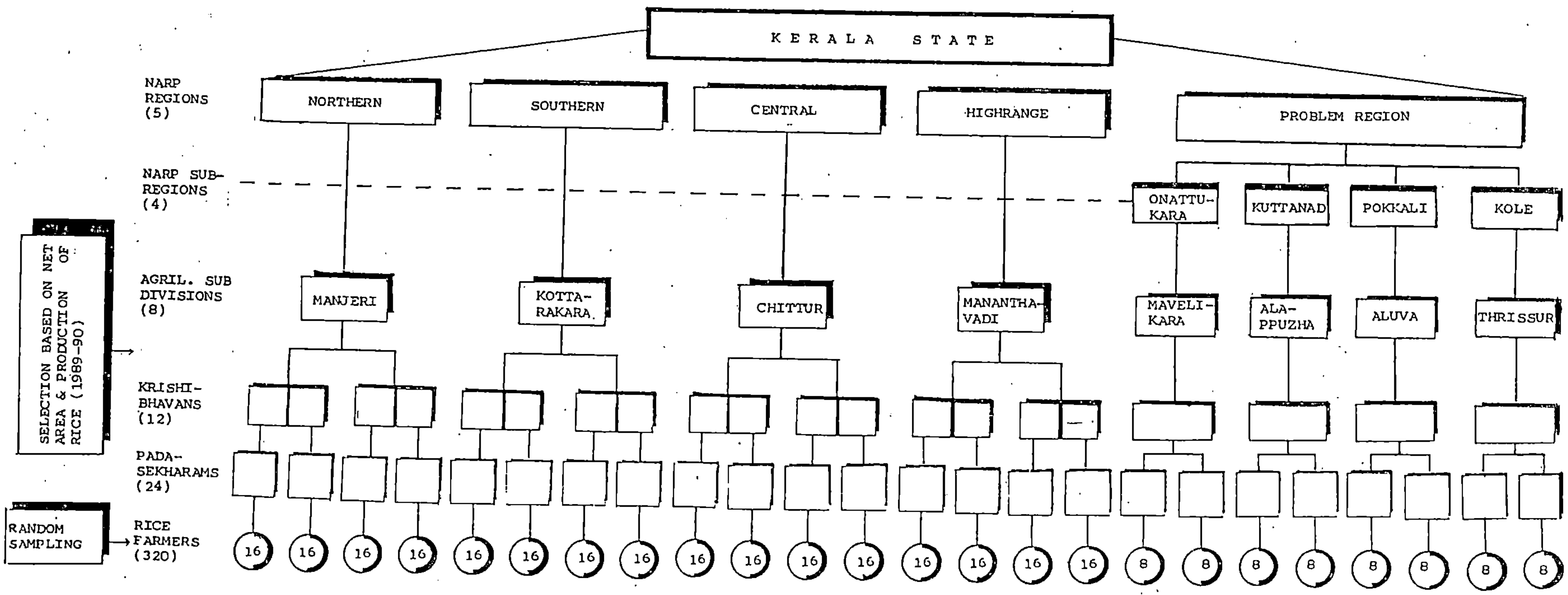
The respondents from each <u>padasekharam</u> were selected using random sampling technique with a purpose to select 16 farmers. In the case of <u>padasekharams</u> under the special zone of Problem Region eight farmers each were selected. Thus there were 320 farmers who formed the sample for the present investigation.

The sampling design for Stage I of the study is schematically presented in Fig. 3.2 and in a tabular form in Table 3.2.

Table 3.2 Details of study area and number of respondents

Sl. No.	NARP regions	Agrl. Sub Divisions	Krishibhavans	Number of respondents
1.	Central Region	Chittur	Nallepilli	32
			Pattencheri	32
2.	Southern Region	Kottarakkara	Chengamanad	32
			Pattazhi	32
3.	Northern Region	Manjeri	Pulamanthole	32
			Aliparamba	32
4.	Highrange Region	Mananthawady	Edavaka	32
			Mananthawady	32
5.	Problem Region Sub regions			
	Onattukara	Mavelikkara	Krishnapuram	16
	Kuttanad	Alappuzha	Nedumudi	16
	Pokkali	Aluwa	Panangad	16
	Kole	Thrissur	Adat	16

Fig. 3.2 DIAGRAMATIC REPRESENTATION OF SAMPLING DESIGN OF THE STUDY



3.4 Survey of the implements and machinery used by the rice farmers

A major bottleneck in the popularization of improved agricultural implements and machinery in India has been the documentation gap. Many original developments of research institutions, manufacturers and even farmers have not been made known to others. Consequently, other research workers, manufacturers and farmers could not take advantage of these developments which also resulted in the duplication of efforts in certain areas (Shanmugham, 1981; Sivanappan, 1984). An attempt has been made to collate all available information on the conventional and improved implements and machinery used by the rice farmers of Kerala. The survey was conducted in the five NARP regions of Kerala State. The data were collected with the help of a standard proforma suggested by the Council for Advancement of Peoples Action and Rural Technology (CAPART) with suitable modifications to satisfy the requirements of the present study. Besides interviewing the 320 respondent farmers, reviewing literature, official documents, manufacturers' catalogues and directories, the researcher held discussions with manufacturers and suppliers of farm implements and machinery, agricultural engineers, extension workers and farm machinery scientists.

The following details of each implement/machine were recorded and or calculated :

1. Popular name of implement/machine
2. Local name
3. Salient features
4. Functions
5. Specifications
   (a) Type (whether hand tool/animal driven/power driven)
   (b) Power requirement (whether human/animal/mechanical)
   (c) Work capacity (hectare per hour or quintal per hour)
   (d) Capital cost
   (e) Cost of operation (Rupees per hectare, Rupees per quintal, Rupees per hour)
   f) Custom service charge
   g) Availability and status of use

3.5 Extent of adoption of implements and machinery for rice farm mechanization

For quantifying adoption behaviour, researchers have developed various methods. Notable among them were Hoffer (1942), Wilkening (1952), Marsch and Coleman (1955), Fliegel (1956), Coates and Bertrand (1958), Beal and Rogers (1960), Bose (1961, 1962), Chattopadhyay (1963), Supe (1969), Jaiswal and Dave (1972), Singh and Singh (1974), Samantha (1977), Singh (1981), Singh (1983), Audirac and Bealieu (1986) and Carlson and Dillman (1988).

Hoffer (1942) introduced an important variable in the measurement - the potentiality of adoption by a particular farmer by noting the nature of applicability of the practice. Hoffer studied adoption of a practice in terms of the ratio of the number of possible adoption to the number of actual adoption, as well as in terms of the number of practices adopted by each grower.

Wilkening (1952) also considered the importance of potentiality of adoption. The index of adoption used was the proportion of practices adopted to the total number of practices applicable to that farmer. Because of the differential nature of practices, he suggested differential weights in the adoption index.

Marsch and Coleman (1955) used 'Practice Adoption Scores' computed as the percentage of applicable practices adopted.

Fliegel (1956) constructed an 'Index of Adoption' of farm practices using the correlation of several adoption variables. He factor analysed each of the 11 factors selected. Non adoption was given a value of 'zero' and adoption a score of one.

Coates and Bertrand (1958) devised a simplified statistical methodology for measuring adoption of farm mechanization. They used a unique single-digit system of coding and standardising data using sten scores and developed a technique of correlation analysis. They also devised a method for assigning weights to the various implements and machinery used by the farmers.

Beal and Rogers (1960) computed a simple adoption scale which credited an individual with one point for adoption and 'zero' point for non adoption.

Bose (1961) defined adoption index as the number of practices adopted. For example, if a farmer uses only improved seeds then his adoption index is one, if he also takes fertilizer in addition, his adoption index is two and so on. It was not clear whether the researcher took into consideration the potentiality or the applicability of the practices. A more mature type of adoption index was used by Bose (1962). This index was the "total number of years a farmer had used various improved practices". Thus, if a farmer had used fertilizer for 10 years, plant protection chemicals for four years and seed drill for three years, then the adoption index was 17. He did not consider the applicability or the potentiality of adoption of practices. Moreover he had given equal weights to all the selected 13 practices.

Chattopadhyay (1963) constructed an 'Adoption Quotient' to measure farm practices adopted by farmers. He has taken into consideration the different variables such as potentiality, extent, weightages and time in developing the adoption quotient.

Supe (1969) used an unweighted practice adoption score. He selected 10 cultivation practices for cotton and for each practice the total score for complete adoption was six. The practices divisible were assigned partial scores for partial adoption.

Jaiswal and Dave (1972) and Singh and Singh (1974) used a similar Adoption Quotient as above, which were also modifications of the one developed by Chattopadhyay (1963).

Samantha (1977) measured the extent of farm mechanization by developing a Farm Mechanization Index. The number of years each farm implement/machine used by the farmer was multiplied by its weightage and was added up for all the farm implements/machinery the farmer had used. The total score indicated the level of farm mechanization of the particular farmer. The weightages assigned to the implement/machine were as follows :

Sl.No.	Machines/Implements		Weightage
1	Tractor	..	3
2	Power Tiller	..	2
3	Disc Harrow	..	2
4	Cultivator	..	1
5	Trailer	..	1
6	Mould Board Plough (Bullock drawn)	..	1
7	Seed Drill	..	1
8	Pumpset	..	3
9	Wheel Hoe	..	1
10	Paddy Weeder	..	1
11	Sprayer	..	2
12	Duster	..	1

Singh (1981) used the Farm Mechanization Index of Samanta (1977) by subsequently adding the item 'Thresher' by assigning it a weightage of two.

Singh (1983) calculated the Farm Mechanization score of individual farmers by assigning percentage weightage to the power machinery used for wheat cultivation. The percentage weightages assigned were as follows :

Sl.No.	Name of operation		Percentage weightage
1	Tillage and seed bed preparation	..	18
2	Seed and fertilizer placement	..	18
3	Irrigation	..	22
4	Weed control (weedicide application and interculture)	..	8
5	Plant protection	..	2
6	Harvesting	..	14
7	Threshing (including cleaning)	..	13
8	Transportation and storage	..	5
			100

If an operation (out of the above mentioned) was done with the use of power machinery the percentage weightage indicated against each operation was allotted to that operation. These weightages were multiplied with the number of acres in which power machinery was used to conduct that operation. The added total of scores for all the operations were divided with the total area under wheat to obtain the mechanization score of a particular respondent.

Audirac and Bealieu (1986) listed five groups of factors related to the technology affecting its diffusion/adoption. They are : (i) Research and Development of the technology (ii) Diffusion infrastructure and Diffusion agencies' strategies (iii) Characteristics of the technology (iv) Access conditions for adoption (v) consequences of adoption. They have evolved devices for measuring the above five groups of factors.

According to Carlson and Dillman (1988) the complexity involved in the use of improved farm implements and machinery requires mechanical skill in the farmers for their adoption. They computed the adoption scores by asking detailed question about all past uses of farm implements and machinery and future expectations. They used the variable 'the year of first use' of the farm implements and machinery. They also used mechanical complexity scores and equipment scores.

Adoption researches made in the last four decades have measured adoption either as a single-practice adoption of an individual farmer, or as a multi-practice adoption of an individual farmer, or as a community behaviour of adoption of one or more practices. The present investigation has measured adoption as a multi-practice adoption of an individual farmer as was done by Kolte (1967).

The step-by-step development of Farm Mechanization Quotient and measurement technique of adoption behaviour of farmers employed in this study are elaborated in the forthcoming sections from 3.5.1 to 3.5.7. The technique basically depends on the method devised by Chattopadhyay (1963). But several modifications to suit the specific situations contained in the rice farm mechanization of Kerala have been made in the present investigation.

3.5.1 Measures of adoption relevant to the specific implement/machine

3.5.1.1 Potentiality

Potentiality of use of improved farm implements and machinery for rice cultivation is conceived as the maximum degree to which a rice farmer can extent his adoption, if he so wishes, depending on the maximum utilization of the resources he commands or can command. For example, the possession of five hectares of paddy land by a rice farmer justifies the use of a power tiller if it is either available in the market for purchase or available in the locality for custom-hiring. This means that he has the potentiality of adoption of a power tiller. But if two hectares of paddy land is not accessible to the use of a power tiller, his potentiality in such a case is only three hectares. For this study a list of implements and machinery recommended for rice farm mechanization in Kerala was prepared after review of literature and discussion with progressive farmers and extension officers. Potentiality for different implements and machinery considered for computing the Farm Mechanization Quotient (FMQ) was calculated after ascertaining their possibility for use in the locality and availability either for purchase or for custom-hiring.

3.5.1.2 Extent

Extent of adoption in this study is the degree to which a farmer has actually adopted a recommended and available improved implement/machine for rice cultivation. When the extent of adoption equaled the potentiality of use, adoption was recognised as full at that time, and when the extent was nil, it was considered as non-adoption. Between these two extrémes à number of positions can be conceived and generally observed.

3.5.1.3 Time

While measuring adoption the year of first use of an improved implement is an important variable (Dillman et al, 1987). It is necessary to know how long the farmer has been adopting it. In the present study the following aspects related to the time factor were considered:

(a) The year w[illegible] the improved implement/machine was first avai[illegible]le in the markets of the State.

(b) The year [illegible]en the improved implement/tool was first adop[illegible] by the farmer.

(c) The year w[illegible] the investigation was carried out.

3.5.1.4 Consistency

Steady continuity in the use of an improved farm equipment is an important factor in the calculation of Farm Mechanization Quotient. While measuring adoption over several years, the gaps, if any, in their use are also to be considered. Adoption research suggests: the individuals move through several stages before adopting an innovation (Rogers, 1983). Trying a practice for the first time is a stage in this progression that precedes adoption, but does not assume that adoption will take place. Many more farmers may try improved implements and machines than will actually adopt them. Possibilities for discontinuance, either temporarily or permanent, cannot be ruled out. According to Carlson and Dillman (1988) there is clear cut distinction among initial try, staggered use and continuous use (adoption). Consistency in the present study refers to the continuity in the adoption of improved implements/machinery for rice cultivation. Two gaps, if any, were reckoned in the computations.

3.5.1.5 Weightage

Ashby (1982) stated, "Sociological diffusion research has been notably deficient in attention to the diverse physico-biological, technical and economic requirements of agricultural technologies and to variation in farming environments influencing farmers' adoption behaviour. As a result characteristics of different technologies have not been considered relevant data in explaining difference in adoption among farmers". This indicates the need for attention to differences among technological innovations when analysing farmer adoption. The improved farm equipment communicated to the farmers differ in their difficulty of adoption. The intrinsic characteristics of the technology which cause intrinsic differential difficulty in the adoption define the 'conditions for access' to the innovation of potential adopters (Diaz Bordenave, 1976; Pearse, 1980; Brown, 1981).

According to Chattopadhyay (1963) it is customary to give more credit to the performance of a more difficult task. Logically, then the farmers who adopt more complex, difficult and efficient farm equipment should get credit (weightage) for this aspect. Hence it was reasonably assumed in the present study that relative ease or difficulty, based on the complexity of use, both intrinsic and extrinsic, and based on the work efficiency parameters, constituted an important variable in the construction of a Farm Mechanization Quotient.

3.5.2 Farm Mechanization Quotient (FMQ)

Farm Mechanization Quotient is a numerical ratio designed to quantify the adoption behaviour of an individual with respect to the adoption of farm implements and machinery.

3.5.2.1 Constituent variables in the Farm Mechanization Quotient

3.5.2.1.1 Potentiality of adoption

i_1 = Total number of implements/machines

i_2 = Total number to which the individual has the potentiality to adopt.

i_3 = Total number of implements/machinery adopted by the individual.

3.5.2.1.2 Potentiality and extent of adoption of a particular implement/machine

e_1 = Potentiality of use (or potential extent) in any given year.

e_2 = Actual extent of adoption in any given year.

e_{tp} = Extent of adoption at the time of investigation.

e_{t2} = Extent of adoption at the time of first adoption.

e_{1tp} = Potentiality of use at the time of investigation.

3.5.2.1.3 Time

t_1 = Time of first introduction of the implement machine to the farming community.

t_2 = Time when it was first adopted by the individual.

tp = Time of investigation.

3.5.2.1.4 Consistency

g = Period of discontinuance (time gap) in the use of an implement/machine.

3.5.2.1.5 Weights

w = The weightage assigned to each implement/machine.

Using the above symbols the Farm Mechanization Quotient was developed through five phases as was done by Chattopadhyay (1963).

Phase I

$$FMQ = [\, x + (\sum Y/N) \,] / 2$$

where, $X = i_3 / i_2$

N = Number of implements and machinery from which Y is calculated.

and $$Y = [((tp-t2) - g) \frac{(etp - et2)}{e1\ tp}] / (tp - t1)$$

(tp − t2) − g represents the total number of years the individual is using the implement/machine and (tp − t1) is the total span of time since its introduction. As both are expressed in the same unit, after division pure ratio is obtained. The part (etp − et2) represents the change in the extent of adoption. The fluctuations in consistency within the period has not been included in the present study.

Phase II

$$FMQ = X + [(\sum Yj/N)] / 2$$

where, $X = i3/i2$

N = Number of implements/machinery from which Yj is calculated,

and $$Yj = (\sum_{tp - t1}^{1} e_2 / e_1 / tp - t1)$$

In the above formula all the variables discussed earlier have compositely been fused except the weights. The factor will produce the ratio of the extent to potentiality for each year and the consistency included therein, as also this ratio will be obtained in each year of adoption. For the period for which the individual has not adopted, namely t1 to t2, the e2, that is, extent will be 'zero'. The factor (tp - t1) gives the total span of time period from introduction to time of investigation, (tp - t1) factor being constant at given time of investigation for a particular implement/machine. Whatever credit an individual gets for adoption is in relation to this time span. As the X and Y factors have been averaged out, hypothetically ideal adopter who adopts in the very first year of introduction to the full extent and continues it without any gap will have a Farm Mechanization Quotient as unity while on the other hypothetical extreme is a complete non adopter who will have a Farm Mechanization Quotient as 'zero'.

To avoid the gross effects of X factor, the formula was remodelled as follows :

Phase III

$$FMQ = \frac{\displaystyle\sum_{j=1}^{N} \frac{\left(\displaystyle\sum_{i=1}^{tp - t1} e_2/e_1 \right)}{tp - t1}}{N}$$

Phase IV

$$FMQ = \sum_{j=1}^{N} Yj$$

$$\text{where, } Yj = \frac{\displaystyle\sum_{1}^{tp - t1} e2j/e1j}{tp - t1}$$

where, j indicates the jth practice.

To the above formula weights have to be added. Apart from this, the formula will be more convenient to use if it is expressed in percentage.

Phase V

$$FMQ = \frac{\displaystyle\sum_{j=1}^{N} Yj\ Wj}{\displaystyle\sum_{j=1}^{N} Wj} \times 100$$

where,

$$Yj = \frac{\sum_{1}^{tp - t1} (ej/pj)}{tp - t1}$$

N = Number of implement/machinery for which the individual has the potentiality to adopt.

$\sum_{j=1}^{N}$ = Summation over each of N number of implements/machine, of which any one is the jth implement/machine.

Wj = Weight to be assigned to a jth implement/machine based on its difficulty of adoption determined from a list of differential weights.

$\sum_{1}^{tp - t1}$ = Summation over each year from t1 to tp.

ej = Extent of adoption of any particular (jth) implement/machine in a particular year.

tp = Time of investigation.

$t1$ = Time of first introductin of jth implement/machine in the farming community (year).

pj = Potentiality of j^{th} implement/machine.

In the final formula as given above, both 'e' and 'p' are conceived as changing from year to year. If they are static over years, ie. if e/p ratio remains constant over years, the formula can be further simplified as,

$$FMQ = \frac{\sum_{j=1}^{N} \left(\frac{ej/ph \times ta}{tp - t1} \times Wj \right)}{\sum_{j=1}^{N} Wj}$$

where, ta = years of adoption = (tp − t2 − g)

If the extent of adoption varies and the potentiality remains the same, the formula can be modified as follows :

$$FMQ = \frac{\displaystyle\sum_{j=1}^{N} \frac{\left(\displaystyle\sum_{tp - t1}^{i = 1} ej \times Wj \right)}{(tp - t1)\ pj}}{\displaystyle\sum_{j=1}^{N} Wj} \times 100$$

The range of Farm Mechanization Quotients as per both the above two formulae very from 'zero' to 100.

3.5.3 Assignment of weightage to individual implement/machine

3.5.3.1 The specific farm implements and machinery selected

The specific implement/machine selected for determination of weights were those which have been recommended by farm machinery researchers and agricultural engineers for rice cultivation in Kerala or elsewhere. The initial list contained names of 64 implements/machinery. In the light of the discussions with progressive farmers, agricultural extension officers and scientists regarding the feasibility of the selected implements/machinery for rice cultivation in Kerala, 32 types for 'owning-using' and 31 types for 'custom-hiring' were included in the final list for determination of weights(column 3 Table 3.3 and Table 3.4 respectively). Hand tools and conventional implements were not included in the list.

3.5.3.2 The procedure

Weights assigned to the specific implement/machine are an indication of not purchase cost or sophistication alone. Factors like feasibility, work efficiency, field capacity, saving in time and energy, quality of work, reduction in drudgery and the like associated with improved farm implements and machinery have to be accredited. Moreover the entrepreneurship and the risk bearing capacity exhibited by the adopters have to be given due weights.

A rating scale was prepared to get rating on the intrinsic and extrinsic factors associated with the selected farm implements and machinery (Appendix I). Each implement/machine was to be rated on a Five-point scale under both the situations of use, namely, 'owner-user' and 'custom-hirer'. Detailed instructions were given explaining the dimensions on which each one was to be rated. Details on purchase cost, operational cost, field capacity and special features related to each implement/machine were supplied to the judges. The scale points were on the dimensions of difficulty of adoption - 'Very difficult to adopt', 'Difficult to adopt', 'Medium difficult to adopt', 'Less difficult to adopt' and 'Least difficult to adopt'.

The judges were approached in person with the checklist for rating. Out of a total 68 check lists used, 12 responses could not be considered due to want of complete

Table 3.3 Weightage scores for selected farm implements and machinery (56 Judges)

(A. 'Owner-user')

Class No.	Sl. No.	Name of farm implement/machine	Judges' weight (w)	Field capacity (c)	Score value (w x c)	Difference between each successive score	Mean score of the classes	Modified mean score after deducting 0.067 from the mean	Modified mean score expressed as % rounded off	Approximate multiples of common factor 20	Weights (W)
1	2	3	4	5	6	7	8	9	10	11	12
1	1.	Paddy weeder	2.526	0.019	0.048		0.067	0	0	0	1
	2.	Bose plough/improved iron plough	2.097	0.031	0.065	0.017					
	3.	Hand operated seed drill (single-row)	2.778	0.027	0.075	0.010					
	4.	Mould Board plough	2.167	0.036	0.078	0.003					
2	5.	Channel-cum-bund former (animal drawn)	3.331	0.060	0.201	0.123	0.242	0.175	20	1	2
	6.	Pedal Thresher	2.736	0.091	0.249	0.048					
	7.	Bund former (power tiller drawn)	3.671	0.070	0.257	0.008					
	8.	Manual sprayer	2.837	0.092	0.261	0.004					
3	9.	Granule applicator	4.144	0.090	0.373	0.112	0.373	0.306	30	2	3
4	10.	Bullock drawn seed drill	3.792	0.125	0.474	0.101	0.567	0.500	50	3	4
	11.	Special single-way plough of power tiller	3.912	0.125	0.489	0.015					
	12.	Single row seed dribbler	3.536	0.140	0.495	0.006					
	13.	Special two-way slat plough of power tiller	4.696	0.125	0.587	0.092					
	14.	Simple paddy winnowing fan	3.947	0.150	0.592	0.005					
	15.	Helical blade puddler	4.040	0.149	0.602	0.010					
	16.	Seed-cum-fertilizer drill	4.080	0.150	0.612	0.010					
	17.	Larger modified wooden leveller	2.178	0.314	0.684	0.072					
5	18.	Motorised mini thresher	3.930	0.200	0.786	0.102	0.825	0.758	80	4	5
	19.	Patella harrow (animal drawn)	2.077	0.416	0.864	0.078					
6	20.	Tractor drawn disc plough	3.679	0.268	0.986	0.122	1.008	0.941	100	5	6
	21.	Kerosene/Electric motor pumpset	2.339	0.440	1.029	0.043					
7	22.	Diesel engine pumpset	2.872	0.440	1.264	0.235	1.338	1.271	130	6	7
	23.	Pumpset attachable to power tiller	2.470	0.541	1.338	0.074					
	24.	Paddy harvester (Vertical conveyor reaper)	4.872	0.290	1.413	0.075					
8	25	Multi bottom Mould Board plough (Tractor drawn)	3.549	0.446	1.583	0.170	1.583	1.516	150	7	8
9	26	Tractor drawn harrow	3.059	0.557	1.704	0.121	1.743	1.676	170	8	9
	27	Motorised/engine driven winnower	3.564	0.500	1.782	0.078					
10	28	Power Sprayer/Duster	2.820	0.690	1.946	0.164	1.946	1.879	190	9	10
11	29	Tractor drawn seed drill	3.361	0.620	2.084	0.138	2.084	2.017	200	10	11
12	30	Power tiller with rotor	5.887	0.399	2.349	0.265	2.349	2.282	230	11	12
13	31	Motorised/engine driven thresher	4.456	0.550	2.451	0.102	2.451	2.384	240	12	13
14	32	Tractor with cultivator	6.056	0.449	2.719	0.268	2.719	2.652	270	13	14

Table 3.4 Weightage scores for selected farm implements and machinery (56 Judges)

(B. 'Custom-hirer')

Class No.	Sl. No.	Name of farm implement/machine	Judges' weight (w)	Field capacity (c)	Score value (w x c)	Difference between each successive score	Mean score of the classes	Modified mean score after deducting 0.067 from the mean	Modified mean score expressed as % rounded off	Approximate multiples of common factor 20	Weights (W)
1	2	3	4	5	6	7	8	9	10	11	12
1	1.	Paddy weeder	1.684	0.019	0.023						
	2.	Mould Board plough	1.028	0.036	0.037	0.014					
	3.	Bose plough/improved iron plough	1.258	0.031	0.039	0.002					
	4.	Hand operated seed drill (single-row)	1.741	0.027	0.047	0.008	0.067	0	0	0	1
	5.	Manual sprayer	1.022	0.092	0.094	0.047					
	6.	Channel-cum-bund former (animal drawn)	1.600	0.060	0.096	0.002					
	7.	Pedal thresher	1.066	0.091	0.097	0.001					
	8.	Bund former (power tiller drawn)	1.414	0.070	0.099	0.002					
2	9.	Granule applicator	2.278	0.090	0.205	0.106					
	10.	Special single-way plough of power tiller	1.744	0.125	0.218	0.013	0.224	0.157	20	1	2
	11.	Bullock drawn seed drill	1.992	0.125	0.249	0.031					
3	12.	Helical blade puddler	2.376	0.149	0.354	0.105					
	13.	Special two-way slat plough of power tiller	3.024	0.125	0.378	0.024					
	14.	Single row seed dribbler	2.793	0.140	0.391	0.013	0.392	0.325	35	2	3
	15.	Larger modified wooden leveller	1.299	0.314	0.408	0.017					
	16.	Simple paddy winnowing fan	2.860	0.150	0.429	0.021					
4	17.	Motorised mini thresher	3.165	0.200	0.633	0.204					
	18.	Seed-cum-Fertilizer drill	4.253	0.150	0.638	0.005	0.648	0.581	60	3	4
	19.	Patella harrow (animal drawn)	1.620	0.416	0.674	0.036					
5	20.	Kerosene pumpset	1.868	0.440	0.822	0.148					
	21.	Diesel engine pumpset	1.902	0.440	0.837	0.015	0.839	0.772	80	4	5
	22.	Tractor drawn disc plough	3.201	0.268	0.858	0.021					
6	23.	Paddy harvester (Vertical conveyor reaper)	3.693	0.290	1.071	0.213	1.071	1.004	100	5	6
7	24.	Tractor drawn harrow	2.210	0.557	1.231	0.160	1.268	1.201	120	6	7
	25.	Multi-buttom Mould Board plough (Tractor drawn)	2.926	0.446	1.305	0.074					
8	26.	Motorised/engine driven winnower	2.852	0.500	1.426	0.121	1.428	1.361	140	7	8
	27.	Power tiller with rotor	3.581	0.399	1.429	0.003					
9	28.	Power sprayer/duster	2.387	0.690	1.647	0.218	1.689	1.622	160	8	9
	29.	Tractor drawn seed drill	2.794	0.620	1.732	0.085					
10	30.	Tractor with cultivator	4.156	0.449	1.866	0.134	1.874	1.807	180	9	10
	31.	Motorised/engine driven thresher	3.424	0.550	1.883	0.017					

rating. Thus the final number of judges fully responded to the checklist were 56. These 56 judges comprised of the scientists of Kerala Agricultural University from the disciplines of Agronomy, Agricultural Engineering, Agricultural Economics, Agricultural Extension and Assistant Directors and Agricultural Officers of the Kerala State Department of Agriculture.

3.5.3.3 Scaling the weights

The responses were quantified using a Five-point scale. The points ranged from 1 to 5.

Response category		Score
Very difficult	–	5
Difficult	–	4
Medium difficult	–	3
Less difficult	–	2
Least difficult	–	1

The mean score received by each implement/machine was calculated to get the weights assigned to them (w) (column 4 in Table 3.3 and Table 3.4).

3.5.4 Effective Field Capacity/Material Capacity

The rate at which an improved implement or machine can cover a field, for example, ploughing (Field Capacity) or a task like threshing (Material Capacity) is one of the considerations in determining its advantageous use over conventional ones. The effective field capacity of a machine is a function of the rated width of the machine, the percentage of rated width actually utilised, the speed of travel, and the amount of field time lost during the operation.

The effective field capacity of the listed implements/machinery in this study was determined by the formula:

$$C = \frac{SW}{10} \times \frac{Ef}{100}$$

where, C = effective field capacity, in hectares per hour.

S = speed of travel, in kilometres per hour.

W = rated width of implement.

Ef = field efficiency, in per cent.

For the most tillage and other operations a field efficiency of 82.5 per cent is assumed and in this situation, the effective field capacity is :

$$C = \frac{\text{Width in metres} \times \text{Speed in Kilometres per hour} \times 0.825}{10}$$

The effective field capacity of sprayers and dusters were calculated using the following formula :

$$C = \frac{L \times S}{1000} \times \frac{Ef}{100}$$

where,

C = effective field capacity, hectares per hour.

L = length of boom, in centimetres.

S = forward speed, in kilometres per hour.

Ef = field efficiency in percentage.

The weights (w) assigned to each implement/machine were multiplied by its effective field capacity (c) to get the corresponding score values (column 6 in Table 3.3 and Table 3.4). The listed implements/machinery were arranged in increasing order of score values.

The seventh vertical column in Table 3.3 and 3.4 represents the difference between each successive scores, ie., difference between the second and first, between the third and second and so on.

A careful observation of the scores showed that it was necessary to classify the listed implements/machinery. An attempt was made to find out whether some of them could be grouped together if the difference in their score were not very marked. Study of the scores in different ways suggested a scaling system. The difference between the scores were taken as the basis of grouping. In order to get groups, it was decided to keep 0.10 as the criterion of difference. Accordingly some implement/machinery could be differentiated and grouped. In the case of 'owner-user' list, breaks could be brought between item numbers 4 and 5, 8 and 9, 9 and 10, 17 and 18, 19 and 20, 21 and 22, 24 and 25, 25 and 26, 27 and 28, 28 and 29, 29 and 30, 30 and 31, 31 and 32 (column 1 in Table 3.3).

In the case of 'custom-hire' list, the breaks brought were between items 8 and 9, 11 and 12, 16 and 17, 19 and 20, 22 and 23, 23 and 24, 25 and 26, 27 and 28 and 29 and 30 (column 1 in Table 3.4).

Column number 8 in Table 3.3 and Table 3.4 represents the mean scores of the above mentioned classes grouped in column number 1. Column number 9 in Table 3.3 and Table 3.4 represents the modified mean scores when 0.067 in the case of 'owner-user' list and in the 'custom-hire' list, the lowest mean scores of the classes (in column 8), were deducted from all the mean scores in order to put the scores in a better comparative way. These scores were then rounded and multiplied by 100 (column 10) to avoid excessive decimals. When the scores in column 10 were carefully observed, it was seen that 20 could be used as a common denominator. All the values in column 10 were divided by 20. The values thus obtained (column 11) did not show variation beyond ± 10 and such a deviation, not being too large, was ignored.

The final weights, thus obtained are presented in column 12 of Table 3.3 and Table 3.4.

3.5.5 Validity of the Farm Mechanization Quotient Scale

A list of 10 rice farmers who were known to be high users of improved implements/machinery and 10 other farmers who used conventional methods alone for rice cultivation belonging to the Akathethara Krishibhavan of Palakkad district was prepared in the light of discussion with three progressive farmers of that locality. This Krishibhavan was purposively selected because power machines like power tillers, tractors, pumpsets, power sprayers and paddy threshers were extensively used by the rice farmers. The names of these 20 farmers were randomly shuffled and this list was given to three judges for rating them on a three-point continuum, namely, high, medium and low users of improved implements/machines for rice cultivation with scores of 3, 2 and 1 respectively. These judges were the agricultural extension officer and two agricultural assistants of the same Krishibhavan who had intimate information on the activities of the farmers included in the list. The judges were given detailed instructions on the criteria based on which they would rate the farmers in the checklist. The Farm Mechanization Quotient of the 20 farmers were measured by the researcher by personal interview using the Farm Mechanization Quotient tool developed for the study.

The ratings done by the judges and the measured Farm Mechanization Quotients are furnished in Table 3.5.

Table 3.5 Ratings by judges and the Farm Mechanization Quotients of 20 farmers.

Farmer No.	Judges' rating Judge-A	Judge-B	Judge-C	Pooled rating score	FMQ (rounded)
1	3	2	3	8	54
2	3	3	2	8	51
3	1	1	1	3	3
4	2	2	3	7	24
5	1	1	2	4	4
6	1	2	2	5	3
7	2	1	1	4	4
8	3	2	3	8	45
9	3	2	2	7	43
10	2	3	2	7	45
11	1	2	1	4	7
12	2	2	2	6	34
13	3	2	3	8	49
14	3	2	2	7	42
15	1	1	1	3	4
16	3	3	2	8	49
17	1	1	2	4	5
18	2	1	2	5	17
19	1	1	1	3	4
20	2	2	2	6	28

Rank correlation coefficient (rs) = 0.819**

** Significant at 0.01 level.

The computed Spearman's rank correlation coefficient 0.819 was significant at 0.01 level of probability. The inference, therefore, might be drawn that the Farm Mechanization Quotient scale developed for the study was valid enough to warrant its use in measuring the adoption behaviour of farmers in terms of rice farm mechanization.

3.5.6 Farm implements and machinery selected for measuring adoption behaviour

From among the items listed in the checklist for assigning weights by judges (Appendix I). Fifteen numbers of implements/machinery as presented in Table below were selected for measuring the adoption behaviour of farmers either as 'owner-user' or 'custom-hirer'. The screening was made based on preliminary interviews with some farmers selected at random to eliminate those items which had gained too little adoption to justify their diffusion with community. Hand tools and conventional implements were not included in the list. Very recent introductions were also not listed as the present investigation was aimed at the study of some recognisable extent of adoption of the specific farm implements/machinery having prospectful use under Kerala situation.

Table 3.6 List of specific farm implements and machinery selected for measuring adoption behaviour of farmers with respect to rice farm mechanization.

Sl.No.	Item
1	Improved country (iron) plough
2	Bose plough
3	Helical blade puddler
4	Larger modified wooden leveller
5	Power tiller (2w)
6	Tractor (4w)
7	Kerosene pumpset
8	Electric motor pumpset
9	Diesel engine pumpset
10	Manual sprayer/Manual duster
11	Power sprayer/Power duster
12	Pedal thresher
13	Motorised/Engine-operated thresher
14	Simple winnowing fan (motorised)
15	Motorised/Engine-operated Winnower

3.5.7 The data for measurement of adoption behaviour

The ultimate unit of sample for the study was individual rice farmers selected from five NARP regions of Kerala as furnished in Table 3.1 and as depicted in fig. 3.2. The 320 respondents were personally interviewed during the year 1990 commencing from the virippu to the punja crop seasons. Data were collected with the help of a pre-tested and suitably modified schedule (Appendix III).

Farm Mechanization Quotients of the farmer respondents were calculated using the following formula developed for the study.

$$FMQ = \frac{\sum_{j=1}^{N} YjWj}{\sum_{j=1}^{N} Wj} \times 100$$

where,

$$Yj = \frac{\sum_{1}^{tp - t1} (ej/pj)}{tp - t1}$$

The values assigned to the symbols contained in the above formula are,

N (no. of improved implements/machines)	:	15
tp (time of investigation)	:	1990
t1 (time of first introduction of the item)	:	
(a) Improved country (iron) plough	:	1968
(b) Bose plough	:	1968
(c) Helical blade puddler	:	1986
(d) Larger modified wooden leveller	:	1969
(e) Power tiller (2w)	:	1972
(f) Tractor (4w)	:	1974
(g) Kerosene pumpset	:	1967
(h) Electric motor pumpset	:	1971
(i) Diesel engine pumpset	:	1973
(j) Manual sprayer/Duster	:	1968
(k) Power sprayer/Duster	:	1974
(l) Pedal thresher	:	1969
(m) Motorised/Engine operated thresher	:	1986

(n) Simple Winnowing fan (motorised) : 1980

(o) Motorised/Engine-operated winnower: 1986

W=(weights assigned to each implement/machine)

Weights assigned to the selected 15 items could be obtained from Table 3.3 and Table 3.4. For example, a weight of 10 was given if power sprayer was owned and used by a farmer (Table 3.3). If power sprayer was used on custom hire basis, a weight of 9 was given (Table 3.4).

Data on the extent of adoption of improved implement/machinery by the respondents during the five years preceding the time of investigation, that is 1990, were considered for this study (1985 to 1989).

3.6 Identification of constraints

Constraints in the production system constitute the basic point in the development of any new technology. According to Moigne (1979) it is absolutely necessary to determine the constraints faced by a producer before proposing any technology package that attempts to overcome them. If the constraints are artificially disguised, the problem is not solved and the technology may meet with obstacles.

Conceptually, constraint analysis envisaged in this study is expected to identify the factors responsible for the adoption gaps existing in the case of various farm implements and machinery for rice farm mechanization and across the regions. Constraint analysis must identify the factors responsible for the adoption gaps, quantify the individual and joint contribution of factors and find out ways and means of overcoming the constraints to reduce the adoption gaps (Prakash, 1989).

Sanghi (1987) suggested the following steps for the analysis of technologies as well as non-technological constraints in crop production.

1. Take a stock of technologies already tested/demonstrated;
2. Sort out unsuitable technologies;
3. Prepare categorisation of successful technologies;
4. Analysis of technological constraints to find out the different specific technological reasons for the differential performance of a given technology between the research stations and the farmers' field;
5. Analysis of non-technological constraints with respect to those technologies which are not spreading among farmers despite their good performance in the research stations/demonstrations/trials.

Gomez *et al.* (1977) reported that IRRI used an Integrated Experiment - Survey method involving the conduct of both controlled agronomic experiments in farmers' fields and farm surveys. This method consists of field experiments and surveys. The field experiments would provide data for identifying the technological constraints. In the surveys, attention is given to the economic, institutional, social and psychological constraints. According to them, the farmers' perceptions of the important constraints are valuable for understanding the constraints.

Nickade and Bhople (1989) conducted a study to identify and classify the constraints to the adoption of farm innovations in Maharashtra. The perception of the farmers on the intensity of the specific production constraints were grouped into seven categories namely, economic, input, information, technological, psychological, infrastructural and situational.

Prakash (1989) used the Policy Delphi version of the Delphi technique for the sequential analysis of constraints in increasing production of rice and coconut in Kerala. He used four steps consisting of three steps for the identification of constraints and a fourth step for rating of feasibility of the solutions. The respondents, in his study, comprised of extension personnel, researchers, farmers and input agencies.

Sharma *et al.* (1989) also used Delphi technique to seek the opinion of scientists in different countries to identify the major constraints to the realisation of higher production of cassava at farm level.

In the light of the above studies, it was assumed in this investigation that the extension sub system, by virtue of its close contact with the farming situation, would be the most suitable agents to suggest the constraints and the client sub system who are the direct users of farm implements and machinery would be the best judges to rate and rank the constraints according to their intensity and to suggest practical solutions to overcome them.

As the first stage mailed questionnaires were sent to judges comprising of 30 agricultural officers and 30 agricultural assistants working in the 30 randomly selected *Krishibhavans* in the five NARP regions of Kerala. Under each NARP region, six *Krishibhavans* were randomly selected. The agricultural officer and one agricultural assistant working in the *krishibhavan* were asked to list the important constraints they felt to the use of farm implements and machinery for rice cultivation in their jurisdiction. Twenty seven out of the 30 agricultural officers and 24 out of the 30 agricultural assistants returned the filled in response sheets. The constraints thus obtained were pooled together and screened to avoid superfluousness. Thirty three constraints to the adoption of improved farm implements and machinery for rice farm mechanization as perceived by the extension personnel were finally retained (Appendix II). As the second stage, these pooled constraints were again sent to the same group of extension personnel and they were requested to rate them on a five-point continuum ranging from 'most relevant' to 'most irrelevant'. Scores were given at 5,4,3,2 and 1. Each point in the continuum was defined in detail to have a correct distinction between each point as was done by Jillison (1975) (Table 3.7).

Table 3.7 Definition of points in the relevancy scale

Scale reference with score in parenthesis	Definitions
Most relevant (5)	A most relevant constraint. First order priority. Has direct bearing on the issue.
Relevant (4)	Is relevant Second order priority Significant impact
Moderately relevant (3)	May be relevant Third order priority May have impact May be a determining factor
Irrelevant (2)	Insignificantly relevant Low priority Has little impact Not a determining factor
Most irrelevant (1)	No priority No relevance No measurable effect

Twenty six Agricultural Officers and 21 Agricultural Assistants returned the pooled constraints after relevancy rating. Each constraint was compared on the basis of relevancy weightage for qualifying its inclusion in the study.

Relevancy weightage was worked out as follows :

$$\text{Relevancy weightage} = \frac{\text{Actual score obtained by a constraint}}{\text{Maximum possible score that constraint could secure.}}$$

Hypothetically relevancy weightage could range from 0.2 to 1.0. In this study the relevancy weights secured by the constraints ranged from 0.36 to 0.88. Taking the mid value as the cutting point, 24 constraints which secured relevancy weight of 0.62 and above were finally selected. These 24 constraints were incorporated in the schedule for interviewing the farmer respondents.

3.7 Measurement of the identified constraints

It was necessary to measure the occurrence and intensity of the identified constraints in the actual field situation to prove their validity and to find out the extent to which they influence the extent of rice farm mechanization. The practicing farmers are the best judges to perceive the field level constraints.

The tools and procedures used to measure the constraints to rice farm mechanization as perceived by the 320 respondents of this study are furnished in Table 3.8.

Table 3.8 Tools and techniques used for measuring the constraints to the adoption of improved farm implements and machinery

Sl.No.	Constraint	Tool/technique used
1.	Small farm size	Structured schedule developed for the study.
2.	Fragmentation	Fragmentation index (Roy et al. 1968).
3.	Unevenness	Unevenness index developed for the study.
4.	Conversion of paddy lands	Conversion index developed for the study.
5.	Low cropping intensity	Cropping intensity index developed for the study.
6.	Conveyance inaccessibility to the field	Conveyance inaccessibility index developed for the study.
7.	Lack of co-operation among farmers	Structured schedule developed for the study.
8.	Lack of awareness of improved farm implements and machinery	Structured schedule developed for the study.
9.	Lack of knowledge on improved farm implements and machinery	Knowledge test developed for the study.
10.	Negative attitude towards improved farm implements and machinery	Attitude scale developed for the study.

11.	High capital cost of improved farm implements and machinery	Structured schedule developed for the study.
12.	High cost of operation of improved farm implements and machinery	Structured schedule developed for the study.
13.	Non-availability of suitable farm implements and machinery	Structured schedule developed for the study.
14.	Non-availability of spares	Structured schedule developed for the study.
15.	Inadequate repair and service facilities for farm implements and machinery	Structured schedule developed for the study.
16.	High mechanical comple- xity of improved farm implements and machinery	Structured schedule developed for the study.
17.	Low custom hire facili- ties for farm implements and machinery	Structured schedule developed for the study.
18.	Lack of credit facilities	Credit orientation scale (Nair, 1969).
19.	Low profitability of rice cultivation	Structured schedule developed for the study.
20.	Plentiful availability of human labour	Structured schedule developed for the study.
21.	Cheap labour availabi- lity.	Structural schedule developed for the study.
22.	Opposition from farm labourers	Structural schedule developed for the study.
23.	Low level of entrepre- neurship among rice farmers	Entrepreneurship index (De D, 1981).
24.	Low use of information sources.	Procedure used by Nair (1969)

Description of the tools and techniques used for measurement of constraints

3.7.1 Small farm size

The respondents were asked whether the area of rice fields possessed/cultivated by them was sufficient for the use of improved farm implements and machinery. The perception was measured using the following scoring procedure :

Response category		Score
Quite sufficient	..	1
Somewhat sufficient	..	2
Not sufficient	..	3

3.7.2 Fragmentation of holdings

Fragmentation is defined as a stage in the evolution of the agricultural holdings in which a single farm consists of numerous discrete parcels, often scattered over a wide area. The degree of fragmentation was measured by the fragmentation index used by Roy *et al*. (1968). Fragmentation index used in this study refers to the ratio of the total area of paddy field cultivated by a farmer to the number of non-contiguous plots.

$$\text{Fragmentation index} = \frac{\text{Number of non-contiguous plots} \times 100}{\text{Total area of the plots (cents)}}$$

For example, if a farmer has five non-contiguous plots of paddy area with a total area of four acres, the fragmentation index for his holding is

5/400 x 100 = 1.2.

3.7.3 Unevenness

Power machines like tractor, power tiller and reaper warrant even terrain of plots for efficient operation.

For the purpose of this study, the unevenness of the plots was calculated as follows :

$$\text{Unevenness} = \frac{\text{Area having uneven terrain (cents)}}{\text{Total area of rice plots (cents)}} \times 100$$

If a farmer has five acres of paddy land out of which one acre is uneven, the unevenness index for his holding is 100/500 x 100 = 20.

3.7.4 Conversion of paddy lands

Due to unremunerative profit status of rice cultivation in Kerala, many farmers are indiscriminately converting paddy lands for cultivation of high value upland crops and for non-agricultural purposes like building construction (Gopalakrishnan, 1989). Conversion of paddy lands has become a serious setback to the augmentation of rice production in Kerala.

For the purpose of this study, conversion of paddy lands was calculated as follows :

$$\text{Conversion index} = \frac{\text{Area converted (cents)}}{\text{Area under paddy before conversion (cents)}} \times 100$$

3.7.5 Cropping intensity

One of the dominant arguments for farm mechanization is that it should lead to significant increase in cropping intensity (Lockwood _et al_. 1983).

Cropping intensity of rice farmers, in this study, was measured by the formula,

$$\text{Cropping intensity} = \frac{\text{Total cropped area of rice (cents) in one agricultural year}}{\text{Total cultivated area under rice (cents)}} \times 100$$

Low cropping intensity as a constraint was taken as the gap between the assumed maximum potential cropping intensity index of the respective NARP region and the actual cropping intensity index of the respondent. The maximum potential cropping intensity indices of the NARP regions were as follows :

NARP region	Cropping intensity index
Northern Region	300
Central Region	300
Southern Region	300
Highrange Region	200
Problem Region	
(a) Kuttanad	200
(b) Onattukara	200
(c) Kole	100
(d) Pokkali	100

3.7.6 Conveyance inaccessibility

Power machines, especially those move on wheels, require road facilities to reach the fields. One of the obstacles reported for rice farm mechanization in Kerala is the lack of road facilities for the conveyance of farm machines. Even if farmers are willing to use power tillers and tractors, they cannot do so due to lack of conveyance facilities.

In this study, inaccessibility index was measured as follows :

$$\text{Inaccessibility index} = \frac{\text{Area without road facilities (cents)} \times 100}{\text{Total area under rice (cents)}}$$

3.7.7 Lack of co-operation among farmers

It has been proved that by collectively ensuring the inputs and conducting the field operations would ensure better economic returns to Kerala rice farmers (Bhaskaran and Menon, 1990). If operations like land preparation with power machines, irrigation with pumpsets, plant protection operations with power sprayers and dusters, harvesting with mechanical reapers, threshing and winnowing with power threshers and winnowers are done by the farmers of an area on a co-operative basis, the cost of production can be reduced considerably.

The constraint lack of co-operation among farmers was measured in terms of the degree to which the farmer is co-operating with other farmers in doing various farm operations with improved implements/machinery on joint basis. The scoring for the responses was as follows :

Category		Score
Always	-	1
Sometime	-	2
Never	-	3

3.7.8 Lack of awareness of farm implements/machinery

Farmers' awareness of any improved farm technology plays a major role in their sequential decision taking to adopt it (Ban and Hawkins, 1988). 'Awareness' in this study implies vigilance in observing or alertness in drawing inferences from what the farmers have observed, experienced and known about. Hence in this study, the farmers' awareness about improved farm implements and machinery had to be measured.

A list of 15 implements/machinery for rice farm mechanization was prepared based on the experience of the researcher derived from the results of the pilot study and discussions with extension personnel (Appendix III).

The respondents were asked to state whether they had heard of and were aware of the above implements/machinery and their use. A score of 'one' was given for a 'yes' answer and a score of 'zero' for the 'no' answer. The total score obtained by the respondent formed his level of awareness. The maximum and minimum scores obtainable on this test was 15 and 'zero' respectively.

Lack of awareness as a constraint was taken as the difference between the maximum obtainable score (15) and the actual score obtained by the respective respondent.

3.7.9 Lack of knowledge on improved farm implement/machinery

In this study, the farmers' knowledge about improved implements/machinery for rice farm mechanization had to be measured.

'Knowledge' in this study refers to those behaviour and test indications which emphasise the remembering either by recognition or recall of ideas, materials or phenomena related to the various aspects of rice farm mechanization implements/machinery.

Cronbach (1949) has defined knowledge test as one in which procedures, apparatus and scoring has been fixed so that precisely the same test can be given at different times and places.

A standardised teacher made knowledge test was developed for this study following, in one way or other, Shankariah and Singh (1967), Nair 91969), Jaiswal and Dave (1972), Lokhande (1973), Reddy (1976), Sadatme (1978) and Pillai (1985).

The procedure followed in developing the knowledge test is described below :

3.7.9.1 Collection of items

An ideal pool of questions with respect to the several aspects related to the various equipment and operations in rice farm mechanization was prepared reviewing literature such as the reports of the IRRI, CIAE, guidelines of the ICAR, catalogues, handbooks and text books on farm machinery and discussions with scientists of the faculty of agricultural engineering, extension personnel of the department of agriculture and engineers of the Regional Agricultural Testing Centres.

The selection of items was done on the basis of the following criteria :

(a) the items should promote thinking.

(b) it should differentiate the well informed respondents from the poorly informed ones, and

(c) it should have an item difficulty index.

Altogether 42 items were collected. The items were converted into multiple choice questions (Appendix III)

3.7.9.2 Item analysis

The initially prepared 42 items were checked and modified on the basis of pre-testing and administered to 30 randomly selected rice farmers of Shoranur subdivision of Palakkad district who were different from the sample selected for the main study. Scores of value one and 'zero' were given to the correct and incorrect responses respectively. The maximum and the minimum score obtainable for all the correct answers and for all the incorrect answers could be 42 and 'zero' respectively.

The sum of scores obtained by the 30 respondents were arranged in the descending order and the respondents were divided into three equal groups, namely, G1, G2 and G3 having 10 respondents in each group. For item analysis, the middle group G2 was eliminated, retaining only the terminal ones (G1 and G3) having high and low scores.

3.7.9.2.1 Difficulty index of items

The index of difficulty was determined by dividing the number of correct answers by the number of respondents to whom it was fed. The formula used was,

$$D = R/N$$

where, D = index of item difficulty.

R = number of correct answers.

N = total number of respondents in the sample.

3.7.9.2.2 Discrimination index of items

For calculating the discrimination power of the items, the following formula was used :

$$V = \frac{(r1) - (r3)}{N/3}$$

where, V = Discrimination index.

r1 and r2 = the frequencies of correct answers in the groups G1 and G3 respectively.

N = Total number of respondents in the sample.

Twenty five items having medium difficulty index (0.11 0.64) and high discrimination power (0.35 - 0.5) were selected for the final study. The summation of scores for the correct answers over all the items for a particular respondent indicated his level of knowledge on improved implements/machinery for rice farm mechanization. The maximum score attainable by a farmer in this test was 30 and the minimum was 'zero'.

3.7.9.2.3 Reliability

The test-retest method was used for calculating the reliability of the test by administering it twice to a group of 30 rice farmers of Kodalur village near the Regional Agricultural Research Station, Pattambi, at an interval of 15 days. The coefficient of correlation between these two independent sets of scores was worked out (0.791) which indicated that the developed knowledge test was reliable.

Validity

Care was taken to include items covering the entire universe of relevant aspects with respect to the knowledge on the different aspects of rice farm mechanization in Kerala. The items being collected from various authentic sources, the test was considered to have content or intrinsic validity.

Lack of knowledge as a constraint was measured by deducting the actual score obtained by the respondent from the maximum score attainable (25) from the knowledge test developed for the study.

3.7.10 Negative attitude towards improved farm implements/machinery

Farmers' attitude towards any improved farm technology plays a major role in their adoption behaviour. Hence in this study, an attempt has been made to develop a scale to measure the attitude of farmers towards improved farm implements/machinery.

Construction of the scale

Attitude is the degree of positive or negative affect associated with some psychological object (Thurstone, 1929). The psychological object considered in this study is the improved farm implements/machinery. Many past researchers have identified attitude as one of the important psychological variables that influence acceptance and adoption of improved farm practices by farmers and hence the necessity to measure attitude of rice farmers towards the use of improved farm implements and machinery.

A number of attitude scales have been developed by various researchers to measure the attitude of individuals towards various psychological objects. Among them the Thurstone and Chave's (1929) Equal Appearing Interval technique and the Likert's (1932) Summated Rating technique are the most commonly employed ones. Research studies have revealed that the Thurstone and Chave's technique obviates some of the difficulties experienced in the case of Likert's technique. Therefore, the Thurstone and Chave's Equal Appearing Interval technique was adopted to develop the attitude scale in the present study.

Collection of statements

A list of 42 statements reflecting the attitude towards improved implements and machinery were prepared through review of literature, discussion with agronomists, agricultural engineers, extension functionaries and progressive farmers. Due care was taken to cover all possible dimensions of farm mechanization through these statements. The statements were edited to meet the standards prescribed by Edwards (1957) and finally 33 statements were arrived at.

Determination of scale values

To find out the scale values, 40 judges were asked to sort out each of the 33 statements on a nine-point continuum - 1st denoting 'most unfavourable', 5th 'neutral', and 9th 'most favourable' expression of opinion. Based on the response of the judges, nine statements were finally selected keeping in view the highest and equally spaced scale values and relatively smaller 'Q' values.

Reliability and validity of the scale

To establish the reliability of the scale, the split half method was used. The scale was administered to 20 respondents. The number of statements were split into two halves on the basis of odd and even numbers and they were administered for calculating correlation coefficient between the two sets of scores. The reliability of the test was found to be 0.807. This showed that the scale was highly reliable.

The validity of a scale depends upon the fidelity with which it measures what it purports to measure. The scale developed was tested for two types of validity.

(a) Content validity

The main criterion for content validity is how well the contents of the scale represent the subject matter under study. The present scale had this validity since all the possible items within the universe of content had been included.

(b) Construct validity

This was tested by calculating the correlation coefficient between Rice Farm Mechanization Quotient scores and attitude. Rice Farm Mechanization Quotient of 20 respondents were measured and the correlation between the two scores was found to be 0.786.

Negative attitude as a constraint was measured by deducting the attitude score of each respondent from the maximum possible attitude score (45) on the scale.

3.7.11 High capital cost of improved farm implements/machinery

In this study the high cost of various implements/machinery for rice farm mechanization was measured in terms of the farmers' perception of the capital cost of the following selected 12 types of improved implements/machinery :

(a) Improved animal drawn ploughs (b) Power tiller (c) Tractor (d) Helical blade puddler (e) Pumpset (f) Manual weeders (g) Hand compression sprayer (h) Power sprayer/duster (i) Improved sickles (j) Vertical conveyor reaper (k) Mechanical thresher (l) Mechanical winnower. Photographs and details of the performance and present market prices of the above items were also shown to the respondents to guide them to give their correct perception. The scoring procedure used was as follows :

Response category		Score
Very high	–	3
High	–	2
Reasonable	–	1

3.7.12 High operational cost of improved farm implements/machinery

Farmers are highly conscious of the operational costs and pay off from technology adoption. In this study high operational cost of implements/machinery was measured in terms of farmers' perception of the operational cost of the selected 12 types of implements/machinery as listed under 3.7.11. The details of cost of operation per unit area or unit piece of work with respect to each item were given to the respondents for their perceptive rating. The following scoring procedure was used :

Response category		Score
Very high	–	3
High	–	2
Reasonable	–	1

3.7.13 Non-availability of suitable implements/machinery

For the purpose of this study the perception of farmers regarding the availability of the selected 12 types of implements/machinery in their locality was measured using the following scoring procedure :

Response category		Score
Not available	–	3
Available but not in time	–	2
Easily available	–	1

3.7.14 Non-availability of spares for implements/machinery

Local non-availability of spare parts for the various farm implements/machinery is a serious problem especially during peak periods of farm operations. In this study, the availability of spares of implements/machinery was measured using schedule developed for the purpose. The scoring procedure adopted was as follows :

Response category		Score
Not available	–	3
Available but with difficulty and not in time	–	2
Easily available	–	1

3.7.15 Inadequate repair and service facilities

Rice farming, being a strictly season bound enterprise, the farm machines are put to continuous and intensive work during peak periods of operations. They often get damaged. Frequent breakdowns will offbalance the farm operations. Hence service and repair facilities should be available locally. The farmers' perception of the adequacy of service and repair facilities was measured using the following scoring procedure :

Response category		Score
Not available	–	3
Available but not sufficient and in time	–	2
Easily available	–	1

3.7.16 High mechanical complexity

The intrinsic characteristics of the technology like simplicity and complexity can influence its adoption to a great extent. For the purpose of this study the perception, of the respondents, of the mechanical complexity related to the selected 12 implements/machinery was measured using the following scoring procedure :

Response category		Scores
Highly complex	–	3
Moderately complex	–	2
Not complex	–	1

3.7.17 Low custom hire facilities

In countries where the majority of the rice farmers belong to the small farmer category, due to their economic backwardness are found to use farm machinery by hiring custom operators. The cost per unit of machine work may be less with custom hiring than for a large-scale farmer-owner-operator with his own large machine.

In the light of this situation, the respondents were asked to give their perception of availability of 12 types of improved farm implements/machinery, selected for the study, for custom work in their locality. It was measured using the following scoring procedure :

Respondent category	scores
Not available	3
Available but not sufficientand in time	2
Easily available	1

3.7.18 Lack of credit facilities

Availability and source of credit are important factors determining farmers' investment in high cost equipment (Juarez and Pathnopas, 1983). For the purpose of this study, this was measured using the credit orientation scale developed by Nair (1969). The scale consisted of a set of four questions (Appendix III).

3.7.19 Low profitability of rice cultivation

Profitability, here, is viewed as the intensity of reward measured in economic terms, resulting in cultivation of different crops by the farmer. It is quite logical that farmers in general will hesitate to adopt modern technologies related to a crop if they are convinced that it is no more profitable.

In this study, profitability in rice cultivation was operationalised as the perception of profit occurring from cultivation of rice when compared to other crops of Kerala.

A five-point rating scale to quantify the farmers' perception of the level of profitability of rice cultivation as shown below, was used for the present study.

Score	1	2	3	4	5
Respondent category	Very Profi-table	Profi-table	Somewhat profitable	Least profi-table	Not at all pro-fitable

3.7.20 Plentiful availability of human labour

One of the arguments against rice farm mechanisation in over populated developing economies is that it leads to massive labour displacement. But the recent experience in Kerala is that in rice tracts seasonal shortage of labour, especially during peak periods of operations, is a serious problem. To ascertain this situation in the light of farm mechanisation, the farmers were asked to indicate the availability of labour for doing the following eight operations in rice cultivation: (a) Tillage operations (b) Sowing/transplanting (c) Fertilizer application (d) Weeding and intercultural operations (e) Plant protection operations (f) Harvesting (g) Threshing (h) Winnowing.

Response category		Score
Easily available	-	3
Available but not sufficient	-	2
Not available	-	1

From the cumulative scores for all the eight operations, the mean score was found for each respondent.

3.7.21 Cheap labour availability

Another argument against rice farm mechanisation in Kerala is that human labour is cheaper when compared to the operational costs of machines. But the reality is that Kerala has the highest wage rate in the country. This hike in wages has resulted in the reduction of area under food crops, especially rice (James, 1989). In the light of these contradictory arguments, it was envisaged in this study to measure the perception of the farmers regarding the cheapness of human labour activity for rice cultivation in Kerala.

The scoring procedure was as follows:

Respondent category		Score
Very cheap	–	3
Somewhat cheap	–	2
Not at all cheap	–	1

3.7.22 Opposition from farm labourers to the use of improved implement/machinery

It is often said that in Kerala, where there is a well united labour force, any move for large scale mechanization will be opposed by the farm labourers for fear of unemployment. But the farmers often complaint that it is very difficult to get enough labour force especially during peak periods of farm operations. An attempt was made in this study to measure the perception of the farmers regarding such situations of opposition from the traditional ploughmen and other labourers when machines are used for farm operations. The response categories and the scores assigned were as follows.

Response category		Score
Very high opposition	–	3
High opposition	–	2
Moderate opposition	–	1
No opposition	–	0

3.7.23 Low level of entrepreneurship among rice farmers

According to Pareek and Nadkarni (1978) entrepreneurship can be conceived as an innovative action. An entrepreneur starts a new activity. Apparently this is like adoption of a new idea or a new practice. Entrepreneurship is a package of personality characteristics of entrepreneurs.

For the purpose of this study, entrepreneurship of rice farmers were measured by the entrepreneurship index developed by De D. (1981). This index consisted of 32 items (Appendix III) covering a package of personality characteristics, namely, risk taking, future oriented, hardworking, persistent, sets goals and realistic step by step sub-goals, drive for independence, goal oriented, ability to exploit situations, success oriented, makes decisions, opportunity seeker, competitive, innovative, likes challenges, dynamic, leadership, wants to make a lot of money and the like. Responses of respondents were obtained in the four points which were - 'I am very much like this', 'I am somewhat like this', 'I am not at all like this' and 'I can't say', with the respective weights of 3, 2, 1 and 'zero' for the positive statements, where as scoring system was reversed in case of negative items. Maximum score an individual could obtain on this index was 96 and the minimum was 'zero'. The versions of the statements in the vernacular of the five regions were prepared and administered. Low level of entrepreneurship as a constraint was measured by deducting the actual score obtained by the respondent from the maximum score possible on the entrepreneurship index.

3.7.24 Low use of information sources

An individual gains knowledge through information sources. The extent of use of different information sources by the farmers for obtaining the different technical information will have a direct bearing on adoption of technology (Prakash, 1980).

interest in it. Moreover local testing of the implements/machinery builds farmers' confidence in their use.

In the light of the above facts, it was envisaged in this study to conduct result tests with the selected package of implements and machinery for rice farm mechanization.

According to Gibbons and Schroeder (1983) the result test is neither an experiment nor a demonstration.Only one variable is selected for testing (e.g. a new practice or a specific "package" of practices) and is compared with the present or "traditional" practice. The result tests are designed to obtain information about a practice, not to promote it. They are conducted on farmers' fields, but the purpose is to prove the worth of the practice. The two treatments ("old" and "new") are not randomised and replicated as an experiment, rather the result test is repeated simultaneously on a number of local farms, since the goal is to get an overall idea of the performance of the new practice(s) in the area. Extension workers and extension scientists with good training in the reference practice can competently supervise result tests.

On the basis of the above suggestions made by Gibbons and Schroeder (1983), an attempt was made in this study to conduct result tests using two separate "packages" of farm implements and machinery to prove their worth and to study the farmer's relative perception of about the utility, scope, cost advantage and the like in comparison with the "conventional package".

3.8.1 The procedure

Result tests using the selected "packages" of farm implements and machinery were conducted during the *virippu* season and the *mundakan* season of 1991. Three rice farmers each from Thrithala, Koottanad and Keezhayur villages in Palakkad district were purposively selected to conduct the result tests. Besides the recommendations of the local extension workers, the following criteria were observed in the selection of participating farmers:

a) They were ready to co-operate with the researcher for the tests.

b) They had enough area under rice to hold the result tests.

c) They were thoroughly familiarised with and/or ready to internalise the 'what', 'why', 'when' and 'how' of the various operation and package of practice recommendations for scientific rice cultivation.

Out of the nine farms selected, five were used during *virippu* and the other four during *mundakan* seasons of the year 1991.

3.8.1.1 Selection of plots

Sites having conspicuous location and road facilities were selected. The land and soil of the sites represented the local farmers' situation. The size of plots were decided in such a way that they were large enough to be realistic but at the same time not so big that it was difficult to visually compare the conventional and improved practices plots side by side. It was also logical not to select large plots as it was easier to find co-operative farmers as they knew that the plots were small, thus minimising any perceived risk.

For result testing package of farm implements and machinery, researchers have used plot sizes ranging from 0.10 hectares to 0.40 hectares (Lekshminarayanan,1981; Jayasurya and Shand, 1983; Bansal and Jain, 1986;Rao, 1986; Shanmugham et al., 1986).

For the present study, the plot sizes that could obtain at the nine locations were, 0.32 ha,0.36 ha, 0.40 ha, 0.42 ha, 0.52 ha, 0.58 ha, 0.64 ha, and 0.76 ha. Each plot was divided into three approximately equal sub plots. Due to already established separation of fields by bunds, it was not possible to lay out plots of equal area. The farmers were not willing to remove the existing bunds. Thus the area of sub plots in all locations varied in general.

The three packages, namely, "Low mechanization package" (LMP), "Medium mechanization package" (MMP), and "High mechanization package" (HMP) were tested in each of the three sub plots in one location. The sub plots, as far as possible, were laid out side by side as depicted below:.

In this study "low mechanization package" which was used as a control is the traditional farm implements used and methods followed by the farmers of the particular locality for rice cultivation. The implements/machinery for"medium mechanization package" and"high mechanization packages" were selected based on the differential weightages assigned to each specific implement/machine as described in section 3.5.3 of this study.

3.8.1.2 Components of the three "packages"

<u>Low mechanization package (LMP)</u>

a. Country plough.

b. Country leveling board.

c. Counterpoise lift ('etham').

d. Hand weeding.

e. Knapsack sprayer/hand compression sprayer.

f. Country sickle.

g. Threshing by beating and/or treading by feet.

h. Winnowing the conventional way.

Medium mechanization package (MMP)

a. Bose plough.

b. Helical blade puddler and improved leveling board.

c. Pumpset.

d. Wet land weeder.

e. Power sprayer.

f. Improved sickle.

g. Motorised small thresher.

h. Motorised winnower.

High mechanization package (HMP)

a. Power tiller/Tractor.

b. Cage wheel and large leveling board of power tiller/tractor.

c. Pumpset.

d. Manual weeder.

e. Power sprayer.

f. Vertical conveyor reaper windrower (Mechanical harvester).

g. Rasp-bar type paddy thresher cum winnower.

All the implements/machinery except the knapsack sprayer, pumpset, counterpoise lift and country sickles were arranged by the researcher. Animal and human labour for various operations except that for working power sprayer, vertical conveyor reaper windrower, paddy thresher and motorised winnower were supplied by the co-operating farmer. Skilled workers were arranged by the researcher to operate power sprayer, vertical conveyor reaper windrower, paddy thresher and winnower.

All the other inputs like seeds, fertilizers, organic manures, irrigation water and plant protection chemicals were kept the same for the three sub plots in each of the nine locations. Only the "package" of implements/machinery varied. The package of practices recommendations of the Kerala Agricultural University were followed in all the sub plots. Jyothi was the rice variety used in all the sub plots.

3.8.2 Observations/data recorded during result tests

3.8.2.1 Efficiency and economic parameters related to farm equipment

Effective field capacity

The actual rate of field coverage in the case of field implements/machinery in hectares per hour (ha/h), and the actual output in Kilograms per hour (kg/h) for thresher and winnower were calculated for each sub plot, based on the formula as described in selection 3.5.4 of this thesis.

Labour requirement

Requirement of human labour to perform various operations were worked out in terms of hours per hectare (h/ha) and man days per hectare (d/ha). In case of thresher and winnower it was hour per hectare and hours per Quintal (h/q).

Cost of operation

The cost of operation for each sub plot was worked out using a combination of the actual data on the implements/machinery, a set of assumptions and by taking observations during the result tests. The following cost parameters were considered.

Fixed costs

Fixed costs included those for depreciation, interest, insurance and taxes, shelter and repairs and maintenance.

Variable costs

The costs of labour/operator, fuel and lubricants were included under variable costs. In the present study the actual use of labour/operator and the consumption of fuel and lubricants were recorded while the operation was on. The cost of lubricants such as engine oil, grease, transmission oil and hydraulic fluid were taken as 15 per cent of cost of fuel as is generally recommended (Pandey and Ojha, 1986). The local charges in vogue for skilled and unskilled labour required to perform the operations with the implements/machinery were considered for computation of cost of operations.

Hourly cost of operation of the different implements/machinery was calculated using the following formula developed by Pandey and Ojha (1986):

$$H.C.O. = [\,0.9/y.H + 0.55(I + 3.5)/100\ H + F_m\,)\ C + 1.15\ F_c \times R_f + N_o \times R_2\,].\ F_{oh}$$

where,

H.C.O. = Hourly Cost of Operation.

Y = Life of implement/machine (year).

H = Annual use of implement/machine (h).

I = Interest rate (per cent).

F_m = Maintenance cost factor (per h per unit purchase price).

C = Purchase price of implement/machine(Rupees).

F_c = Fuel consumption of machine (litre/hour).

R_f = Fuel price per litre (Rupees).

N_o = Number of operators required*.

Re = Hiring rate (wage) of labour/operator (Rupees per hour *).

* If bullock drawn implements were used, then in the hiring rate of operator, the rate of a pair of bullocks was also included.

The per hectare cost of operation of each implement/machine was calculated by dividing the total cost per hour by the effective field capacity of the respective implement/machine.

Cost of cultivation

Cost of cultivation in this study refers to the total cost incurred towards the operation of the farm implements/machinery and costs of inputs like seeds, irrigation water, fertilizer, plant protection chemicals and labour. The costs of cultivation of rice in each sub plot were worked out and converted to per hectare basis (Rs./ha).

Yield

In this study the total grain yield obtained from each sub plot was ascertained. Straw yield was not considered. The yields of paddy harvested from each sub plots were converted to per hectare basis (t/ha).

Net returns

In this study net returns derived from each sub plot was calculated as the total revenue less total cost of cultivation. The net returns from each plot were converted to per hectare basis (Rs./ha).

Benefit Cost Ratio

Benefit Cost Ratio compares the benefits relative to costs. It was computed by the present value of the cash inflow by the present value of the cost flow outlays involved in the crop-implement system. An investment would need a ratio value in excess of one to be considered profitable. A ratio of one would indicate that benefits and costs were balanced.

For the purpose of this study the present value of cost flow were worked out for the crop-implement system which included the cost of all inputs and operations for raising the rice crop in the result test subplots under each "package". The cash inflow was worked out by multiplying the quantity of produce obtained from each plot by the market price in vogue at the time of investigation.

For the purpose of this study, the Benefit cost ratio (BCR) of the three selected "packages" were calculated using the following equation:

$$BCR = \frac{\text{Present value of gross benefits}}{\text{Present value of gross cost}}$$

3.8.3 Measurement of perception of farm mechanization attributes by the farmers involved in the result test

The perception of the participating farmers, of each implement/machine under the three "packages" namely 'low mechanization package' (LMP), ' Medium mechanization packager' (MMP), and 'high mechanization package' (HMP) was measured on the following variables:

a. Scope of each implement/machine for rice farm mechanization.

b. Simplicity of each implement/machine.

c. Quality of work done by each implement/machine.

d. Time saving due to the use of each implement/machine.

e. Cost reduction due to the use of each implement/machine.

The perceptions were recorded immediately after exposing the participating farmers in each operation.

The perceptions of the above mentioned five parameters were measured using arbitrary scales with a five-point continuum as described below:

3.8.3.1 Scope for use

It was measured by asking the respondent how far he perceived the scope of each implement/machine for rice farm mechanization. The scoring procedure adopted was as follows:

Category		Score
Very high scope	–	5
High scope	–	4
Scope neither high nor low	–	3
Low scope	–	2
Very low scope	–	1

3.8.3.2 Simplicity in use

The respondents were asked to rate the degree of simplicity underlying the use of each implement/machine. The response categories and scores assigned were as follows:

Response category		Score
Most simple	–	5
Simple	–	4
Neither simple nor complex	–	3
Less simple	–	2
Least simple	–	1

3.8.3.3 Quality of work done

In this study quality refers to the quality of work done by each implement/machine for which it is designed. The respondents were asked to give their opinion on the quality of work, they perceived, done by the respective equipment. The scoring procedure was as follows:

Response category		Score
Very high quality	–	5
High quality	–	4
Neither higher nor low	–	3
Low quality	–	2
Very low quality	–	1

3.8.3.4 Time saving in use

An attempt was made in this study to measure the perception of the farmers regarding the time advantage obtained due to the use of improved implements/machinery. The respondents were asked to rate each implement/machine on a five point continuum regarding the quickness of operations when compared to the conventional ones. The scoring procedure was as follows:

Response category		Score
Very quick	–	5
Quick	–	4
Neither quick nor slow	–	3
Slow	–	2
Very slow	–	1

3.8.3.5 Cost reduction in use

It is generally assumed that high field capacity of the improved equipment result in lesser cost of operation when compared to traditional implements/methods. The farmers' perception on this was measured by asking them how costly the operation done by each implement/machine was, using the following score procedure:

Response category		Score
Very cheap	–	5
Cheap	–	4
Neither cheap nor costly	–	3
Costly	–	2
Very costly	–	1

The inter package comparative perception and the rank position of each of the five attributes mentioned above were computed from the mean scores.

3.9 Procedure adopted for data collection

For stage I of the study, to accomplish the first three objectives, data were collected from the 320 farmer respondents of the five NARP regions with the help of a pretested interview schedule. The selected respondents were contacted in person with the help of the Agricultural Assistant in charge of the Padasekharams under the respective Krishibhavan. The data related to the salient function, type, power requirement, work capacity, capital cost, operational cost, custom service charge, pre-requisites for adoption and field application, extent of adoption, and constraints to adoption of farm implements and machinery were collected from the farmer respondents in person. The data on the salient features, specifications and latest cost details of the farm implements and machinery were gathered from secondary sources like documents (manufacturers' and dealers' catalogues, directories), and by interviewing manufacturers, dealers distributors, agricultural engineers and farm machinery scientists.

The data pertaining to the effect of the selected mechanization packages (stage II of the study) on labour input, yield, cost of cultivation, net returns, and benefit-cost ratio were gathered by the researcher by taking field observations and recording them in field note books. Data related to selective perception of the participating farmers in the result tests, on attributes viz. scope for use, simplicity in use, quality of work done, time saving in use, and cost reduction in use were collected by interviewing each participant, immediately after the completion of each operation, with the help of an interview schedule.

The data collected were coded, tabulated and fed to a VERSA-IWS Computer at the College of Agriculture, Vellayani.

3.10 Statistical tools employed

3.10.1 Percentages

Percentage analysis was employed to present the results related to the ownership and custom hire use pattern of 37 farm implements/machinery in the five NARP regions, the distribution of the NARP regions and categorisation of the respondents according to farm mechanization quotients, and the perception of intensity of adoption constraints by the respondents.

3.10.2 Pearson's Product Moment Correlation

This measure (simple liner correlation) was employed to determine the nature and degree of relationship between the 24 constraints and the extent of adoption of rice farm mechanization in the pooled sample of the five NARP regions.

3.10.3 Step-wise Regression analysis

Step-wise regression procedures were applied to select the best regression equation and to determine the reliable regression coefficient for predictive purposes (Draper and Smith, 1966) for each of the five NARP regions and also for the pooled sample. This objective is achieved in the step-wise regression technique by systematically adding terms, one at a time, to the regression equation, instead of removing terms, singly or jointly, from an initially large equation (Gomez and Gomez, 1984). This is done for establishing a linear regression equation in a particular response 'y' in terms of 'k' independent or predicted variables, X1, X2, X3...........Xk. A variable which may have been the best single variable to enter at an early stage may, at a later stage, be superfluous because of the relationship between it and other variables now in the regression. To check on this, the partial F criterion for each variable in the regression at any stage of calculation is evaluated and compared with a pre-selected percentage point of the appropriate F distribution. This provides a judgment on the contribution made by each variable entered irrespective of its actual point of entry into the model. The process is continued until no more variables will be admitted to the equation and no more are rejected.

3.10.4 Analysis of variance

The Analysis of Variance (ANOVA), which is a test of significance was used in the stage I and stage II of the study. ANOVA was employed in the stage I to test whether the differences in the farm mechanization quotients existing among the five NARP regions were significant or not. In stage II of the study ANOVA technique was employed to know whether the three mechanization packages differed significantly in terms of labour input, yield, cost of cultivation, net returns and benefit-cost ratio. The coefficient of variation (cv) was computed to indicate the degree of precision with which the treatments are compared as it is a good index of reliability of the experiment. For those variables for which the 'F' values were found to be significant, the least significant Difference (LSD) values were worked out. As suggested by Gomez and Gomez(1984) the LSD served as the boundary between significant and non significant differences between any pair of mechanization packagers in the study. Two packages were declared significantly different at 0.05 level of significance if their difference exceeded the computed LSD value, otherwise they were not significantly different.

3.10.5 Paired t-test

The t-test of significance (for small samples) for difference in means was employed to test whether the three farm mechanization packages differed in terms of the farmers' cumulative perception scores of the five mechanization attributes selected for the study. All possible pairs with the three mechanization packages were formed.Comparisons could be made between LMP-MMP, MMP-HMP, and LMP-HMP. The test statistic 't' was tested for significance at $t_{n1+n2-2}$ degrees of freedom.

3.11 Operationalisation of concepts

According to Kerlinger (1965) operational definition is a specification of the activities of the researcher in measuring a variable or in manipulating it.

He further suggested that an operational definition is a sort of manual of instructions to the investigator.

Rogers and Shoemaker (1971) stated that it might be a scale, index, observation or the answer to a direct question.

The concepts which have not been operationalised in sections 2 and 3 of this thesis, based on review of literature are operationally defined as follows:

3.11.1 Agricultural mechanization

Agricultural mechanization, which is synonymously used for farm mechanization in this study, refers to the application of hand tools, implements operated by animal draft and mechanical power and machines operated using fossil fuels/or electric power for doing various agricultural operations like land preparation, crop production, harvesting and on farm processing.

3.11.2 Rice farm mechanization

Refers to the application of hand tools, implements operated by animal draft and mechanical power and machines operated using fossil fuels/or electric power for doing various rice farm operation like land preparation, sowing, planting, irrigation, weeding, plant protection, harvesting, threshing and winnowing.

3.11.3 Hand tools

Hand tools are defined as devices operated by human beings to do various operations in rice farming.

3.11.4 Farm implements

Farm implements are operationalised as those serve as instruments or tools operated by animal draft, or that are attached to a machine for performing a specific operation in rice farming.

3.11.5 Farm machinery

Refers to an assemblage of parts that transmit forces, motion and energy, one to another in a pre-determined manner, derived by using fossil fuels or electric power for making the implements or end operational parts attached to it/or inbuilt in it for performing specific operations in rice farming.

3.11.6 Farm equipment

A general nomenclature which refers to all tools in the hand tool technology, implements with animal draft or mechanical power and machinery used for performing a specific operation in rice farming.

3.11.7 Farm power

Farm power is operationalised as the actual energy spent in terms of horse power hour (hp-h) to carry out day to day farm business, using the power sources like manual, animal draft or machinery.

3.11.8 Adoption

Adoption in this study refers to the use adoption which occurs when a farmer puts an innovative hand tool, implement or machine into use for doing various operations related to rice farming.

3.11.9 Potentiality of use

Refers to the maximum degree to which a farmer can extent his adoption of innovative hand tools, implements and machinery for rice farming, if so wishes, depending upon the maximum utilization of the resources he commands or can command.

3.11.10 Extent of adoption

It is operationalised as the degree to which a farmer has actually adopted a recommended or available innovative hand tool, implement or machine for rice farming.

3.11.11 Time of adoption

Time of adoption in this study refers to the year when the innovative hand tool, implement or machine for rice farming was first adopted by the farmer.

3.11.12. Weightage

Refers to the credit, in terms of scores, given to a farmer for adopting an innovative hand tool, implement or machine for rice farm operations.

3.12.13. Farm mechanization quotient (FMQ)

It is a numerical ratio developed to quantity adoption behaviour of farmers with respect to hand tools, implements or machinery for doing rice farm operations.

3.11.14 Rice farm mechanization quotient (RFMQ)

It is a numerical ratio developed to quantify adoption behaviour of farmers with respect to hand tools, implements or machinery for doing rice farm operations.

3.11.15 Constraints

The term constraints in this study refers to those items of difficulties, problems or restrictions faced by farmers to the use adoption of innovative hand tools, implements or machinery for doing rice farm operations.

3.11.16 Efficiency of tools, implements or machinery

Refers to the capacity of a rice farm mechanization technology to save time, money, labour and to alleviate drudgery at the same time giving equal or more output.

3.11.17 Cost of farm mechanization

It refers to the expenditure incurred to put rice farm mechanization technology in operation. The expenditure includes initial cost of the equipment, recurring cost for operation and maintenance, cost of labour for working and cost required for overall management.

3.11.18 Availability

In this study it is the degree to which input of mechanization technology for carrying out rice farm operations is available easily in time.

3.11.19 Custom hiring

Refers to using or arranging to use farm mechanization technology by hiring hand tools, implements or machinery by hiring from others by giving hire charges.

3.11.20 Result tests

Result tests refer to a series of tests conducted in farmers' fields, repeating simultaneously in a manageable number of locations to get an overall idea of the performance of the selected farm mechanization technology and also to prove the worth of the innovative tools, implements and machinery for rice farming comparing with the conventional equipment/methods

3.11.21 Mechanization package

It is a set or collection of hand tools, implements and machinery for performing sequential and specific operations in rice farming from land preparation to on farm processing.

3.11.22 Low mechanization package (LMP)

Refers to a set or collection of conventional hand tools, implements and methods for performing sequential operations in rice farming from land preparation to on farm processing.

3.11.23 Medium mechanization package (MMP)

It is a set or collection of innovative tools, implements and machinery that are more efficient, costlier, technically more complex and less drudgerous than the conventional ones, at the same time intermediate between conventional and high level rice farm mechanaization technology.

3.11.24 High mechanization package (HMP)

It refers to a set or collection of innovative implements and machinery that are more efficient, costlier, technically more complex and less drudgerous than the medium or intermediate rice farm mechanization technology.

3.12 General hypotheses set for the study

The following general hypotheses were formulated for the study.

3.12.1 Differential adoption of farm implements and machinery by farmers of the five NARP regions

3.12.1.1 The five NARP regions of Kerala would be on par with respect to farmers' adoption of farm implements and machinery for rice cultivation.

3.12.2 Relationship of the constraints with the extent of adoption improved farm implements and machinery

3.12.2.1 There would be no relationship between the constraint small farm size and extent of adoption of improved farm mechanization technology.

3.12.2.2 There would be no relationship between the constraint fragmentation and extent of adoption of improved farm mechanization technology.

3.12.2.3 There would be no relationship between the constraint unevenness and extent of adoption of improved farm mechanization technology.

3.12.2.4 There would be no relationship between the constraint conversion of paddy lands and extent of adoption of improved farm mechanization technology.

3.12.2.5 There would be no relationship between the constraint low cropping intensity and extent of adoption of improved farm mechanization technology.

3.12.2.6 There would be no relationship between the constraint conveyance inaccessibility to the field and extent of adoption of improved farm mechanization technology.

3.12.2.7 There would be no relationship between the constraint lack of co-operation among farmers and extent of adoption of improved farm mechanization technology.

3.12.2.8 There would be no relationship between the constraint lack of awareness and extent of adoption of improved farm mechanization technology.

3.12.2.9 There would be no relationship between the constraint lack of knowledge and extent of adoption of improved farm mechanization technology.

3.12.2.10 There would be no relationship between the constraint negative attitude and extent of adoption of improved farm mechanization technology.

3.12.2.11 There would be no relationship between the constraint high capital cost and extent of adoption of improved farm mechanization technology.

3.12.2.12 There would be no relationship between the constraint high cost of operation and extent of adoption of improved farm mechanization technology.

3.12.2.13 There would be no relationship between the constraint non availability of suitable farm implements/machinery and extent of adoption of improved farm mechanization technology.

3.12.2.14 There would be no relationship between the constraint non availability of spares and extent of adoption of improved farm mechanization technology.

3.12.2.15 There would be no relationship between the constraint inadequate repair and service and extent of adoption of improved farm mechanization technology.

3.12.2.16 There would be no relationship between the constraint high mechanical complexity and extent of adoption of improved farm mechanization technology.

3.12.2.17 There would be no relationship between the constraint low custom hire facilities and extent of adoption of improved farm mechanization technology.

3.12.2.18 There would be no relationship between the constraint lack of credit facilities and extent of adoption of improved farm mechanization technology.

3.12.2.19 There would be no relationship between the constraint low profitability of rice cultivation and extent of adoption of improved farm mechanization technology.

3.12.2.20 There would be no relationship between the constraint plentiful availability of labour and extent of adoption of improved farm mechanaization technology.

3.12.2.21 There would be no relationship between the constraint cheap labour availability and extent of adoption of improved farm mechanization technology.

3.12.2.22 There would be no relationship between the constraint opposition from farm labourers and extent of adoption of improved farm mechanaization technology.

3.12.2.23 There would be no relationship between the constraint low level of entrepreneurship and extent of adoption of improved farm mechanization technology.

3.12.2.24 There would be no relationship between the constraint low use of information sources and extent of adoption of improved farm mechanization technology.

3.12.3 Result tests with the three packages of farm implements and machinery:

3.12.3.1 The low mechanization package, the medium mechanaization package and the high mechanization package would be on par with respect to labour input.

3.12.3.2 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to yield of rice.

3.12.3.3 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to cost of cultivation of rice.

3.12.3.4 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to net returns per hectare.

3.12.3.5 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to cost-benefit ratio.

3.12.3.6 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to the perception of the attribute 'scope for use' by the farmers.

3.12.3.7 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to the perception of the attribute 'simplicity in use' by the farmers.

3.12.3.8 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to the perception of the attribute 'quality of work done' by the farmers.

3.12.3.9 The low mechanization package, the medium mechanization package, the high mechanization package would be on par with respect to the perception of the attribute 'time saving in use' by the farmers.

3.12.3.10 The low mechanization package, the medium mechanization package and the high mechanization package would be on par with respect to the perception of the attribute 'cost reduction in use' by the farmers.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The results of the study are presented and discussed under the following broad sub-heads:

4.1 Survey of the farm implements and machinery used by the rice farmers of Kerala.

4.2 Extent of adoption of improved farm implements and machinery by the rice farmers of Kerala.

4.3 Constraints to the adoption of improved farm implements and machinery.

4.4 Result tests with the three packages of farm implements and machinery: low mechanization package (LMP), medium mechanization package (MMP), and high mechanization package (HMP).

4.5 Empirical model for predicting adoption behaviour of farmers with respect to rice farm mechanization.

4.6 Empirical model of result tests with selected packages of farm implements and machinery.

4.1 Survey of the farm implements and machinery used by the rice farmers of Kerala.

In this study an attempt was made to collate all available information on the pattern of ownership and use ('owner-user' and 'custom-hirer'), salient functions, type, power requirement, work capacity, capital cost, operational cost, custom service changes, prerequisites for adoption, and field application of the conventional and improved farm implements and machinery in vogue in Kerala. The data were elicited mainly by interviewing the 320 respondents belonging to the five NARP regions. Relevant details of the implements and machinery were also gathered by reviewing literature, official documents, manufacturers' catalogues directories and by holding discussions with manufacturers and dealers, farm machinery engineers, scientists and extension personnel. The details and data pertaining to each implement/machine are presented and discussed under the headings, 4.1.1 to 4.1.8. The pattern of ownership and use of the implement/machinery are presented in Table 4.1.1.

4.1.1 Animal drawn implements

A perusal of the data on the pattern of ownership and use (Table 4.1.1) indicated that among the three types of animal drawn ploughs used in Kerala viz. country plough, improved country plough and Bose plough, except in the Southern Region, the country plough had the highest percentage of respondents as owner-users and custom-hirers. In the Southern Region when 29.69 per cent of the respondents owned and used country plough, only 14.06 per cent custom-hired it. The Bose plough was more popular in the Southern Region (owner-users-23.44% and custom-hirers-35.94%). In the Highrange Region Country plough was the

Table 4.1.1. Ownership and custom-hire use pattern of farm implements and machinery by the rice farmers of different NARP regions (N=320)

Sl. No.	Name of farm implement/ machine	Central Region (n=64)				Problem Region (n=64)				Southern Region (n=64)				Northern Region (n=64)				Highrange Region (n=64)				Pooled Sample (N=320)			
		Owner-user		custom-hirer		owner-user		custom-hirer		owner-user		custom-hirer		owner-user		custom-hirer		owner-user		custom-hirer		owner-user		custom-hirer	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
1	Country plough	10	15.63	12	18.75	8	12.50	15	23.44	19	29.69	9	14.06	8n	12.50	31	48.44	14	21.88	48	75.00	59	18.44	115	35.94
2	Improved country plough	4	6.25	8	12.50	11	17.19	9	14.06	2	3.13	1	1.56	5	7.81	7	10.94	2	3.13	—	—	24	7.50	25	7.81
3	Bose plough	7	10.94	4	6.25	14	21.88	11	17.19	15	23.44	23	35.94	2	3.13	—	—	—	—	—	—	38	11.88	38	11.88
4	Helical blade puddler	6	9.38	2	3.13	1	1.56	3	4.69	—	—	—	—	1	1.56	—	—	—	—	—	—	8	2.50	5	1.56
5	Bullock-drawn puddler	1	1.56	—	—	1	1.56	2	3.13	—	—	—	—	1	1.56	—	—	—	—	—	—	3	0.94	2	0.63
6	Country wet land leveller	9	14.06	8	12.50	7	10.94	12	18.75	11	17.19	29	45.31	7	10.94	30	46.88	14	21.88	48	75.00	48	15.00	127	39.69
7	Modified wet land leveller	6	9.38	3	4.69	5	7.81	7	10.94	3	4.69	2	3.13	1	1.56	1	1.56	—	—	—	—	15	4.69	13	4.06
8	Power tiller	3	4.69	12	18.75	9	14.06	21	32.81	4	6.25	14	21.88	2	3.13	7	10.94	1	1.56	4	6.25	19	5.94	58	18.13
9	Straight tilling blade of Power tiller	3	4.69	11	17.19	9	14.06	21	32.81	4	6.25	14	21.88	2	3.13	7	10.94	1	1.56	4	6.25	19	5.94	57	17.81
10	Two way plough of power tiller	4	6.25	7	10.94	2	3.13	—	—	—	—	—	—	1	1.56	—	—	—	—	—	—	7	2.19	7	2.19
11	Wet land puddling wheel of power tiller	3	4.69	12	18.75	9	14.06	21	32.81	4	6.25	14	21.88	2	3.13	7	10.94	1	1.56	4	6.25	19	5.94	58	18.13
12	Wet land leveller of power tiller	2	3.13	10	15.63	4	6.25	19	29.69	3	4.69	5	7.81	1	1.56	3	4.69	—	—	—	—	10	3.13	37	11.56
13	Tractor	5	7.81	20	31.25	2	3.13	15	23.44	2	3.13	11	17.19	3	4.69	17	26.56	—	—	—	—	12	3.75	63	19.69
14	Cultivator of tractor	5	7.81	20	31.25	2	3.13	15	23.44	2	3.13	11	17.19	3	4.69	17	26.56	—	—	—	—	12	3.75	63	19.69
15	Cage wheel of tractor	5	7.81	20	31.25	2	3.13	13	20.31	2	3.13	9	14.06	3	4.69	15	23.44	—	—	—	—	1	0.31	—	—
16	Paddy puddler of tractor	2	3.13	4	6.25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.63	4	1.25
17	Rotavator of tractor	2	3.13	5	7.81	1	1.56	4	6.25	—	—	—	—	—	—	—	—	—	—	—	—	3	0.94	9	2.81
18	Wet land leveller of tractor	5	7.81	17	26.56	2	3.13	13	20.31	2	3.13	9	14.06	3	4.69	12	18.75	—	—	—	—	12	3.75	51	15.94
19	Counter-poise lift	5	7.81	—	—	8	12.50	—	—	6	9.38	—	—	5	7.81	—	—	6	9.38	—	—	30	9.38	—	—
20	Water wheel	2	3.13	—	—	21	32.81	—	—	17	26.56	—	—	—	—	—	—	—	—	—	—	40	12.50	—	—
21	Swing basket	3	4.69	—	—	12	18.75	—	—	8	12.50	—	—	5	7.81	—	—	5	7.81	—	—	33	10.31	—	—
22	Axial flow pump	—	—	—	—	2	3.13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.63	—	—
23	Kerosene pumpset	15	23.44	8	12.50	8	12.50	5	7.81	6	9.38	7	10.94	11	17.19	6	9.38	4	6.25	2	3.13	44	13.75	28	8.75
24	Diesel engine pumpset	5	7.81	1	1.56	3	4.69	2	3.13	2	3.13	—	—	2	3.13	4	6.25	1	1.56	—	—	13	4.06	7	2.19
25	Electric motor pumpset	18	28.13	—	—	14	21.88	—	—	11	17.19	—	—	10	15.63	—	—	7	10.94	—	—	60	18.75	—	—
26	Knapsac sprayer	8	12.50	11	17.19	9	14.06	14	21.86	6	9.38	12	18.75	5	7.81	3	4.69	6	9.38	17	26.56	34	10.63	77	24.06
27	Hand compression sprayer	12	18.75	22	34.38	10	15.63	13	20.31	7	10.94	11	17.19	7	10.94	18	28.13	7	10.94	19	29.69	43	13.44	83	25.94
28	Power sprayer	2	3.13	8	12.50	2	3.13	6	9.38	1	1.56	2	3.13	—	—	—	—	—	—	—	—	5	1.56	16	5.00
29	Country sickle	18	28.13	41	64.06	14	21.88	34	56.13	22	34.38	47	73.44	12	18.75	45	70.31	15	23.44	49	76.56	81	25.31	226	70.63
30	Improved sickle	4	6.25	7	10.94	3	4.69	—	—	—	—	—	—	2	3.13	—	—	—	—	—	—	9	2.81	7	2.19
31	Paddy harvester (Reaper)	2	3.13	8	12.50	1	1.56	6	9.38	—	—	—	—	1	1.56	3	4.69	—	—	—	—	4	1.25	17	5.31
32	Pedal thresher	5	7.81	—	—	3	4.69	1	1.56	1	1.56	—	—	—	—	—	—	1	1.56	—	—	10	3.13	1	0.31
33	Motorised mini thresher	4	6.25	9	14.06	4	6.25	6	9.38	1	1.56	2	3.13	1	1.56	3	4.69	—	—	—	—	10	3.13	20	6.25
34	Axial flow thresher	2	3.13	10	15.63	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.63	10	3.19
35	Flow-through thresher	3	4.69	12	18.75	2	3.13	7	10.94	1	1.56	4	6.25	—	—	—	—	—	—	—	—	6	1.88	23	7.19
36	Simple winnowing fan (motorised)	1	1.56	—	—	2	3.13	—	—	1	1.56	—	—	—	—	—	—	—	—	—	—	4	1.25	—	—
37	Motorised/engine driven winnower	2	3.13	9	14.06	2	3.13	5	7.81	—	—	—	—	—	—	—	—	—	—	—	—	4	1.25	14	4.38

F = Frequency

most predominantly used plough (owner-users-21.88% and custom-hirers-75%). In the Problem Region and Northern Region also country plough was more commonly used than the other two types.

The salient features and specifications of the three types of animal drawn ploughs are furnished as serial numbers 1-3 in Table 4.1.2. It is interesting to find that country plough, the versatile farm implement of Kerala, had the lowest work capacity of 0.02 - 0.03 ha/h when compared to that of improved country plough (0.03 ha/h) and Bose plough (0.04 ha/h). There were only marginal differences in their capital costs. But it is worth reporting that when their operational costs were compared, Bose plough required the lowest cost (Rs.438/ha) followed by improved country plough (Rs.550/ha) and country plough (Rs.583/ha). It is encouraging to find that there was a saving of Rs.145/- and Rs.33/- for each hectare cultivated when land preparations were done by Bose plough and improved country plough respectively.

Bose plough occupied an envious status among the three types of ploughs, as it had the highest work capacity, lowest operational cost and superior work quality. The country plough does not invert the soil. But the Bose plough pulverises and inverts the soil. The reason for low cost of operation with the Bose plough was its higher work capacity.

Table 4.1.2 Functions, specifications, costs, custom service details, availability and field application of farm implements & machinery for rice cultivation

Sl. No.	Name of implement/ Machine	Salient functions	Type	Power requirement	Work capacity	Capital cost (Rs.)	Operational cost (Rs.)	Custom service charge (Rs./h)	Availability & field applic
1	2	3	4	5	6	7	8	9	10
A	Animal drawn implements.								
1	Country plough	Used for shallow ploughing, puddling, seed bed preparation, for making furrows for sowing/dibbling	Animal drawn single bottom local plough	A pair of bullocks & 1 person	0.02-0.03 ha/h	150	583/ha	11	Versatile local plough used in regions. Does not invert soil. Available with local artisans a local dealers.
2	Improved country plough	Used for shallow ploughing. Depth & width of ploughing is more. Used for making seed beds, puddling etc.	Animal drawn single bottom iron plough	A pair of bullocks & 1 person	0.03 ha/h	160	550/ha	11-12	Used selectively in all region More common in Central Region. Available in local hardware sh
3	Bose plough	For ploughing and inverting soil & for puddling, seed bed preparation and for making furrows for soil/ dibbling.	Animal drawn single bottom plough	A pair of bullocks & 1 person	0.04 ha/h	165	438/ha	11	Used extensively in Southern R & Problem Region. Works well i loose textured soil/sandy soil. Available with local artisans a dealers.
4	Helical blade puddler.	For puddling in wet lands after initial ploughing. Good churning, slicing & puddling.	Animal drawn rolling puddler.	A pair of bullocks & 1 person	0.075 ha/h	800	320/ha	12-13	Selectively used in some areas Central Region. Suitable for a types of soil. Not popular in Kerala. Available with manufac rers.
5	Bullock drawn puddler	For puddling in wet lands after initial ploughing. Good churning, slicing & puddling.	Animal drawn rolling puddler.	A pair of bullocks & 1 person	0.08 ha/h	800	315/ha	--	Not popular in Kerala. Not ava for custom hiring.
6	Country wetland leveller	For levelling well puddled soil to have even stand of water & to prevent percolation loss of water.	Animal drawn wooden levelling board.	A pair of bullocks & 1 person	0.20 ha/h	75	89/ha	11	Used in all regions. Available local artisans & dealers.
7	Modified wetland leveller	For levelling well puddled soil. The two small wooden wings on sides carry excess puddled soil forward.	Animal drawn modified wooden leveller.	A pair of bullocks & 1 person	0.55 ha/h	200	43/ha	11	Used in Central & Problem regio Very efficient leveller. Avail with selected local dealers &a
B.	Power tiller drawn implements								
8	Straight tilling blades	For rotary tilling & pulverising. Shallow tilling. Soil is not inverted.	Power tiller operated rotary blades.	9-12 hp power tiller & 1 operator	0.10 ha/h	450	445/ha	60-70	Used in all regions. Blades a sturdy enough to till stoney & areas. Available with manufact & dealers.
9	Two way plough	For deep ploughing with better soil inversion. Soil can be inverted to either sides as desired.	Power tiller operated single bottom plough.	9-12 hp power tiller & 1 operator	0.12 ha/h	1600	508/ha	60-70	Only selectively used in Centra gion. Not available for custom ing. Not popular in Kerala.

co

Table 4.1.2 contd.

1	2	3	4	5	6	7	8	9	10
10	Wetland puddling wheel	For puddling after initial ploughing.	Power tiller operated rotary wheels.	9-12 hp power tiller & 1 operator	0.20-0.30 ha/h	1550-2025	305/ha	55-60	Used in all regions. Most suited t puddle loose textured soil. Drum t heavy wheels are required for heav soils. Available with manufacturer dealers.
11	Wetland leveller	For levelling well puddled soil.	Power tiller operated wooden leveller.	9-12 hp power tiller & 1 operator	0.40 ha/h	800	60/ha	55-60	Selectively used in Southern & Problem regions. Available with manufactures & dealers.
C	Tractor drawn implements								
12	Cultivator (9 tine)	For secondary tillage, light ploughing & initial weeding. Soil is not pulverised & inverted.	Tractor drawn multi-tined cultivator.	4 wheel tractor & 1 operator	0.40 ha/h	6300	208/ha	115-120	Used in all regions. A versatile i lement in all regions for tractor ploughing. Available with manufactu rers & dealers.
13	Cage wheel	For puddling after initial ploughing with tractor.	Tractor drawn steel cage wheel.	4 wheel tractor & 1 operator	0.50 ha/h	3500	160/ha	120-125	An ideal implement for puddling. P dling is fast & cheap. Available with manufacturers & dealers.
14	Wetland leveller	For levelling after initial ploughing & puddling.	Tractor drawn steel levelling board.	4 wheel tractor & 1 operator	0.75 ha/h	3000	48/ha	120-125	A very efficient implement for qui & cheap levelling operation. More common in Central & Problem region Available with manufacturers & dea
15	Rotovator	The rotating implement can produce a seed bed with 1 or 2 passes. Ideal in wet paddy conditions.	Tractor drawn double or triple bladed rotor.	4 wheel tractor & 1 operator	0.50-0.60 ha/h	25000-30000	115/ha	120-125	A very efficient implement for lan preparation. Due to high capital c it has not gained popularity in Ke ala. Available with manufacturers.
16	Paddy puddler	The rotating implement puddles soil as the tractor moves forward. The fields can be prepared with 3 to 4 passes.	Tractor drawn rotary puddler.	4 wheel tractor & 1 operator	0.22 ha/h	7000	113/ha	120-125	An efficient implement to prepare fields faster. Not popular in Kera Not available for custom use. Avai able with manufacturers.
D	Water lifting devices								
18	Counter-poise lift	For lifting water (by counter weight) from shallow water sources of 2 to 4 m depth.	Manually operated counter-poise lift.	1 person	8000-9000 l/h	150	8/h	--	Commonly used for puncha crop. The strain and drudgery is very high. Suitable to lift water from shallo sources. Available with local artisans and hardware dealers.
19	Water wheel	Manually rotated series of treaddles can lift water within 0.6m depth.	Manually operated paddle wheel.	1 person	10000-14000 l/h	250	8/h	--	Suitable only to lift water from s llow sources. Commonly used for pu crop. Available with local dealers.

contd

Table 4.1.2 contd.

1	2	3	4	5	6	7	8	9	10
20	Swing basket	Indigenous water lifting device with a lift of 0.5-1.2m.	Manually operated low head basket.	2 persons	7000-10000 l/h	60	14/h	--	Suitable only to lift water from s llow sources. Commonly used for pu crop. Available with local dealers.
21	Kerosine pumpset	Used to lift water from deep sources.	Kerosine engine operated pumpset.	Kerosine engine & 1 person	0.01 ha/h	1500-2000/ hp	14/h for (3hp)	20	Convenient pumpset for use in area inaccessible to electricity. Light weight & easily portable. Availabl with local dealers.
22	Diesel engine pumpset	Used to lift water from 4m to 60m head.	Diesel engine operated pumpset.	Diesel engine & 1 person	Depends on speed & hp.	2500-3000/ hp	20/h	30	Convenient pumpset for use in are inaccessible to electricity. Cost engine is very high. Available wit major dealers.
23	Electric motor pumpset	Used to lift water from deep sources to give a discharge upto 60l/second.	Monoblock or directly coupled electric pumpset.	Electric motor & 1 person	Depends on rpm & hp	1250/ hp	5/h	--	Well adapted to usual pumping services where electricity is availab Operation is cheap & not at all da dgerous. Available with local deal
E	Plant Protection equipment								
24	Knapsack sprayer	For spraying insecticides, fungicides, & weedicides. The pump is operated with one hand & spray lance with the other.	Manually operated knapsack sprayer.	1 person	0.15 ha/h	900-1100	8/h (70/ha)	6	A simple & convenient sprayer. Le efficient & more time consuming. A ilable with local dealers.
25	Hand compression sprayer	For spraying insecticides, fungicides & weedicides. Reciprocating air charge pump sprays the fluid.	Manually operated compression sprayer	1 person	0.25-0.50 ha/h	800-950	8/h (70/ha)	6	A simple & convenient sprayer. Les efficient & more time consuming. Commonly used in all regions. Ava lable with local dealers.
26	Power sprayer	Used for spraying & dusting insecticides, fungicides & weedicides. Ultra low volume spraying is also possible.	Knapsack power mist blower cum duster.	Petrol engine (1.25hp) 1 person	0.50-0.75 ha/h	4500-5000	25/h	40-45	A highly efficient sprayer. Sprayi is very fast. Selectively used spr yer. Available with major dealers.
F	Harvesting devices								
27	Country sickle	Used for harvesting rice crop.	Manually operated conventional sickle	1 person	0.006 ha/h (125-130 h/ha)	25-30	6/h (1000/ ha)	--	Versatile harvesting tool of Keral Simple & easy to use sickle. Very work efficiency. Available with lo artisans & dealers.
28	Improved sickle	Used for harvesting rice crop.	Manually operated improved sickle	1 person	0.011 ha/h	40-50	6/h (600/ ha)	--	A sickle having double the work ef iciency of country sickle. Not po ular in Kerala. Available only wit a few selected dealers.

contd.

Table 4.1.2 contd.

1	2	3	4	5	6	7	8	9	10
29	Vertical Conveyor Reaper windrower	For harvesting rice crop. The cut crop is conveyed to the side by a conveyor mechanism & are windrowed in a line.	IRRI model 1.0m reaper windrower	5 hp diesel engine & 1 operator	0.25-0.30 ha/h	24000	32/h (130/ha)	55-60	Very efficient harvesting device. More suited for short to medium statured, non-lodging crop & field without standing water and mud. Availabl with manufacturers.
G	<u>Threshers</u>								
30	Pedal thresher	Used for threshing paddy. Threshing is done by holding bundle of sheaves against rotating wire loop drum by pedalling with foot.	Hold on type foot thresher	2 persons	80-100 kg grains/h	2500	325/ha	--	Most suited to thresh short to mediu statured varieties. It is drudgerou to operate the pedal. Available wit a selected few manufacturers/dealers
31	Motorised mini thresher	Used for threshing paddy. Threshing is done by holding bundle of sheaves against rotating wire loop drum rotated by a small electric motor.	Hold on type motorised small thresher.	0.5 hp motor & 2 persons	450kg grains/h	6050	300/ha	--	Very efficient & portable thresher. Most suited to thresh short to mediu statured varieties. It is not at al drudgerious. Very convenient to use places with access to electricity.
32	Peg tooth type paddy thresher	Used for threshing & winnowing paddy. Threshing is done by a peg tooth cylinder. The blower, rotary screen & grain auger cleans & conveys the threshed grains.	Peg tooth type power thresher.	10 hp diesel engine or motor	800-1000 kg/h	35000	48/h (216/ha)	8/q grains	A very efficient power thresher. Threshing & winnowing are very quick The thresher has the disadvantage of cutting the straw. Available wit manufacturers.
33.	Rasp-bar type paddy thresher	Used for threshing & winnowing paddy. Threshing is done by a rasp-bar cylinder. Cleaning & winnowing operations are also done by the machine.	Rasp-bar type power thresher.	5-7.5 hp diesel engine or motor	600-800 kg/h	25000	33/h (165/ha)	8/q grains	A very efficient power thresher. Threshing & winnowing are very quick. It has the added advantage of delivering uncut straw. Available with manufacturers.
H	<u>Winnowing machinery</u>								
34	Motorised simple winnowing fan	Used for small scale winnowing of threshed grains.	Power operated paddy winnowing fan.	0.25 hp motor & 2 persons	300-400 kg/h	2000	12/h (90-120/ha)	--	A simple devices to winnow paddy. Suited for small scale winnowing. Th machine is portable & simple. Not av ilable for custom use. Available wit manufacturers.
35	Paddy winnower (big size)	Used for large scale winnowing of threshed grains.	Power operated paddy winnower.	1.0 hp motor/ engine & 2 persons.	600-700 kg/h	4000-4500	16/h (80-100/ha)	8/q grains (25-30/h)	A very efficient winnower for large scale operation. Winnowing is very quick. Ideal for joint/group use. Available with manufacturers.

A critical analysis of data in Table 4.1.1 indicated that Bose plough was being extensively used by the farmers of Southern Region and Problem Region. It might be due to its proven adaptability to loose textured soils of the study area of these regions. It was not found popular in the other three regions. But the researcher could observe it being used by a few farmers of the Central Region where the texture of the soil was medium heavy. Some farmers were found to use a slightly heavier type of Bose plough, which according to them could work well in soils having more clay content. These observations were sufficient to prove the potentiality of Bose plough as an efficient animal drawn plough. It could be made to work well in the heavy soils of Central, Northern and Highrange regions also by making the share point and body sturdier and by slightly increasing the weight of the plough. For very heavy clayey soils of the Central, Northern and High range regions where the modified Bose plough cannot work well, the improved country plough could be used.

In the light of the above discussion it is suggested that the commonly used country plough can be replaced either by the Bose plough or the improved country plough so as to bring down the cost of ploughing operations.

The use pattern of two types of animal drawn puddlers viz. the helical blade puddler and the bullock drawn puddler are presented in Table 4.1.1. While the use of the animal drawn puddler was negligible, a few farmers of the Central Region (owner-user - 9.38% and custom-hirer - 3.13%) and one farmer each of the Problem Region and Northern Region were found to use the helical blade puddler.

In conventional animal ploughing the puddling operations in all the NARP regions were found to be done with the country plough. The helical blade puddler was found to be an efficient implement for puddling. When compared to the work capacity of country plough (0.03 ha/h), the helical blade puddler had got double the efficiency as it could puddle 0.075 hectare in an hour. As against the high operational cost of country plough (Rs.583/ha) puddling operations with helical blade puddler required only Rs.320/ha. This is an encouraging finding as there could be a saving of Rs.263/- for each hectare of rice crop if the conventional country ploughs were replaced by the helical blade puddler for puddling operations. As the puddler was found suitable for all types of soils, and as the helical geometry facilitated better churning and slicing, it could be an efficient implement for all the NARP regions.

A cursory glance at the data furnished in Table 4.1.1 revealed that majority of the farmers of all the NARP regions used the country wet land leveller for levelling operations. In the Highrange Region the country leveller alone was found used (owner-user 21.88% and custom-hirer-75%). A few farmers of the other four regions, especially the Central Region, Problem Region and the Southern Region used the modified wet land leveller.

As shown in Table 4.1.2 (Sl.No.6) the country wet land leveller used by majority of the rice farmers of all the five NARP regions was inferior in all respects to the modified wet land leveller. When the work capacity of the country leveller was a meagre 0.2 ha/h, the improved leveller could cover an area of 0.55 ha in one hour of operation. Though the improved leveller was costlier by Rs.125/-, its operational cost was just half of that of country leveller. The longer and wider plank of the improved leveller helped to cover a larger area per unit time than the country leveller. Moreover, the two small wooden wings and the wider plank facilitated better levelling.

In the light of the above discussions it could be suggested that the commonly used country wet land leveller if replaced by the modified wet land leveller could bring down the cost of levelling operations.

4.1.2 Power tiller drawn implements

Serial numbers 8 - 12 listed in Table 4.1.1 refer to power tiller and the implements operated by a power tiller. The use pattern furnished in the Table revealed that Problem Region had the highest percentage of users of power tiller, straight tilling blade, wet land puddling wheel and wet land leveller. In this region there were 14.06 per cent respondents as owner-users and 32.81 per cent as custom-hirers of power tiller and its commonly used attachments. The Highrange Region had only negligible percentage of power tiller users. In all the regions power tillers were found to be used both for primary and secondary tillage.

Serial number eight listed in Table 4.1.2 pertains to the straight tilling blade of power tiller. It had a work capacity of0. 1 ha/h. The operational cost was Rs.445/ha. The custom service charge in vogue was Rs.60-70/ha. The main limitation of the implement was its inability to invert the soil and shallow tilling.

The use pattern of the two way plough of power tiller mentioned in Table 4.1.1 indicated that it was used highly selectively and to a very small extent in the Central Region, Problem Region and Northern Region.

A perusal of the details furnished as serial number nine in Table 4.1.2 revealed that the two way plough ploughed to a depth of 30 cm as against 19 cm depth achieved by the straight tilling blade. The plough also facilitated better soil inversion. These features made the two way plough highly efficient for deep ploughing especially in heavy clayey soils where the commonly used straight tilling blades were difficult to work with.

As presented in Table 4.1.1. puddling and levelling were done by the wet land puddling wheels and wet land leveller attached to the power tiller in cases where primary and secondary tillage were done with power tillers. When wet land puddling wheels (Serial number 10 in Table 4.12.2) were attached to the power tiller, puddling could be done very fast (0.2 to 0.3 ha/h) and less expensively (Rs.52/ha.). Two types of puddling wheels were found used: the lighter (type I) wheels in areas having loose textured soils and the heavier (type II) wheels to work on heavy clayey soils. The puddling being done quickly and cheaply, it could be suggested that wherever paddy lands are accessible to power tiller, puddling operations could be advantageously done using the wet land puddling wheels.

Serial number 11 in Table 4.1.2 highlights the features, functions and specifications of power tiller operated wet land leveller. It could be seen from Table

4.1.1 that farmers of the Problem Region made use of this type of leveller in fields were the primary tillage and puddling operations were done by engaging power tiller. In the other regions, it had not gained much popularity. As is presented in the Table, the work capacity of the leveller was 0.40 ha/h and the operational cost required was Rs.60/ha. Considering the quickness of operation and reduction in operational cost it would be worthwhile to use the power tiller operated wet land levellers in places where power tiller ploughing is possible.

4.1.3. Tractor-drawn implements

Serial numbers 12 - 17 listed in Table 4.1.1 refers to the implements drawn by a tractor. As is evident from the use pattern furnished in the Table, tractor ploughing had gained popularity in all the regions except the Highrange Region. The Central Region had the highest percentage of users of tractor and its implements like cultivator, paddy puddler, rotavator and wet land leveller. In this region there were 7.81 per cent respondents as owner-users and 31.25 per cent as custom-hirers of tractors with cultivator and cage wheel. Northern Region was second to Central Region in the use of tractor and tractor operated implements. It is interesting to find that in the Highrange Region none of the respondents of the study area were found to either own or custom-hire tractor for paddy cultivation.

The data furnished as serial number 12 in Table 4.1.2 pertains to the cultivator of tractor. It was found to be a commonly used tillage implement in all the regions except the Highrange Regions (Table 4.1.12). It was found used both for primary and secondary tillage. From the survey it could be observed that 9 tine cultivator was more common in Kerala. Ploughing with the cultivator was found to be fast as it had a work capacity of 0.40 ha/h. and the cheapest when compared to animal drawn and power tiller operated implements. The cost of operation was Rs.208/ha . The custom service charge in vogue was Rs.115-120/h. Considering the faster coverage and low operational costs it would be economical and advantageous to rice farmers to do tractor ploughing with cultivator in areas accessible to tractor operations.

Puddling and levelling operations in fields where tractors were engaged, were done by the tractor cage wheel and wet land leveller respectively (Table 4.1.1). As furnished in Table 4.1.2 (Sl. No.13) when puddling operations were done by the cage wheels, it could be very fast and cheap. Similarly the wet land leveller of the tractor (Sl. No. 14 in Table 4.1.2) being very wide, paddy fields could be levelled quickly and less expensively. Both the cage wheel and wet land leveller were found suitable for all the regions. It could be suggested that wherever paddy lands are accessible to the operations of tractors, puddling and levelling could be quickly and economically done with the cage wheel and leveller respectively.

The researcher could observe the operation of tractor drawn rotavator (two units) in the Central Region and one unit in the Problem Region). A perusal of Table 4.1.2 (Sl.No.16) revealed that the high work capacity of the rotavator and the special feature of the implement that it could produce a seed bed with one or two passes, and with a low operational cost of Rs.115/ha land preparation could be completed very quickly and cheaply. Its high cultivation width of 1400-1730mm facilitated high coverage. Despite all these advantages, the rotavator was not found popular in any of the NARP regions. The reason could be its high capital cost of Rs.30,000/- and its very recent introduction.

Two units of tractor-operated paddy puddlers were found functioning in the Central Region. The details and data presented in Table 4.1.2 (Sl.No.16) indicated that the implement could puddle the field efficiently with three or four passes. The work capacity was very high (0.22ha/h) when compared to the animal drawn and power tiller drawn puddlers. The high work capacity was due to the higher speed of the tractor and the high width of the implement (2310 mm). As in the case of rotavator, the paddy puddler was not found popular in any of the regions. The reasons could be its high capital cost of Rs.7,000/- and its recent introduction in Kerala.

4.1.4 Water lifting devices

Serial numbers 19 - 22 listed in Table 4.1.1 refer to the water lifting devices for irrigating paddy. The use pattern furnished in the Table revealed that Problem Region had the highest percentage of users of the three manually operated devices viz. counter poise lift, water wheel and swing basket. All these three devices were exclusively owned and used. In the Problem Region there were 7.81 per cent respondents as users of counterpoise lift, 32.81 per cent as users of water wheel and 18.71 per cent as users of swing basket. The other four regions had only negligible percentage of users.

The data furnished in Table 4.1.2 (Sl.No.18) pertains to the counterpoise lift. It has a work capacity of 8000-9000 l/h. The operational cost was Rs.8/h. The main limitations of the counter poise lift were its low work capacity, inability to lift water from depths more than 4 m and the drudgery in manually operating it.

A perusal of the details furnished as serial number 19 in Table 4.1.2 revealed that water wheel could lift water up to a height of 0.6m and its function was to drive water from one field or channel to another or from the outlet of a group of plots to an outer area. Its work capacity was 10,000-14,000 l/h. The operational cost was Rs.8/h. The main limitation of the device was its inability to lift water to heights more than 0.6 m and the strain to the operator on continuous pedalling.

Swing basket was also found to be an indigenous water lifting device used in some parts of the study area. It has a lift of 0.5-1.2m. It required to persons to operate which could give a water output of 7,000-10,000 l/h. The capital cost was low (Rs.60/-) and the operational cost was Rs.14/h. As in the case of counterpoise lift and water wheel, it had the limitations of low output and drudgery.

The use pattern of the axial flow pump mentioned in Table 4.1.1 indicated that it was used only in the Problem Region, that too by a negligible number of farmers (3.13%). The pump was found to be used in Kuttanad to operate the petti and para to drain water to make paddy fields ready for cultivation.

Serial numbers 23-25 listed in Table 4.1.1 refer to the mechanically operated irrigation pumpsets. The use pattern of Kerosene pumpsets indicted that the Central Region had the highest percentage of owner-users (23.44%) and custom-hirers (12.50%) followed by the Northern Region (17.19% and 9.38% respectively). Similarly diesel engine pumpsets and electric motor pumpsets were also used in the Central Region in more numbers (by 7.81% and 28.13% respondents respectively) than in the other four NARP regions.

A comparative analysis of the use pattern brought light to the fact that farmers used electric motor pumpsets more than that of either Kerosene or diesel pumpsets. This might be due to the lesser capital and operational costs, low mechanical complexity, less frequent mechanical troubles and availability of electricity at cheaper rates than kerosene or diesel. Though some of the farmers were found to possess concessional permits to buy kerosene for pumping operations, the availability was found insufficient and not in time. But it may be pointed out that kerosene or diesel engine pump sets were the only alternative irrigation devices in areas inaccessible to electric power supply.

In the light of the above discussion it is suggested that for small scale irrigation purposes and to lift water from shallow sources and in places were labour in cheap and plenty, the conventional water lifting devices could be used. Wherever farmers have got access to electric power, electric motor pumpsets would be profitable. To overcome the constraints like non availability of electricity, low voltage problems and frequent power failures, kerosene pumpsets or diesel engine pumpsets would be useful.

Kerosene pumpsets though cheaper than diesel engine pumpsets, timely availability of Kerosene in sufficient quantities would be a problem. In such situations diesel engine pumpsets would be preferable to irrigate paddy fields.

4.1.5 Plant protection equipment

Serial numbers 26–28 listed in Table 4.1.1. are the commonly used plant protection devices. The use pattern of knapsack sprayer presented in the Table revealed that the Problem Region had the highest percentage of owner users (14.06%) and custom hirers (21.86%). Hand compression sprayer had the highest percentage of owner users (18.75%) and custom hirers (34.38%) in the Central Region. In the Highrange Region 29.69 per cent of the respondents custom hired hand compression sprayer. The status of use of power sprayer as owner-user was negligible in all the regions. Both the Central Region and Problem Region had 3.13 per cent as owner-users. The custom hire use pattern was in the order of 12.5 per cent in the Central Region and 9.38 per cent in the Problem Region. It is interesting to note that in the study areas of the Northern and Highrange Regions the researcher could not come across the use of power sprayers.

The data furnished as serial number 24 in Table 4.1.2 pertains to the knapsack sprayer. It had a work capacity of 0.14 ha/h. The operational cost was Rs.8/h

(Rs.70/ha) and the custom service charge in vogue was Rs.6/h for the sprayer alone and Rs.14/h including the wages of the operator. The main limitations of the equipment was lesser work efficiency and more time required to cover the field when compared to the power sprayer. The details of hand compression sprayer are presented in Table 4.1.2 (Sl.No.25). Its work capacity was 0.25 – 0.05 ha/h with an operational cost of Rs.8/h (Rs.50-70/ha). The custom service charge was Rs.6/h for the sprayer alone and Rs.14/h Including the wages of the operator.

The salient features, work efficiency and cost details of Power Sprayer are furnished as serial number 26 in Table 4.1.2. It had a work capacity of 0.5 – 0.75 ha/h for spraying and 1 – 1.15 kg/min. for dusting. The operational cost and custom hire charge were Rs.25/h and Rs.60 – 75/h.

As indicated by the ownership pattern (Table 4.1.21), in all the NARP regions hand compression sprayers followed by knapsack sprayers were generally used for application of pesticides and weedicides. When compared to the capital cost of power sprayer (Rs.4,000 – 5,000) the knapsack sprayer (Rs.900-1,100/-) and hand compression sprayer (Rs.800 – 950/-) cost lesser. Moreover, they are devices devoid of much mechanical complexity and are easy to operate. Power sprayer requires gasoline to operate the engine. The high cost of fuel along with high capital cost of the sprayer, mechanical complexity and mechanical skill required to operate might have prompted the farmers not to use power sprayer.

It would be worthwhile to have a comparison of the work capacity and cost of spraying of the manually operated sprayers and the power sprayer. When a power sprayer completed spraying one hectare of rice crop in about two hours, the manual sprayers required four to six hours. Consequently the cost of spraying with the power sprayer was found much cheaper than the manual sprayers. To overcome the limitation of high capital cost of power sprayer it would be appropriate to use it on a joint or group basis at padasekharam level. There could be a saving of about Rs.45/-for each hectare for spraying once with a power sprayer in place of the conventional spearers.

In the light of the above discussion it is suggested that for individual and staggered plant protection operations the manual sprayers, preferably the knapsack sprayer would be more suitable than the power sprayer. But if farmers could join together on a group basis it would always be advantageous to use or custom hire sprayers as it can save time, money and alleviate drudgery.

4.1.6 Harvesting tools/machinery

Serial numbers 29-30 listed in Table 4.1.1. refer to the equipment used for harvesting paddy. The use pattern indicated that country sickle was owned and used and custom hired (along with labourers to harvest) by the preponderant majority of rice farmers of all the regions. The Southern Region had the highest percentage of owner-users (34.88%) whereas 75.76 per cent of respondents of the Highrange Region custom hired country sickle. Improved sickles were not at all found to be used in the Southern and Highrange regions whereas it was negligible in the Central, Northern and Highrange regions. The mechanically operated paddy harvester (vertical conveyor reaper windrower) had also negligible number of users in the Central Region, Problem Region and Northern Region. It was not at all in use in the study areas of the Southern Region and Highrange Region. In the Central Region when 3.13 per cent of the respondents were owner-users of paddy harvester, 12.50 per cent were found to have used it on custom hire basis.

Results mentioned in the preceding paragraphs throw light to the fact that country sickle was the most popular and versatile harvesting tool in all regions of Kerala. As indicated by the data furnished in Table 4.1.2 (Sl.No.27), the country sickle had a work capacity of 0.007 ha/h indicating that 125-130 man hours were required to harvest one hectare of rice crop. Its capital cost was Rs.25-30/- and operational cost Rs.6/ha. The data presented as serial number 28 in Table 4.1.2 revealed that the improved sickle (CIAE Model 'Naveen') had a higher work capacity of 0.011 ha/h indicating that it required about 90-95 man hours to harvest one hectare. The peculiar shape of the handle, the long, wide and heavy blade of the sickle warranted enough practice to use the sickle.

Serial number 29 in Table 4.1.2 pertains to the self propelled vertical conveyor reaper windrower. It had a work capacity of 0.25-0.30 ha/h. The capital cost of the reaper was Rs.24,000/- inclusive of the cost of a 5 hp diesel engine and other essential accessories. The operational cost per hour and per hectare were Rs.32/- and Rs.130/- respectively. The mechanical harvester had the advantages of high work capacity and quick completion of harvesting. High capital cost, mechanical complexity, requirement of skill to operate, requirement of a non lodging and short to medium statured crop and difficulty to traverse deep clayey and muddy fields were its notable limitations.

The results related to the harvesting devices could be discussed by comparing their advantages and limitations. Due to its light weight, easy to use design, low cost and local availability, the country sickle was the most commonly used harvesting tool in all the regions. The improved sickle on the other hand was heavier, with unconventional handle shape and longer and wider blade. The farmers had not got enough exposure to the sickle due to its recent introduction and poor propaganda. These might be the reasons for its low popularity in Kerala. The vertical conveyer reaper windrower undoubtedly had commendable work capacity. It required only four man hours to harvest one hectare of rice crop as against that of 125 man hours required by sickle harvesting. Harvesting with the country sickle cost the farmers about Rs.750-780/ha. In the case of the vertical conveyer reaper windrower it was only Rs.130/ha for owner-users and Rs.220-240/ha for custom-hirers. Thus there could be a saving of Rs.530-540 per each hectare of rice crop harvested if the vertical conveyer reaper windrower were used in place of the country sickles. Though

is a highly encouraging finding the vertical conveyer reaper windrower had several constraints as were gathered by the researcher from the owner-users and custom-hirers of this machine. Efficient harvesting with the reaper requires non lodging and short to medium statured varieties. Moreover, in most of the rice tracts of Kerala the paddy fields at the time of harvest of the <u>virippu</u> crop would be muddy. Farmers had reported that it was very difficult for the machine to move in deep clayey and muddy fields and hence there were missing hills and field loss. The fields at the time of <u>mundakan</u> harvest would be dry. But most of the farmers of Kerala, especially of the Southern, Central, Northern and Highrange regions prefer long duration, long statured varieties for mundakan season. The vertical conveyer reaper windrower, even in a dry field could not harvest a lodged crop. These paradoxical situation are thought provoking.

In the light of the above discussion it could be suggested that popularisation of improved sickles need concentrated efforts through result demonstrations and imparting skill and experience in farmers to make them convinced and well-versed in use. The use of the self propelled vertical conveyor reaper windrower could be recommended to areas where non lodging varieties are grown and to fields which are not too muddy during the virippu season. It could be efficiently used for harvesting the mundakan and punja crop in the Southern, Central, Northern and Highrange Regions in fields where erect and short medium statured varieties are cultivated.

4.1.7 Threshers

A perusal of the data on the pattern of ownership and use (Table 4.1.1) indicted that among the four types of devices used for mechanical threshing of harvested paddy (Serial numbers 32 - 33) indicted that in general, mechanical threshing has not gained momentum in Kerala. In the Central Region, though the number of owner users of mechanical threshers was negligible, farmers of the region had custom hired motorised mini threshers (14.06%), peg tooth type thresher (15.63%) and rasp-bar type thresher (18.75%).

Details of the manually operated pedal thresher are furnished as serial number 30 in Table 4.1.2. The thresher costing Rs.2,500/- had a work capacity of 80 - 100 kg/h, with an operational cost of Rs.325/ha (Rs.11/quintal paddy). The threshers though used by a few farmers, were not available for custom hiring.

The data furnished in Table 4.1.2 (Sl.No.31) brought to light some encouraging factors. The motorised mini thresher had a high output of 450 kg/ha which was more than three fold than that of a pedal thresher. When conventional methods of threshing requires about 150 - 175 man hours to thresh one hectare paddy crop, the motorised mini thresher can do it with about 14 man hours. It requires about Rs.800/- to thresh one hectare of rice crop if done by the conventional methods, where as the same piece of work can be done by a motorised mini thresher at a cost of about Rs.300/-. Thus, if manual threshing were substituted by the motorised mini thresher there could be a saving of Rs.500/- for each hectare of rice crop threshed. The light weight,portability, simplicity and ease of operation of the mini thresher could make it a potential thresher suitable for all the rice growing tracts of Kerala.

The peg tooth type thresher (Sl. No.32 in Table 4.1.2) and the rasp-bar type thresher (Sl.No.33 in Table 4.1.2) are big threshers. Obviously their work capacity were also found to be more. The costs of operation were Rs.216/ha And Rs.165/ha for the peg tooth type and for the rasp-bar type respectively. In between these two types, farmers had high opinion about the rasp-bar type as its capital cost and cost of operation were less. Moreover it did not cut the straw. When compared to the cost of manual threshing the use of rasp bar type thresher had a substantial cost advantage of Rs.635/ha. In the light of the above discussion it is suggested that the rasp-bar type threshers would be suitable for large scale threshing if farmers of an area join together either as joint owner-users or joint/group hirer-users of this thresher. For small scale operations and for exclusive owner-user operations, the motorised mini thresher would be suitable.

4.1.8 Winnowing machinery

Serial numbers 36 and 37 listed in Table 4.1.1 pertain to the machinery used for winnowing the threshed paddy. The motorised simple winnowing fan (axial flow fan) and motorised/engine operated big winnower were found only selectively being used in the Central Region and Problem Region. A perusal of the data furnished in 4.1.1 indicated that only a very small percentage of the farmers used mechanical winnowers. The simple winnowing fan operated by a 0.25 hp electric motor was found to be owned by one farmer in the Central Region and by two farmers in the Problem Region. It was not available for custom hiring. The motorised/engine driven big winnower was found to be owned and used by two farmers each of the Central and Problem regions. The custom hirers of this winnower in the Central Region and Problem Region were 14.06 per cent and 7.81 per cent respectively.

The details of the motorised simple winnowing fan are furnished as serial number 34 in table 4.1.2. This machine costing Rs.2,000/- could winnow 300 - 400 Kg paddy in an hour. Its cost of operation was Rs.12/h (Rs.90-120/ha). The machine was found easy to operate and hence no special skill was required to use it.

The big size paddy winnower (Sl.no.35 in Table 4.1.2) run by a one hp electric motor had higher work capacity (600 - 700 kg/h). The machine costing Rs.4,000/- - 4,500/- required an operational cost of Rs.16/h(Rs.80 - 100/ha).

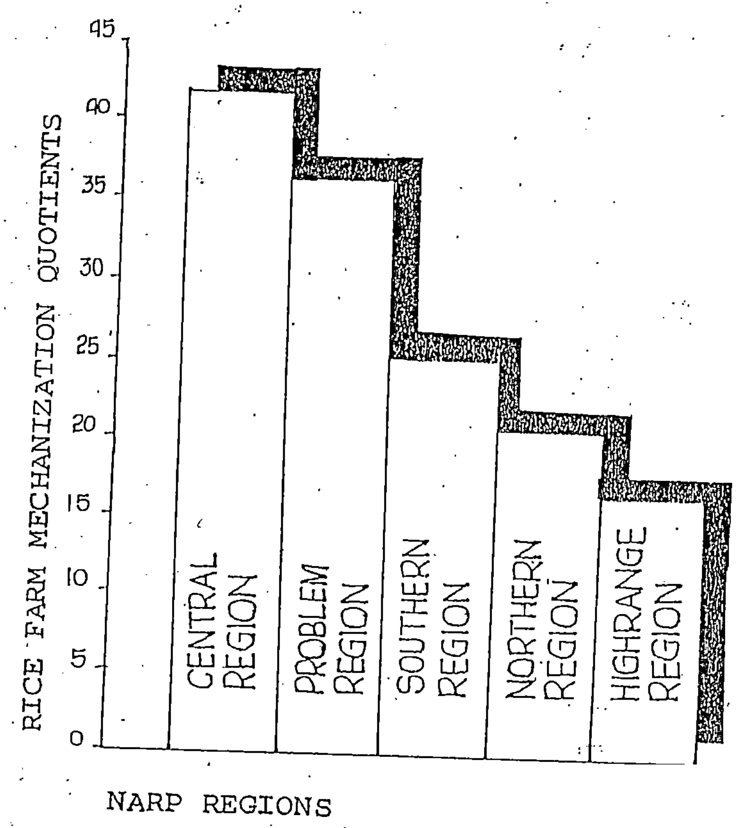
The potential of these two types of winnowers could be highlighted when their grain output were compared with the conventional method of winnowing. On an average two persons can winnow 100 kg paddy in an hour by the conventional way, two persons using the motorised small winnowing fan can winnow 300 - 400 kg/h and with the big type winnower,600- 700 kg/h. By the conventional method,about 60 man hours are required to winnow the grains of one hectare rice crop. The motorised small winnowing fan can do it using 16 - 20 man hours and the big type winnower can do the same piece of work in 8 - 10 hours. When the cost of winnowing were compared,the conventional method required about Rs.300/ha, the simple winnowing fan required Rs.90 - 120/ha, and the big type winnower required Rs.80 — 100/ha. These comparisons revealed that if conventional method of winnowing were substituted by mechanical method,there could be a per hectare saving of Rs.220 - 280/-, depending upon the type of the winnower used.

The results described above were highly encouraging. Besides cost reduction and time saving, alleviation of drudgery was also a substantial advantage of mechanical winnowing. In the light of the above discussion it could be suggested that for small operations, farmers could own and use the motorised simple winnowing fan, and for large scale operations, the big type motorised winnower could be used either as joint/group owner-users or joint/group custom-hirers.

1.2 Extent of adoption of improved farm implements and machinery by the rice farmers of Kerala

In this study the adoption behaviour of the

Fig. 4.1 RICE FARM MECHANIZATION QUOTIENTS OF NARP REGIONS OF KERALA



farmers with respect to rice farm mechanization was measured by developing a formula to compute Farm Mechanization Quotient (FMQ) as described in section 3.5 of this thesis. FMQ of the 320 respondent farmers were worked out by considering the variables namely potentiality, extent, weightage, and time of adoption. Weightage scores were assigned to 32 types of improved farm implements and machinery following a step by step systematic procedure under both situations of use namely, 'owner-user' and 'custom-hirer'.

4.2.1 Profile analysis of the NARP regions of Kerala with respect to rice farm mechanization

The profile of the five NARP regions covered in the study to find out the extent of adoption of improved farm implements and machinery for rice cultivation is presented in Table 4.2.1.

A cursory glance at the data in the Table revealed the relative position of the NARP regions of Kerala regarding the extent of adoption of rice farm mechanization technology. Central Region occupied the first position with a FMQ of 42.86 followed by the Problem Region (36.70). The Southern Region and Northern Region had Farm Mechanization Quotients of 25.81 and 21.40 respectively. The Highrange Region with a FMQ of 16.73 occupied the last position among the five NARP regions.

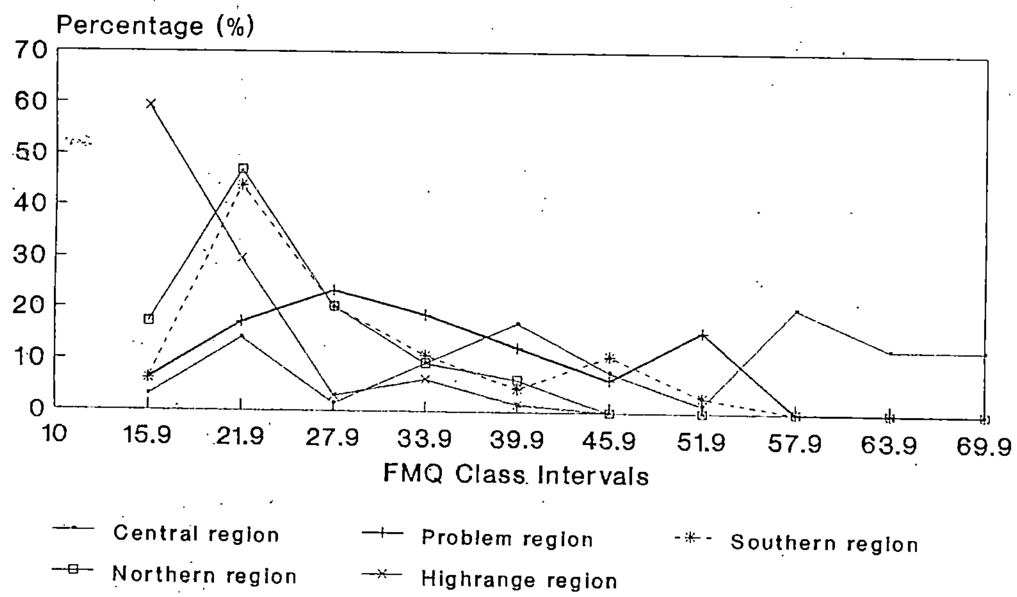
Table 4.2.1 Profile of the NARP regions with respect to adoption of rice farm mechanization

(n = 320)

Sl. No.	NARP region	Range of observed FMQ	Mean FMQ	Standard deviation	Coefficient of variation	Rank
1	Central Region	15.08 - 65.80	42.86	17.05	39.79	I
2	Problem Region	19.76 - 54.92	36.70	11.34	30.91	II
3	Southern Region	14.06 - 60.01	25.81	9.85	38.16	III
4	Northern Region	13.96 - 39.44	21.40	6.94	32.43	IV
5	Highrange Region	11.46 - 37.37	16.73	5.37	32.09	V

FMQ = Farm Mechanization Quotient

Fig.4.2 Distribution of NARP regions according to Farm Mechanization Quotients of rice farmers



As it could be seen from Table 4.2.2, when 20.31 per cent of the farmers of the Central Region belonged to the FMQ class of 52 - 57.9, there were none from the other four regions. The highest class observed in the Problem Region was 46 - 51.9 having 51.63 per cent of the farmers. Preponderant majority of the farmers of the Highrange Region (59.38%) belonged to the lowest class of FMQ (10 - 15.9) indicating the lowest extent of adoption of farm implements and machinery when compared to the other regions of the State.

Categorisation of the farmers of the five NARP regions according to Farm Mechanization Quotients.

The categorisation of the respondent farmers of NARP regions according to their FMQ is presented in Table 4.2.

It is thought provoking to find that none of the regions could come under the 'High category', where as only the Central Region with 17.19 per cent of the farmers could be included in the 'Medium to high category' of adopters of farm implement machinery. Nearly 36 per cent of the farmers from the Central Region and 58 per cent from the Problem Region belonged to the 'Medium category'. The low status of

4.2.2 Frequency distribution of Farm Mechanization Quotients of the five NARP regions.

As it could be seen from Table 4.2.2, when 20.31 per cent of the farmers of the Central Region belonged to the FMQ class of 52 - 57.9, there were none from the other four regions. The highest class observed in the Problem Region was 46 - 51.9 having 51.63 per cent of the farmers. Preponderant majority of the farmers of the Highrange Region (59.38%) belonged to the lowest class of FMQ (10 - 15.9) indicating the lowest extent of adoption of farm implements and machinery when compared to the other regions of the State.

4.2.3 Categorisation of the farmers of the five NARP regions according to Farm Mechanization Quotients.

The categorisation of the respondent farmers of the five NARP regions according to their FMQ is presented in 2.3.

It is thought provoking to find that none of the regions could come under the 'High category', where as only the Central Region with 17.19 per cent of the farmers could be included in the 'Medium to high category' of adopters of farm implement machinery. Nearly 36 per cent of the farmers from the Central Region and 58 per cent from the Problem Region belonged to the 'Medium category'. The low status of

Fig. 4.3 Categorisation of the farmers of the NARP regions according to Farm Mechanization Quotients

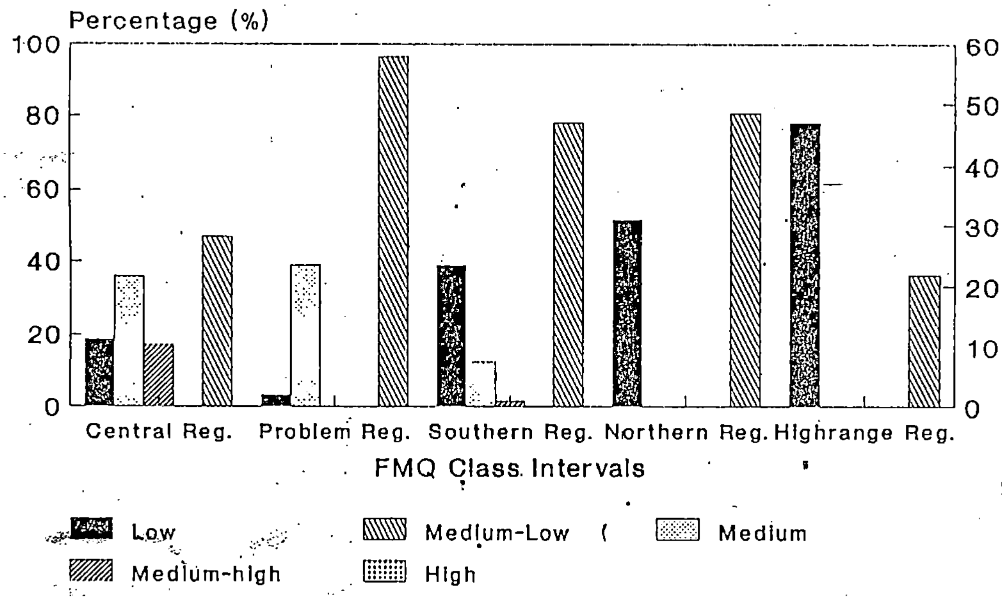


Table 4.2.2 Distribution of NARP regions according to Farm Mechanization Quotients of rice farmers.

(n = 320)

F M Q Class Intervals	Central Region		Problem Region		Southern Region		Northern Region		Highrange Region	
	Frequ-ency	Perce-ntage	Frequ-ency	Perce-ntage	Frequ-ency	Perce-ntage	Frequ-ency	Perce-ntage	Frequ-ency	Perce-ntage
10-15.9	2	3.13	4	6.25	4	6.25	11	17.19	38	59.38
16-21.9	9	14.06	11	17.19	28	43.75	30	46.88	19	29.69
22-27.9	1	1.56	15	23.44	13	20.31	13	20.31	2	3.13
28-33.9	6	9.38	12	18.75	7	10.94	6	9.38	4	6.25
34-39.9	11	17.19	8	12.50	3	4.69	4	6.25	1	1.56
40-45.9	5	7.81	4	6.25	7	10.94	..	..	..	..
46-51.9	1	1.56	10	15.63	2	3.13	..	..	..	..
52-57.9	13	20.31	..	..	..	..	..	..	..	..
58-63.9	8	12.50	..	..	..	..	..	..	..	..
64-69.9	8	12.50	..	..	..	..	..	..	..	..

Table 4.2.3 Categorisation of the farmers of the NARP regions according to Farm Mechanization Quotients

(n = 320)

F M Q Category	Central Region		Problem Region		Southern Region		Northern Region		Highrange Region	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Low	12	18.75	2	3.13	25	39.06	33	51.56	50	78.13
Medium-Low	18	28.13	37	57.81	30	46.88	31	48.44	14	21.87
Medium	23	35.94	25	39.06	8	12.50	..	..	..	..
Medium-High	11	17.19	..	..	1	1.56	..	..	..	..
High	..	..	..	..	..	..	..	..	..	..

the Highrange Region and Northern Region with respect to adoption of farm mechanization technology was evident on perusing the data in the Table as about 78 per cent and 52 per cent, respectively, of the farmers belonged to the 'Low category'. This analysis clearly indicated the low status of rice farm mechanization in Kerala.

4.2.4 Comparison of the differential adoption of farm implements and machinery by farmers of the five NAARP regions.

To test whether the differences in FMQ existing among the five NARP regions were significant or not, the Analysis of variance technique was employed. The results of the ANOVA are presented in Table 4.2.4.

As observed in the Table the F ratio indicated significant difference among the NARP regions of Kerala with respect to extent of adoption of farm implements and machinery by rice farmers. As evidenced by the C.D. value the differences existing between each region were significant. This result, besides supplementing the preceding findings conclusively corroborated that the Central Region, followed by the Problem Region occupied the first and second ranks respectively with regard to extent of adoption of farm mechanization technology, where as the Highrange Region was placed in the last position.

Table 4.2.4 Differential adoption of rice farm mechanization by farmers of different NARP regions

(n = 320)

Sl. No.	NARP Regions	Mean FMQ	Mean squares between samples	Computed F ratio
1	Central Region	42.86		
2	Problem Region	36.70		
3	Southern Region	25.81	7510.77	63.27**
4	Northern Region	21.40		
5	Highrange Region	16.73		

C D = 3.775

Significant at 0.01 level

Several reasons could be attributed to the envious status the Central Region occupied in the farm mechanization scenario of the State. The Central Region is the major rice growing tract accounting for about 50 per cent of the area under rice and 52 per cent of the Production of rice in Kerala. Palakkad district, the 'rice bowl' of Kerala which accounts for about one-fourth of the total area under rice belongs to this region. Rice cultivation in the region is highly intensive. The cropping intensity is very high. Majority of the paddy fields being in the command areas of irrigation projects, farmers take three rice crops a year. To facilitate such an intensive nature of cropping and for timely operations, the Central Region from long time back has been the fore runner in the use of improved implements, sprayers, power tillers, tractors, mechanical paddy threshers and winnowers. The vast and continuous stretch of paddy fields allow operational and conveyance accessibility for improved implements and machinery.Moreover, Palakkad is adjacent to the Coimbatore district of Tamil Nadu, a state having high power utilisation of about 0.6 hp/ha and well known for high level of farm mechanization. Coimbatore is famous for the manufacturers and dealers of farm equipment. This proximity allows the farmers of Central Region to easily procure and use improved farm implements and machinery manufactured there. These might be the reasons for the high level of adoption of rice farm mechanization technology in the Central Region

As seen in Table 4.2.1 the Problem Region occupied the second position with respect to rice farm mechanization. The region, comprising the five sub regions namely, Onattukara, Kuttanad, Pokkali and Kole lands is a famous rice tract of Kerala. Incidentally the Problem Region ranks second to Central Region in terms of area and production of rice. All the sub regions have vast stretches of paddy fields where intensive cultivation of rice is followed with high yielding varieties. These might be the favourable factors for the adoption of farm implements and machinery. The use of Power tillers, tractors, Power sprayers, and mechanical threshers and winnowers has become common in this region.

The Highrange Region was the last in the ranking with respect to rice farm mechanization. The unique and special features of rice cultivation in the region could be attributed to this - the undulating terrain, small and fragmented holdings, sloppy and terrace lands, single cropping with long duration local varieties are some among them. These factors have led to the low profitability of rice cultivation in the region (Prakash, 1989). Rice does not enjoy the status of an important crop in the Highrange Region due to the dominance of plantation crops. Cropping intensity rice in the region was the lowest when compared to the [illegible]er regions. Single cropping is the general pattern. Lack of irrigation facilities often force the farmers to leave the paddy lands fallow. Paddy fields are mostly in the valleys formed by hillocks and hence small, fragmented and sloppy. Due to these constraints farm operations with power tillers and tractors are not always possible. Their use is confined to the limited land available on the river banks.

The above mentioned disparities existing between the Central Region and Highrange Region throw light to the conclusions put forth by Ashby (1982), Hooks et al. (1983), Audirac and Bealieu (1986) and Ban and Hawkins (1990) that characteristics of the technology, the access conditions, contextual factors, physico-biological factors and variations in farming environments greatly influence the farmers' adoption behaviour. There must be a match between the characteristics of the technology, conditions for access to the innovation, the potential users' ecological (location, natural resource endowment), structural characteristics like farm size, terrain, capital, labour, profitability, etc

The preceding discussion regarding the differential adoption of farm mechanization technology corroborates the effect of structural aspects influencing the adoption behaviour of farmers. It is posited that apart from the personal, behavioural and psychological orientation of the farmers as put forth by Rogers and Shoemaker (1971), and the distributional characteristics of the innovation (extension infrastructure, extension strategies) and intrinsic characteristics of the technology (capital cost, operational cost, labour saving, drudgery alleviating, etc.) as reported by Diaz Bordenave (1976), Pearse (1980) and Brown (1981), the characteristics of the farm business (for example, status of the crop in the farm sector, yield, cost of cultivation, profitability, etc.) as well as the locational and ecological characteristics with respect to topography, conveyance accessibility, proximity to manufacturers, dealers and extension network, should contribute more reliable indicators of adoption of high level technologies like farm mechanization.

Based on the finding and with the support of the discussion the hypothesis that there will be no significant difference among the five NARP regions of Kerala with respect to adoption of farm mechanization technology is rejected.

4.3 Constraints to the adoption of improved farm implements and machinery

4.3.1 Intensity of adoption constraints to rice farm mechanization in different NARP regions

The intensity of constraints to the adoption of farm implements and machinery observed in the five NARP regions are presented in Table 4.3.1. A perusal of the data presented in the Table revealed the following.

Among the five regions the Highrange Region was studded with multifarious constraints with high levels of intensity. The constraints namely, unevenness of the field (44.33), conveyance inaccessibility (75.59), lack of awareness (8.47), lack of knowledge (13.23), negative attitude (25.27), high capital cost (28.70), high cost of operation (25.27), non availability of suitable farm implements and machinery (26.44), plentiful availability of human labour (2.25), cheap labour availability (3.30), low level of entrepreneurship (54.42), and low use of information sources (28.03) had the highest levels of intensity in the Highrange Region. None of the constraints out of the 24 selected for the study, were found less intensive in this region.

The Southern Region was characterised by high levels of intensity of constraints namely, fragmentation of holdings (0.74), non availability of spares (2.59), and low profitability of rice cultivation (3.84). Seven constraints were found less intensive in the Southern Region. They were: high capital cost (24.55), high cost of operation (20.45), non availability of suitable farm implements and machinery (24.09), high mechanical complexity (23.41), low custom-hirer facilities (25.41), cheap labour availability (1.23), and low use of information sources (21.20).

Table 4.3 Intensity of adoption constraints to rice farm mechanization as perceived by the farmers in different NARP regions

Sl. No.	Constraints	Northern Region (n = 64)		Central Region (n = 64)		Southern Region (n = 64)		Problem Region (n = 64)		High Range Region (n = 64)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Small farm size	2.84	0.80	2.11	0.80	2.59	0.73	2.34	6.41	2.56	0.64
2	Fragmentation	0.66	0.85	0.45	0.55	0.74	0.73	0.26	0.51	0.61	0.60
3	Unevenness	10.08	14.09	8.52	11.89	8.83	10.97	4.94	6.06	44.33	30.01
4	Conversion of paddy lands	4.77	5.46	4.38	5.86	9.49	12.61	6.29	13.77	9.19	20.26
5	Low cropping intensity	119.36	42.95	75.42	42.35	117.96	40.92	53.32	47.94	98.54	22.11
6	Conveyance inaccessibility to the field	57.62	41.43	57.31	39.50	51.22	41.84	46.68	45.53	75.59	31.46
7	Lack of co-operation among farmers	1.77	0.66	1.88	0.63	3.56	12.28	3.55	12.29	2.23	0.62
8	Lack of awarness	7.03	2.19	5.19	1.75	6.20	2.21	5.76	2.84	8.47	11.84
9	Lack of knowledge	13.08	4.25	11.94	3.66	13.22	3.85	11.37	3.74	13.23	5.33
10	Negative attitude	21.19	12.76	16.41	7.44	17.56	8.36	16.53	13.17	25.27	12.47
11	High capital cost	26.58	10.41	26.48	3.90	24.55	5.16	27.94	9.65	28.70	10.24
12	High cost of operation	21.72	5.37	24.63	3.74	20.45	5.43	24.91	4.21	25.47	5.32
13	Non availability of suitable implements/machinery	24.48	5.41	24.53	3.58	24.09	5.53	25.41	4.69	26.44	3.66
14	Non availability of spares	2.52	1.80	1.94	0.56	2.59	3.54	2.41	3.68	2.53	1.77
15	Inadequate repair and service	2.81	8.77	2.02	0.61	2.13	0.73	2.45	3.19	2.75	3.74
16	High mechanical complexity	25.66	5.28	24.84	4.09	23.41	6.33	25.75	4.76	25.00	4.67
17	Low custom hire facilities	26.44	5.29	27.22	2.64	25.41	4.90	26.75	2.59	26.47	2.29
18	Lack of credit facilities	3.92	2.52	3.09	1.30	3.66	3.27	4.11	4.36	3.88	3.11
19	Low profitability of rice cultivation	3.28	0.63	3.58	0.53	3.84	0.76	3.80	0.65	3.67	0.80
20	Plentiful availability of labour	2.05	0.55	1.30	0.46	1.50	0.71	1.91	0.58	2.25	0.67
21	Cheap labour availability	2.18	3.48	1.41	0.53	1.23	0.43	2.16	3.45	2.25	3.30
22	Opposition from farm labourers	1.52	3.89	1.13	0.33	1.22	0.42	1.84	3.37	1.50	3.13
23	Low level of entrepreneurship	42.28	18.45	39.0	12.71	37.48	19.14	34.92	14.27	54.42	15.66
24	Low use of information sources	22.70	10.77	23.89	8.91	21.20	12.95	25.13	9.06	28.03	8.94
	Cumulative constraint score	446.54		388.67		426.43		360.53		513.18	

In the Northern Region, the constraints namely, small farm size (2.84), low cropping intensity (119.36), and inadequate repair and services facilities (2.81) prevailed as the most intensely felt constraints to rice farm mechanization.Only two constraints viz. lack of co-operation among farmers (1.77) and low profitability of rice cultivation (3.28) were found to be the least intensive in this region.

In the Problem Region, the intensity of constraints namely, high mechanical complexity (25.75), lack of credit facilities (4.11), and opposition from farm labourers (1.84) was the highest when compared to the other regions. In the Problem Region six constraints were found to be having the lowest intensity. They were: fragmentation (0.26), unevenness (4.94), low cropping intensity (53.32), conveyance inaccessibility (46.68), lack of knowledge (11.37), and low level of entrepreneurship (34.92).

When compared to the other four NARP regions the intensity of constraints present in the Central Region was low. It is interesting to find that the lone constraint having the highest intensity was low custom hire facilities (27.22). Eight constraints were found to be having the lowest intensity in the Central Region. They were: conversion of paddy lands (4.38), lack of awareness (5.19), negative attitude (16.41), non availability of spares (1.94), inadequate repair and service facilities (2.02), lack of credit facilities (3.09), plentiful availability of human labour (1.30) and opposition from farm labourers (1.13).

The preceding results indicated that though most of the constraints were prevalent in all the regions, the varying intensives proved that each region had specific problems in the adoption of rice farm mechanization technology. The relative status of the NARP regions according tothe intensity of adoption constraints could be presented and discussed with the help of the data presented in Table 4.3.2 and also by perusing the total scores of the 24 constraints presented in Table 4.3.1.

The data presented in Table 4.3.2 pertains to the percentage of farmers of each region who perceived the prevalence of each constraint, listed to them by the researcher, as was felt in their farming situation.

As seen in Table 4.3.1 the Highrange Region had a high cumulative constraint score of 513.18. The scores of the other regions were distinctly lesser: Northern Region (446.54), Southern Region (426.43), Central Region (388.67) and Problem Region (360.53). This indicated that the Highrange Region stood out as the distinctly lone zone with

Table 4.3.1 Frequency and percentage adoption constraints to rice farm mechanization as perceived by farmers of different NARP regions

Sl. No.	Constraints	Northern Region (n=64)		Central Region (n=64)		Southern Region (n=64)		Problem Region (n=64)		Highrange Region (n=64)	
		F	%	F	%	F	%	F	%	F	%
1	Small farm size	49	76.56	43	67.19	52	81.25	48	75.00	51	79.69
2	Fragmentation	42	65.63	39	60.94	44	68.75	33	51.56	40	62.50
3	Unevenness	45	70.31	36	56.25	38	59.38	36	56.25	56	87.50
4	Conversion of paddy lands	42	65.63	35	54.69	45	70.31	39	60.94	39	60.94
5	Low cropping intensity	47	73.44	34	59.13	46	71.88	50	78.13	52	81.25
6	Conveyance inaccessibility to the field	43	67.19	35	54.69	33	51.56	39	60.94	57	89.06
7	Lack of co-operation among farmers	41	64.06	42	65.63	54	84.38	46	71.88	44	68.75
8	Lack of awarness	42	65.63	33	51.56	38	59.38	36	56.25	41	64.06
9	Lack of knowledge	34	53.13	26	40.63	36	56.25	29	45.31	35	54.69
10	Negative attitude	31	48.44	23	35.94	33	51.56	27	42.19	32	50.00
11	High capital cost	39	60.94	41	64.06	42	65.63	42	65.63	51	79.69
12	High cost of operation	38	59.38	35	54.69	31	48.44	36	56.25	40	62.50
13	Non availability of suitable implements/machinery	41	64.06	34	53.13	44	68.75	40	62.50	52	81.25
14	Non availability of spares	38	59.38	31	48.44	37	57.81	30	46.88	40	62.50
15	Inadequate repair and service	38	59.38	32	50.00	37	57.81	36	56.25	41	64.00
16	High mechanical complexity	36	56.25	31	48.44	42	65.63	35	54.69	33	51.56
17	Low custom hire facilities	45	70.31	50	78.13	43	67.19	50	78.13	52	81.25
18	Lack of credit facilities	50	78.13	45	70.31	48	75.00	51	79.69	50	78.13
19	Low profitability of rice cultivation	42	65.63	38	59.38	49	76.56	45	70.31	41	64.06
20	Plentiful availability of labour	12	18.75	11	17.19	10	15.63	13	20.31	30	46.88
21	Cheap labour availability	8	12.50	7	10.94	6	9.38	9	14.07	22	34.38
22	Opposition from farm labourers	14	21.88	10	15.63	11	17.19	31	48.44	15	23.44
23	Low level of entrepreneurship	7	10.94	8	12.50	10	15.63	9	14.06	13	20.31
24	Low use of information sources	28	43.75	21	32.81	27	42.19	24	37.50	23	35.94

a multiplicity of intensively felt constraints to rice farm mechanization. This situation could be further affirmed by a cursory look at the percentage of the respondents who perceived each constraint. Out of the 24 constraints studied, the Highrange Region had the highest percentage of farmers perceiving the 11 constraints, which accounted for nearly 50 per cent of the total number of constraints. When the data in Tables 4.3.1 and 4.3.2 were perused, they were more or less equally agreeable - that is the intensity of the constraints actually measures by the researcher and the intensity perceived by the farmers had good matching. This result corroborated that the 11 constraints namely, unevenness of fields, low cropping intensity, conveyance inaccessibility to the field, high capital cost of farm implements and machinery, high cost of operation of improved farm implements and machinery, non availability of suitable implements/machinery, non availability of spares, inadequate repair and service facilities, low custom hire facilities, plentiful availability of labour, and cheap labour availability were distinctly specific to the Highrange Region when compared to the other four NARP regions.

There are a multiplicity of reasons why the Highrange Region had a plethora of constraints to rice farm mechanization. As discussed in section 4.2, the Highrange Region had the lowest status of rice farm mechanization with a very low FMQ of 16.73. The region has its unique agro-climatic and physiographic peculiarities. The undulating terrain, and the positioning of paddy fields on the slopes and terraces of hillocks are some among them. The bulk of the paddy lands lies in the hills and hence are inaccessible to power machinery like power tillers and tractors due to difficulties in their transportation. The uneven and fragmented fields pause problems for the easy operation of improved farm implements and machinery. These might be the reasons why the constraints unevenness of the fields, and conveyance inaccessibility had high intensity in the Highrange Region. Rightly these were perceived as major constraints by more than 80 per cent of the farmers of the region (Table 4.3.2).

The specific reason for low cropping intensity as a major constraint as reported by 81.25 per cent of the farmers of the Highrange Region was quite obvious. Cropping intensity was the least in the region when compared to the other four NARP zones. Only a single season crop with long duration local variety of paddy is taken in most of the areas. Thus rice fields have to be kept fallow for several months. If rice farmers purchase the improved implements and machinery they will have to keep them idle for a long period every year, which the farmers felt was an investment wasted.

Nearly 80 per cent of the respondents of the Highrange Region felt that high capital cost of the improved implements and machinery was a major constraint especially for their procurement and use. In the Highrange Region rice farm mechanization being not popular, there is a dearth of local manufacturers, small scale industrial units and dealership networks related to farm implements and machinery. Such agencies are mostly concentrated in the Central and Southern regions of Kerala. So the farmers of the Highrange Region, even if are desirous of owning and using improved farm equipment, have to purchase them from far off places like Palakkad and Coimbatore at a high cost. This situation was affirmed by a high percentage (79.69%) of farmers reporting high cost of farm implements and machinery as a major constraint.

High cost of operation of improved farm implements and machinery as a constraint was felt by 62.50 per cent of the farmers. Two reasons could be attributed to his. Due to the uneven terrain and conveyance inaccessibility, there could be considerable time loss while in transit and during field operations of farm equipment. Consequently they operate at a lesser work capacity. The high cost of the equipment and the high custom service charges of the region also contributed to the high cost of operation.

More than 60 per cent of the respondents of the Highrange Region perceived the four constraints - non availability of suitable farm implements and machinery, non availability of spares, inadequate repair and service facilities, and low custom hire facilities as major ones. On closer analysis these constraints were not only related to each other but also influenced by the low adoption and popularity of improved farm equipment in the region. Due to low adoption and low scope for use of the improved farm equipment, the network of dealers of farm implements and machinery, spare parts, local manufacturers, repair and service agencies, and custom hiring agencies were considerably lacking in the Highrange Region. These might be the reasons for the prevalence of the aforesaid four constraints in the region.

It is quite interesting to find that farmers of the Highrange Region perceived two constraints related to labour - plentiful availability of labour (46.88) and cheap availability of labour (34.38%) as constraints to rice farm mechanization. This may sound illogical if the general trend in Kerala State is considered as rice farmers often lament on the non availability of farm labourers and the tremendous hike in wage rates. But the situation in Highrange Region was quite different. The study area had a high proportion of tribal population at its farm labour front. Due to the predominance of plantation crops which are perennial in nature, the labourers have a lot of workless days. The rice farmers utilise this opportunity and get plenty of labourers at cheap wage rates to carry out the seasonal works related to rice farming. Thus dearth of farm labourers was not a problem in this region. Moreover as reported by Prakash (1989) as farmers of the Highrange Region utilised more family labour for rice farm operations when compared to other regions, labour availability was easier. Obviously, when labour availability was easy and cheap, farmers had a tendency to stick on to the manual and conventional methods rather than going for mechanical farming.

The specific constraints to rice farm mechanization prevailed in the Southern Region were - fragmentation of holdings, lack of co-operation among farmers, non availability of spares and low profitability of rice cultivation. The cumulative constraint score for the region was 426.43 (Table 4.3.1).

As indicated in Table 4.3.2, 68.75 per cent of the farmers of the Southern Region felt that fragmentation of holdings was a major problem in the adoption of improved farm equipment. Southern Region is well known for the prevalence of tiny holdings due to the high pressure of population on land in the region when compared to the other regions. Fragmented holdings do not facilitate easy access and operational efficiency to improved farm equipment. ies of Prakash (1989) lend support to this finding. of co-operation among the farmers was another important straint felt by the farmers (84.38%) of the Southern ion.Most of the farm equipment, especially the power inery, being costly, systems of informal joint ership, or co-operative ownership and group use are ential to make rice farm mechanization thrive. This can achieved only in the background of whole hearted co- ation among thee farmers. Such a scenario was found ing in the Southern Region. Political polarisation and er socio political complexities prevalent among the ers of this region in particular and the predominance of part-time farmers could be the possible explanations for the emergence of the constraint lack of co-operation among farmers. Part-time farmers seldom find time to organise and device a system for group ownership or group use of improved farm equipment. These results are in conformity with the observations of Prakash (1989). Non availability of spares was another major constraint present in the Southern Region. Nearly 58 per cent of the farmers perceived it as an important constraint to rice farm mechanization. This might be due to the fact that when compared to the prevalence of dealers and distributors of farm implements and machinery in the region, the number of spare parts dealers were not sufficient. Southern Region was also characterised by the low profitability of rice cultivation. As discussed earlier, the predominance of part-time farmers, and absentee landlordism and the other constraints as reported by Prakash (1989) viz. drought, non availability of agricultural labour and high cost of production in the Southern Zone, might be the reasons for low profitability. Now-a-days farmers consider any type of farming as a business. Their desire is to derive maximum profit out of the enterprise. But when profitability is not experienced in earlier attempts, it is quite natural that farmers show reluctance to adopt high level technologies like farm mechanization technology.

The cumulative constraint score recorded in the Northern Region was 446.54. A high proportion of farmers (81.25 per cent) perceived small farm size as a major constraint to rice farm mechanization. Due to the division of joint family system into several nuclear families and the ceiling on land holdings and other land reforms act enforced resulted in the prevalence of many tiny farm holdings in the region. Obviously tiny holdings are unsuitable for the efficient working of improved farm equipment especially power machines like power tillers, tractors, power sprayers and harvesters. These might be the reasons why the respondents of the Northern Region perceived small farm size as a constraint to rice farm mechanization.

The Problem Region was characterised by a low cumulative constraint score of 360.53. Lack of credit facilities as a major constraint was reported by 79.69 per cent of farmers of the Problem Region. Rice cultivation operations in the region is so intensive,vast and time bound that farmers required a lot of finance from banks and co-operative institutions if they wanted to mechanize their cultivation operations. Though lack of credit facilities and indebtedness and common to the rice farm sector of Kerala as a whole, a lot of regional imbalances exist. Lack of a good network of credit institutions in the public sector banking and co-operative sectors was evident in the Problem Region. As a consequence, this constraint has been felt as an obstacle to rice farm mechanization.

It is interesting to find that the Problem Region typically stood out as the lone region where a considerable proportion of the farmers (48.44%) felt that opposition from farm labourers was a major constraint to the use of improved farm implements and machinery. A peep into the history of labour struggles and trade union activities in Kerala would reveal that the Problem Region comprising the Kuttanad, Onattukara, Kole and Pokkali areas have been places were the maximum labour unrest, peasant and agricultural labour upheavals existed. Even now traces of labour union militancy are observable in these tracts. For example, if a farmer of the Kuttanad area wanted to plough his land with a tractor, he has to first engage a a traditional ploughman to plough at least one pass. No doubt this is a waste to the farmer. But such practices have become customary and obligatory on the part of the farmers of the Problem Region due to the pressure of labour unions. Opposition against mechanization of similar nature existed in the case of other major activities like harvesting and threshing of paddy. These might be the reasons which prompted the respondents to report the constraint opposition from farm labourers as a major obstacle to rice farm mechanization in the Problem Region.

When compared to the other four regions the intensity of constraints experienced by the farmers of the Central Region was low, and that was evident from the low cumulative constraint score of 383.67. It is interesting to find that the lone constraint having the highest intensity (27.22) and that the maximum percentage of farmers reported (78-13%) was low custom hire facilities. The Central Region comprising the Palakkad area is known as the 'rice bowl' of Kerala where rice farm operations are so intensive and hectic that farmers required improved farm implements and machinery to complete the field operations, harvesting and post-harvesting works as quickly as possible. Though the number of custom hiring agencies were more in the Central Region when compared to the other regions, farmers felt that they were too meagre to meet the demands during peak periods of operations.Besides local custom hiring agencies, farm machinery contractors from far off places like Ernamkulam, Thodupuzha and Muvattupuzha use to camp in the region. Even with these the availability of improved implements and machinery were found not to satisfy the requirements of the farmers.

4.3.2 Relationship of the constraints with the extent of adoption of improved farm implements and machinery (Pooled sample of 320 respondents)

Simple linear correlation analysis was employed to establish the relationship of the 24 constraints with the extent of adoption of improved rice farm mechanization technology. The pooled 'r' values are presented in Table 4.3.2. These variables being expressed in absolute terms in the constraint form, all the relationships understandably were on the negative side.

A cursory glance at the data in Table 4.3.2 and Fig.4.3 revealed that out of the 24 constraints, 10 constraints established significant relationship with extent of adoption. The constraints, were: small farm size, conveyance inaccessibility to the field, lack of co-operation among farmers, lack of knowledge, negative attitude, high capital cost, high mechanical complexity, low custom hire facilities, lack of credit facilities and low level of entrepreneurship.

Table 4.3.2 Pearson's product moment correlation between the Selected constraints and extent of adoption of farm implements and machinery (Pooled sample)

(N = 320)

Sl. No.	Constraints	Pooled 'r' value
1	Small farm size	-0.1387*
2	Fragmentation	-0.1120NS
3	Unevenness	-0.1018NS
4	Conversion of paddy lands	-0.1080NS
5	Low cropping intensity	-0.1129NS
6	Conveyance inaccessibility to the field	-0.5274**
7	Lack of co-operation among farmers	-0.1269*
8	Lack of awareness	-0.1017NS
9	Lack of knowledge	-0.1135*
10	Negative attitude	-0.3158**
11	High capital cost	-0.4638**
12	High cost of operation	-0.1038NS
13	Non availability of suitable implements/ machinery	-0.1009NS
14	Non availability of spares	-0.1094NS
15	Inadequate repair and service	-0.1117NS
16	High mechanical complexity	-0.4826 **
17	Low custom hire facilities	-0.3856 **
18	Lack of credit facilities	-0.4078 **
19	Low profitability of rice cultivation	-0.1109NS
20	Plentiful availability of labour	-0.1001NS
21	Cheap labour availability	-0.0961NS
22	Opposition from farm labourers	-0.1092NS
23	Low level of entrepreneurship	-0.1210 *
24	Low use of information sources	-0.1125NS

* Significant at 0.05 level

** Significant at 0.01 level

NS Not significant

The establishment of significant relationship of the above mentioned 10 constraints with the extent of adoption are subjected to indepth discussion hereunder.

4.3.2.1 Small farm size

The value of pooled 'r' (-0.1269) indicated that there was significant correlation (at 0.05 level) between the constraint small farm size and extent of adoption. Small farm holdings are unsuitable for the efficient working of most of the improved farm implements and machinery, especially power machines like power tiler, tractor, power sprayer and power harvester. It is quite obvious that farmers who possess only small extent of paddy lands show reluctance to not only own and use power machines but also to custom hire them. For example, in order to custom hire such machinery, there should be a reasonable area of land holding to make the adoption economically meaningful. Most of the custom hiring agencies operate their machines on per hour basis. The minimum charge to be given by a farmer is for a minimum of one hour. Even if a farmer engages such machinery in an area that could be covered in less than one hour, the farmer has to pay one hour's charge to the custom hiring contractor. In such contexts farmers show reluctance to engage improved farm implements and machinery. Similarly it is out of question to a farmer who possesses tiny holdings to own and use most of the improved farm equipment.Moreover, when machines like power tillers and tractors are put to work in tiny holdings, a lot of time is wasted in transit as well as in the field (turn around time). Similar findings have been reported by Rao (1972), Singh (1978), Suri (1978), James (1988), Gupta and Ram (1989) and Prakash (1989).

In the light of the above discussion, the hypothesis that there would be no relationship between the constraint small farm size and extent of adoption of improved farm mechanization technology was rejected.

4.3.2.2 Conveyance inaccessibility to the field

This constraint established a high 'r' value (-0.5274) with the extent of adoption. Conveyance inaccessibility can be viewed as natural/physical barriers for the transit/or smooth operation of farm implements and machinery. Kerala is characterised by the predominance of homestead farms. Transportation of wheeled machines like power tiller and tractor is often arduous as it is difficult to traverse the homestead boundaries, the natural streams, and bunds. Access to small holder fields is more problematic. It is easy for a person or animal to cross a stream, pass between two trees or climb a steep bank in order to approach a field. A a machine does not possess this versatility. Obstructions may need to be removed before access can be gained. Perhaps the most difficult access to arrange is where only a footpath leads between other farmers' field to the desired plot. Unless there is organised effort and co-operation among farmers to remove such obstacles and to facilitate access, it is quite natural that they show reluctance to adopt farm machinery.

This is an example where physical and natural parameters have constrained adoption of high level technologies like farm mechanization. Similar view has been expressed by Ashby (1982) saying that a technology should be suitable to a given set of resources. Earlier reports of Farmer (1979) also emphasised that problems of limited diffusion and adoption of high level technologies in the rice front were related to insufficiently resolved difficulties in adapting the new technology to certain natural, geographical and local environments.

With the support of the above discussion, the hypothesis that there would be no relationship between the constraint conveyance inaccessibility to the field and the extent of adoption of improved farm mechanization technology was rejected.

4.3.2.3 Lack of co-operation among farmers

The value of 'r' (-0.1269) indicated that there was significant correlation (at 0.05 level) between the constraint lack of co-operation among the farmers and the extent of adoption of improved farm implements and machinery. The capital cost of the farm implements and machinery presented in Table 4.1.2 revealed that most of the farm equipment, especially power machinery like power tillers, tractors and their accessories, irrigation pumpsets, power sprayers, paddy harvesters, mechanical threshers and winnowers were so costly that it would not to be affordable to the majority of the rice farmers of Kerala for exclusive ownership and use. When custom service facilities are lacking, farmers might not venture to buy and use such machinery. This situation throws light to the need for the facilitation of systems like informal joint ownership, group ownership, co-operative ownership and joint/or group use of the improved farm equipment. This can be achieved only if the farmers join together on a co-operative basis. To make rice farm mechanization technologies meaningful and affordable to the farmers, they have to make sincere efforts to organise themselves and device a viable system of group ownership/or group use (either ownership and use or custom use) of costly farm equipment. In all the NARP regions under study, such systems were found lacking.

In the light of the above discussion the hypothesis that there would be no relationship between the constraint lack of co-operation among farmers and extent of adoption of improved farm mechanization technology was rejected.

4.3.2.4 Lack of knowledge

Extent of adoption of improved farm implements and machinery was found to be significantly correlated with the constraint lack of knowledge of the farmers on improved farm equipment. In this study the term knowledge referred to the level of technical knowledge related to various aspects of improved farm equipment for rice cultivation. The 'r' value (0.1135) was significant at 0.05 level. Level of technical knowledge possessed by a farmer is one of the most important components of adoption behaviour. It has been even considered by many researchers as a forerunner in the sequential adoption process. Level of knowledge on improved farm equipment might have brought about better appreciation of the rice farm mechanization technology, leading them to put it into practice. As postulated by Gaikward *et al.* (1973) as the level of technical knowledge passes a certain threshold the self generated pressure due to incremental knowledge culminates in practice adoption of innovations. Studies of Misra and Sinha (19809) supported this view in that knowledge of the technology is an unavoidable precedent for adoption to take place. Improved knowledge regarding new technologies through the accumulation of information over time has been hypothesized as one of the main dynamic elements of innovation adoption process. In short, a certain critical level of cumulative information and knowledge must be attained before adoption of a high level technology like farm mechanization and hence the result.

All the preceding discussions boil down and conform to the reports of Feder and O'Maara (1982) that provided the innovation is profitable, the accumulation of knowledge and favourable experiences would have eventually induced most farmers to adopt improved farm implements and machinery.

In the light of the above discussion, the hypothesis that there would be no relationship between the constraint lack of knowledge and extent of adoption of improved farm mechanization technology was rejected.

4.3.2.5 Negative attitude

Significant correlation was noticed between the constraint negative attitude of the farmers towards rice farm mechanization and the extent of adoption of improved farm implements and machinery, with a 'r' value of -0.3158. The very definition given by Newcomb (1950) speaks of attitude as a mental state of readiness for motive arousal and an individual's attitude towards something is his predisposition to perform, perceive, think and feel in relation to it. As putforth by Remmers _et al._ (1967) attitude informally is a feeling for and against something. Attitude, a person - centered variable in the 'Person - blame' hypothesis has been postulated by many researchers as a prelude for adoption or in other words, a causal attribute to adoption of innovations. In Kerala most of the farm mechanization technologies are more or less, recent and the attitude of farmers to mechanization may be decisive of the success or failure of the spread of the technology. Researchers have shown that adoption of farm mechanization technologies is not a snap decision but a mental process on individuals/or groups over a period of time. When a farmer gets a feeling that farm mechanization might be able to benefit his farm enterprise, he decides to adopt improved farm implements and machinery. Reports of Ban and Hawkins (1990) provide ample proof to this.

The results of the present study proved that farmers having positive attitude towards farm mechanization would be more enthusiastic and inclined to adopt improved farm equipment in their field.

Based on the above results, the hypothesis that there would be no relationship between the constraint negative attitude and extent of adoption of improved farm mechanization technology was rejected.

4.3.2.6 High capital cost

The constraint high capital cost of improved farm equipment was found to have significant correlation with adoption. The 'r' value was significant at 0.01 level. The proponents of the economic constraint model related to adoption (Aiakens *et al.*, 1975; Havens and Flinn, 1976) argued that economic constraints frequently prevented farmers from adopting technologies. As to the present context, a farmer might have strong desire to adopt improved farm equipment once he or she was made aware of the advantages of adoption but was unable to do so due to economic constraints. This line of reasoning and the results of the present study suggested that a certain segment of farmers who were unable to own and use or custom hire farm implements and machinery would always be at a comparative disadvantage in the diffusion process due to their perception of high capital investment which could not be matched with their 'economic access'. Hooks *et al.* (1985) in their studies on farm mechanization also found the presence of largest correlation to economic constraints factors than the Socio-psychological and personal variables proving that high cost of technology and economic barriers dominated among the access conditions to the adoption of farm implements and machinery. The results of the present study corroborated the preceding reports. Farmers who had perceived high capital cost of the farm equipment and whose access to capital was meagre might not have adopted the farm mechanization technologies regardless of their psychological propensities to do so.

Hence, the hypothesis that there will be no relationship between the constraint high capital cost and extent of adoption of improved farm mechanization technology was rejected.

4.3.2.7 High mechanical complexity

The value of 'r' (-0.4826) indicated that there was significant correlation between the constraint high mechanical complexity of the improved farm equipment and the extent of adoption. The simplicity-complexity continuum is one of the important intrinsic characteristics of the mechanization technology. Any innovation has two components namely the hardware and the software. In the case of farm mechanization the implements and the machinery are the hardware and the techniques for using them in the field are the software. Farmers must perceive prospective adaptation of both the hardware and software aspects of mechanization to make them adopters of the technology. Several studies have shown that significant adaptation of new technology occurs during the adoption process (Eveland et al., 1977; Mc Laughlin, 1978; Larsen and Agarwala - Rogers, 1977; Rice and Rogers, 1980; Dillman et al., 1987). Farmers who perceived high mechanical complexity in the farm mechanization technology were found to have difficulty to adapt to and use improved farm equipment. As reported by Carlson and Dillman (1988) to cope with the mechanical complexity, farmers require mechanical skill. In other words high level technological innovations like farm mechanization require matching complex knowledge or skills on the part of the farmer to put it into practice. The relationship of mechanical skill of the farmer and extent of adoption of farm mechanization technology established by Carlson and Dillman (1988) gives ample proof to this contention.

All the aforesaid discussions agreed with the results of the present study in that the extent of adoption of farm mechanization technology was significantly influenced by farmers' perception of the simplicity-complexity continuum intrinsic to the farm implements and machinery.

Hence, the hypothesis that there would be no relationship between the constraint high mechanical complexity and extent of adoption of improved farm mechanization technology was rejected.

4.3.2.8 Low custom hire facilities

This constraint expressed a significant relationship with adoption. The 'r' value (-0.3856) was significant at 0.01 level. As discussed in section 4.3.1, even in the Central Region despite with the highest FMQ of 42.86, the constraint low custom hire facilities was highly significant. Such a situation conclusively corroborated the importance of the availability of suitable farm implements and machinery on custom hire basis. Most of the improved farm equipment, especially the power machines are so costly that it was not possible for an ordinary rice farmer of Kerala to become exclusive owner-users. Systems like co-operative ownership or informal joint ownership of farm implements and machinery have not gained momentum in Kerala. Barring in certain rare pockets where the group farming approach has been successful, group use of farm equipment has also not been tried. In such a situation, it was not beyond reasoning why the farmers felt that lack of custom hire facilities was an obstacle to adoption.

Three alternative systems of custom hire service arrangements could be thought of : Public custom hire service; Private custom hire service; Private owner-user with custom hire service for extra capacity. At present the Agricultural Engineering wing of the State department of agriculture is quite ill equipped in all the districts to cater to the custom hire needs of the farmers. Though several private custom hire service agencies are functioning in Kerala, they too are unable to meet the pressing needs of the farmers especially during peak periods of rice cultivation operations. Farmers could adopt improved farm equipment only when they were available according to demand and in correct time. Thus the results of the present study indicted that dearth of custom hire agencies was an important constraint to rice farm mechanization. Hence the result of significant correlation established in the study.

In the light of the above discussion the hypothesis that there would be no relationship between the constraint low custom hire facilities and the adoption of improved farm mechanization technology was rejected.

4.3.2.9 Lack of credit facilities

This constraint manifested a significant relationship with adoption of farm mechanization technology. The 'r' value of -0.44078 was significant at 0.01 level. This result has thrown light on the fact that even if some farmers may be inclined to adopt improved farm equipment, that is, psychologically predisposed to accept innovations quickly, but be unable to act because of situational constraints. Lack of access to credit was found to be an important situational constraint which made it impossible for majority of the rice farmers of Kerala to adopt high level, capital intensive technologies like farm mechanization. Similar findings have been reported by the Kerala State Planning Board (1976), Rajendran (1978), Sharma and Nair (1975), Nair (1979), Nair (1983) and Prakash (1989). To own and use farm equipment, long term credit in large amount, and to custom hire, timely short term credit are required by the farmers. The farmers might have felt that the present setup available in Kerala to facilitate farm credit was insufficient and difficult to make them enable to go for farm mechanization. It was also found that the available credit facilities were for highly selective purposes and most confining to the purchase of power tillers, tractors, pumpsets and sprayers. It was not available for most of the other implements. Moreover, most of the farm equipment, especially power machines like power tillers, tractors, harvesters, threshers etc. being costly, most of the farmers by virtue of their small land holding and low economic assets often were unable to qualify for long term credit. Still another thought-provoking situation existed in most of the study area that the resource-poor farmers were not only unable to capitalize on the benefits of farm mechanization but were also placed at a further competitive distance by those who could. Hence the results of the study.

With the support of the above discussion, the hypothesis that there would be no relationship between the constraint lack of credit facilities and the extent of adoption of improved farm mechanization technology was rejected.

4.3.2.10 Low level of entrepreneurship

Low level of entrepreneurship as a constraint was found to be significantly correlated with adoption of farm implements and machinery. The 'r' value of -0.1210 was significant at0.05 level. Entrepreneurs by and large, havc been proved to be people with a high drive and high activity level, constantly struggling to achieve something which they could call as their own accomplishment, and the perception of economic opportunity, technical skills, managerial competency and motivation to achieve results. Entrepreneurship can be conceived as an innovative action. Apparently, this is like adoption of a new idea or a new practice. High level and capital intensive technologies like farm mechanization have been reported to be adopted more by farmers with high level of entrepreneurship than those who lack it. Rao and Mehta (1978) have listed 57 personality characteristics of entrepreneurs. Thus entrepreneurship is a package of personality characteristics of entrepreneurs. The characteristics conventionally associated with entrepreneurship - leadership, innovativeness, risk bearing and the like are not only associated to each other but also in unison are essential features of adoption of innovations and effective farm business. These might be the reasons why significant correlation between the constraint under study with adoption existed. This finding is in agreement with the observations of Pareek and Nadkarni (1978), Rao and Mehta (1978) and De D (1981).

In the light of the above discussion, the hypothesis that there would be no relationship between the constraint low level of entrepreneurship and extent of adoption of improved farm mechanization technology was rejected.

4.3.3. Adoption prediction models for rice farm mechanization in different NAARP regions—the results of Step-wise Regression analysis.

4.3.3.1 Northern Region

The results of the step-wise regression analysis employed for working out the adoption prediction model for rice farm mechanization in the Northern Region are presented in Table 4.3.3 and Table 4.3.4.

It is evident from the data presented in Table 4.3.3 that negative attitude of farmers towards farm mechanization (X10) was the most important constraint in explaining the variation in adoption as 36.17 per cent of the variation could be explained by this single constraint. The predictive power of the regression equation increased with each additional step. The second constraint to enter the equation was conveyance inaccessibility (X6) with an individual contribution of 14.15 per cent to the percentage variation explained. Thus the predictive power of the regression equation increased with each additional step. With the entry of the constraint, unevenness of the field

Table 4.3.3. Step-wise Regression Analysis of adoption constraints to rice farm mechanization in the Nortern Region

(n = 64)

Step Number	Constraints included in the Regression analysis	F ratio	% variation explained	Step-wise increase in % variation
1	X_{10}	35.17	36.17	
2	X_{10}, X_6	30.90	50.32	14.15
3	X_{10}, X_6, X_5	32.84	62.15	11.83
4	X_{10}, X_6, X_5, X_{16}	28.06	65.54	3.39
5	$X_{10}, X_6, X_5, X_{16}, X_3$	26.11	69.24	3.70

Table 4.3.4 Test of significance of Regression Coefficients (Northern Region)

(n = 64)

Constraint No.	Name of the constraint	Regression Coefficient (b)	S.E. of b	't' value
X_3	Unevenness	-9.700434	3.737098	2.5957*
X_{16}	High mechanical complexity	-0.295498	0.1121482	2.6349*
X_5	Low cropping intensity	-5.008073	1.337681	3.7438**
X_6	Conveyance inaccessibility	-0.059656	1.398498	0.0427
X_{10}	Negative attitude	-0.325357	4.596136	0.0708

* Significant at 5% level.

** Significant at 1% level.

(X3) in the fifth step, the step-wise process terminated as none of the regression coefficients associated with the succeeding constraints was found significant in the analysis. Step number 5 comprising of five constraints explained the maximum variation in adoption (69.24%) with a significant F value of 26.11 indicating that the predictive power was the highest at this step.

Though the regression equation with all the five constraints included was significant in prediction as indicated by the high F value, only coefficients of certain constraints were found significant by their 't' values. Data presented in Table 4.3.4 emitted the finding that except 'conveyance inaccessibility' and 'negative attitude', all other constraints were individually significant in prediction.

Thus the regression equation given below is significant in predicting the adoption behaviour with respect to rice farm mechanization of farmers of Northern Region.

$$Y = 46.266 - 9.700^{*} X_3 - 0.295^{*} X_{16} - 5.008^{**} X_5$$

From Table 4.3.3 it is evident that 69 per cent of the variation in adoption in the Northern Region was explained by X10, X6, X5, X16 and X3. All the regression coefficients except for X6 and X10 were found to be significant. The partial regression coefficients in the above equation indicated that a unit increase in the constraint low cropping intensity would result in a decrease of 5.008 units of adoption quotient (EMQ) *ceteris paribus*. With a unit increase in mechanical complexity of the farm implements and machinery 0.295 unit decrease in adoption would be effected, and with a unit increase in the constraint unevenness of fields a decrease of 9.700 unit reduction in adoption of rice farm mechanization would be effected *ceteris paribus*.

4.3.3.2 Central Region

The results of the Step-wise Regression analysis used for working out the adoption prediction model for rice farm mechanization in the Central Region are presented in Table 4.3.5 and Table 4.3.6.

A glance at the data furnished in Table 4.3.5 revealed that 'low custom hire facilities' (X17) was the most important constraint by virtue of its ability to explain 50.18 per cent variation in adoption. Each additional step contributed to increase the predictive power of the regression equation. The second constraint that could enter the step-wise process was 'low cropping intensity' (X5) with a contribution of 26.3 per cent to the percentage variation explained. The predictive power of the

Table 4.3.5 Step-wise Regression Analysis of adoption constraints to rice farm mechanization in the Central Region

(n = 64)

Step No.	Constraints included in the Regression analysis	F ratio	% variation explained	Step-wise increase in % variation
1	X_{17},	62.44	50.18	
2	X_{17}, X_5	99.20	76.48	26.30
3	X_{17}, X_5, X_{10}	119.38	85.65	9.17
4	X_{17}, X_5, X_{10}, X_{23}	99.22	87.01	1.36
5	X_{17}, X_5, X_{10}, X_{23}, X_7	87.30	88.27	1.26
6	X_{17}, X_5, X_{10}, X_{23}, X_7, X_{12}	78.06	89.15	0.88
7	X_{17}, X_5, X_{10}, X_{23}, X_7, X_{12}, X_8	68.81	89.59	0.44
8	X_{17}, X_5, X_{10}, X_{23}, X_7, X_{12}, X_8, X_9	64.79	90.41	0.82
9	X_{17}, X_5, X_{10}, X_{23}, X_7, X_{12}, X_8, X_9, X_{13}	59.36	90.82	0.41
10	X_{17}, X_5, X_{10}, X_{23}, X_7, X_{12}, X_8, X_9, X_{13}, X_{14}	55.76	91.32	0.50

Table 4.3.6 Test of significance of Research Coefficients (Central Region)

(n = 64)

Constraint No.	Name of the constraint	Regression coefficient (b)	S.E. of b	't' value
X_{14}	Non availability of spares	2.610855	1.524112	1.7130
X_{13}	Non availability of suitable farm implements and machinery	-0.449867	0.235285	1.9120
X_9	Lack of knowledge	-0.930776	0.374516	2.4853*
X_8	Lack of awareness	1.665844	0.612678	2.7189**
X_{12}	High cost of operation	-0.237396	0.232615	1.0206
X_7	Lack of Co-operation among farmers	-3.716595	1.249853	2.9736**
X_{23}	Low level of entrepreneurship	-0.151533	0.101459	1.4935
X_{10}	Negative attitude	-0.488478	0.161305	3.0283**
X_5	Low cropping intensity	-0.233475	1.891087	0.1235
X_{17}	Low custom hire facilities	-0.338168	0.166523	-2.9242**

* Significant at 5% level.
** Significant at 1% level.

equation reached a maximum at step number 10. The tenth step with a significant F value (55.76) could explain 91.32per cent of the variation in adoption.

Despite the regression equation being significant with all the 10 constraints included, only the coefficient of constraints namely, lack of knowledge (X9), lack of awareness (X8), lack of co-operation among farmers (X7), negative attitude (X10) and low custom hire facilities (X17) were significant as indicated by their 't' values as seen in Table 4.3.6.

Thus the following form of step-wise regression equation is capable of predicting the adoption behaviour of rice farmers with respect to rice farm mechanization in the Central Region.

$$\hat{Y} = 108.409 - 0.931^{*} X_{9} + 1.666^{**} X_{8} - 3.717^{**} X_{7} - 0.489^{**} X_{10} - 0.338^{**} X_{17}$$

From table4.3.5 it is evident that about 91 per cent of the variation in adoption in Central Region was explained by X17, X5, X10, X23, X7, X12, X8, X9, X13, and X14. Out of the 10 regression coefficients only that of X17, X10, X7, X8 and X9 were found significant. The partial regression coefficients indicated that unit increase in the constraints lack of knowledge and lack of awareness would result in unit decreases of 0.931 and 1.666 respectively in adoption, *ceteris paribus*. Unit increase in the constraint lack of co-operation among farmers would decrease the adoption by 3.717 units. Unit increase in the constraints negative attitude and low custom hire facilities would decrease the extent of adoption of rice farm mechanization by 0.489 and 0.338 units respectively *ceteris paribus*.

4.3.3.3 Southern Region

Table 4.3.7 and Table 4.3.8 contains the results of the stepwise regression analysis used for working out the adoption prediction model for rice farm mechanization in the southern region.

A perusal of the results furnished in Table 4.3.7 indicated that negative attitude of farmers towards farm mechanization (X10) was the first and most important constraint to enter the step-wise Regression process explaining 44.38 per cent of the variation in adoption behaviour. Each additional step contributed to increase the predictive power of the regression equation. The second constraint low cropping intensity (X5), when entered the equation could add 14.76 per cent variation. The predictive power sequentially increased with the joining of each constraint as shown in Table 4.3.7, thus reaching a maximum at step number 11. Thus the 11 constraints jointly

Table 4.3.7 Step-wise Regression Analysis of adoption constraints to rice farm mechanization in the Southern Region

(n = 64)

Step No.	Constraints included in the regression analysis	F ratio	% variation explained	Step-wise increase in % variation
1	X_{10}	49.48	44.38	
2	X_{10}, X_5	44.15	59.14	14.76
3	X_{10}, X_5, X_6	43.74	68.62	9.48
4	X_{10}, X_5, X_6, X_{18}	38.70	72.40	3.78
5	$X_{10}, X_5, X_6, X_{18}, X_{14}$	37.27	76.26	3.86
6	$X_{10}, X_5, X_6, X_{18}, X_{14}, X_{11}$	36.89	79.52	2.94
7	$X_{10}, X_5, X_6, X_{18}, X_{14}, X_{11}, X_4$	36.06	81.84	2.32
8	$X_{10}, X_5, X_6, X_{18}, X_{14}, X_{11}, X_4, X_1$	38.55	82.82	0.98
9	$X_{10}, X_5, X_6, X_{18}, X_{14}, X_{11}, X_4, X_1, X_{17}$	34.67	83.45	0.63
10	$X_{10}, X_5, X_6, X_{18}, X_{14}, X_{11}, X_4, X_1, X_{17}, X_{13}$	31.81	84.13	0.68
11	$X_{10}, X_5, X_6, X_{18}, X_{14}, X_{11}, X_4, X_1, X_{17}, X_{13}, X_7$	30.53	84.65	0.52

Table 4.3.8 Test of significance of Regression Coefficients (Southern Region)

(n = 64)

Constraint No.	Name of constraint	Regression coefficient (b)	S.E. of b	't' value
X_7	Lack of co-operation among farmers	-8.734128	5.85170	1.4926
X_{13}	Non availability of suitable farm implements and machinery	-0.235636	0.152521	1.5450
X_{17}	Low custom hire facilities	-1.013148	1.138825	0.8896
X_1	Small farm size	-0.6647320	0.818542	0.8121
X_4	Conversion of paddy lands	-0.113137	4.738029	0.0239
X_{11}	High Capital Cost	-0.404642	0.168268	2.4047**
X_{14}	Non availability of spares	2.020729	0.488845	4.1336**
X_{18}	Lack of credit facilities	-2.49188	0.483903	5.1495**
X_6	Conveyance inaccessibility	-7.359183	1.526961	4.8195**
X_5	Low cropping intensity	-8.656734	1.398229	6.1912**
X_{10}	Negative attitude	-0.353709	0.130587	2.7086**

* Significant at 5% level.
** Significant at 1% level.

explained 84.65 per cent variation in adoption, with a significant F value of 30.53 indicating that the regression equation was significant in prediction.

Only six out of the 11 constraints included in the equation were found significant by the 't' values of the regression coefficients (Table 4.3.8): high capital cost (X11), non availability of spares (X14), lack of credit facilities (X 18), conveyance inaccessibility (X6), low cropping intensity (X5), and negative attitude (X10).

The regression equation below is significant in predicting the adoption behaviour of farmers of Southern Region with respect to rice farm mechanization.

$$\hat{Y} = 68.502 - 0.405^{*} X_{11} + 2.021^{**} X_{14} - 2.492^{**} X_{18} - 7.359^{**} X_{6}$$

$$- 8.657^{**} X_{5} - 0.354^{**} X_{10}$$

The partial regression coefficients indicated that unit increase in the constraint high capital cost would result in 0.405 unit decrease in extent of adoption, while unit increase in the constraint non availability of spares would decrease the adoption by 2.021 units. Unit increase in the constraints namely, lack of credit facilities and conveyance inaccessibility would decrease the extent of adoption by 2.492 and 7.359 units respectively. Unit increase in the two constraints-cropping intensity and negative attitude towards rice farm mechanization would decrease the extent of adoption by 8.657 and 0.354 units respectively <u>ceteris paribus</u>.

4.3.3.4 Highrange Region

The results of the step-wise regression analysis employed for working out the adoption prediction model for rice farm mechanization in the Highrange Region are furnished in Table 4.3.9 and Table 4.3.10.

It is evident from the data presented in Table 4.3.9 that 'negative attitude towards improved farm implements and machinery' (X_{10}) was the first constraint in explaining the variation in adoption as 38.12 per cent of the variation could be explained by this single constraint. With the entry of each constraint in the regression equation the predictive power increased. When the second constraint conveyance inaccessibility (X_6) entered the equation the percentage variation increased by 20.50 per cent as is evident from Table 4.3.9. The predictive power attained a maximum of 75.80 at step number 6, when the constraint non availability of suitable farm implements and machinery (X_{13}) entered the regression equation. The high F ratio (29.75) at this last step was significant indicating that these six steps jointly could explain 75.80 per cent of the variation in adoption behaviour.

Table 4.3.9 Step-wise Regression Analysis of Constraints to rice farm mechanization in the High Range Region

Step No.	Constraints included in the Step-wise Regression analysis	F ratio	% variation explained	Step-wise increase in % variation
1	X_{10}	38.20	38.12	
2	X_{10}, X_6	43.21	58.62	20.5
3	X_{10}, X_6, X_5	38.69	65.92	7.3
4	X_{10}, X_6, X_5, X_7	36.87	71.42	5.5
5	$X_{10}, X_6, X_5, X_7, X_{17}$	32.65	73.48	2.06
6	$X_{10}, X_6, X_5, X_7, X_{17}, X_{13}$	29.75	75.80	2.32

Table 4.3.10 Test of significance of Regression Coefficients (Highrange Regi

(n = 64)

Constraint No.	Name of constraint	Regression coefficient (b)	S.E. of b	't' value
X_{13}	Non availability of implements/ Machinery	-0.762877	0.356953	-2.1372*
X_{17}	Low custom hire facilities	-0.391284	0.170655	-2.2928*
X_7	Lack of Co-operation among farmers	-2.391494	0.808498	-2.9579**
X_5	Low cropping intensity	-6.805383	0.017349	-3.9226**
X_6	Conveyance inaccessibility	-6.425246	1.487232	-4.3203**
X_{10}	Negative attitude	-0.186067	5.108308	-0.0364

* Significant at 5% level.

** Significant at 1% level.

Despite the regression equation with all the six steps was significant in prediction, coefficient of the constraint negative attitude (X_{10}) was not significant by its 't' value (Table 4.3.10). Thus, the regression coefficients of the constraints namely, non availability of suitable farm implements and machinery (X_{13}), low custom hire facilities (X_{17}), lack of co-operation among farmers (X_7), low cropping intensity (X_5), and conveyance inaccessibility (X_6) were significant as indicated by their 't' values.

Thus the following form of step-wise regression equation is capable of predicting the adoption behaviour of rice farmers of Highrange Region with respect to rice farm mechanization.

$$\hat{Y} = \text{[illegible]} - 0.763^{*} X_{13} - 0.391^{*} X_{17} - 2.391^{**} X_{7}$$
$$6.805^{**} X_{5} - 6.425^{**} X_{6}$$

From table 4.3.9 it is evident that about 76 per cent of the variation in extent of adoption of rice farm mechanization in the Highrange Region was explained by X_{10} X_6, X_5, X_7, X_{17}.

All the regression coefficients except that of X_{10} were found to be significant. The partial regression coefficients indicated that a unit increase in the constraints namely, non availability of suitable farm implements and machinery and low custom hire facilities would decrease the extent of adoption by 0.763 and 0.3912 units respectively <u>ceteris paribus</u>. Unit increase in the constraints namely, lack of co-operation among farmers, low cropping intensity and conveyance inaccessibility would effect decreases in the extent of adoption of rice farm mechanization in the Highrange Region to the tune of 2.391, 6.805 and 6.425 units respectively <u>ceteris paribus</u>.

4.3.3.5 Problem Region

Table 4.3.11 and Table 4.3.12 contain the results of the step-wise regression analysis used for working out the adoption prediction model for rice farm mechanization in the Problem Region.

As indicated in Table 4.3.11, negative attitude towards the use of improved farm implements and machinery (X_{10}) was the most important constraint to explain the highest variation in adoption behaviour (32.15%). When a new constraint, lack of credit facilities (X_{18}) entered the equation, explanation in the percentage variation increased by 19.64 per cent. Thus, as in the case of the NARP regions mentioned earlier, here also each additional constraint by

Table 4.3.11 Step-wise Regression Analysis of Constraints to rice farm mechanization in the Problem Region

(n = 64)

Step No.	Constraints included in the step-wise Regression analysis	F ratio	% variation explained	Step-wise increase in % variation
1	X_{10}	29.38	32.15	
2	X_{10}, X_{18}	32.76	51.79	19.64
3	X_{10}, X_{18}, X_5	77.06	79.39	27.60
4	X_{10}, X_{18}, X_5, X_1	95.59	86.63	7.24
5	$X_{10}, X_{18}, X_5, X_1, X_{22}$	98.45	89.46	2.83
6	$X_{10}, X_{18}, X_5, X_1, X_{22}, X_{15}$	92.34	90.67	1.21
7	$X_{10}, X_{18}, X_5, X_1, X_{22}, X_{15}, X_3$	85.00	91.40	0.73
8	$X_{10}, X_{18}, X_5, X_1, X_{22}, X_{15}, X_3, X_{12}$	78.96	91.99	0.59
9	$X_{10}, X_{18}, X_5, X_1, X_{22}, X_{15}, X_3, X_{12}, X_8$	71.78	92.29	0.30
10	$X_{10}, X_{18}, X_5, X_1, X_{22}, X_{15}, X_3, X_{12}, X_8, X_{23}$	66.02	92.57	0.28
11	$X_{10}, X_{18}, X_5, X_1, X_{22}, X_{15}, X_3, X_{12}, X_8, X_{23}, X_4$	61.49	92.86	0.29

Table 4.3.12 Test of significance of Regression Coefficients (Problem Region

Constraint No.	Name of constraint	Regression coefficient (b)	S.E. of b	't' value
X_4	Conversion of paddy lands	-5.549155	3.883993	-1.4287
X_{23}	Low level of entrepreneurship	-0.108681	6.073562	-0.0180
X_8	Lack of awareness	-0.181934	0.223297	-0.8148
X_{12}	High cost of operation	-0.314065	0.196399	-1.5991
X_3	Unevenness of field	-0.122424	7.576015	-0.0162
X_{15}	Inadequate service and repair facilities	-1.580214	0.384602	-4.1087**
X_{22}	Opposition from farm labourers	-0.247517	0.101360	-2.4420*
X_1	Small farm size	-0.476487	9.482617	-0.0502
X_5	Low Cropping intensity	-0.146556	1.046727	-0.1400
X_{18}	Lack of credit facilities	-0.148015	0.011253	-13.1532**
X_{10}	Negative attitude	-0.251807	8.953923	-0.0281

* Significant at 5% level.
** Significant at 1% level.

virtue of its entry in the equation contributed to increase the percentage variation step by step to reach a maximum of 92.86 per cent at Step number 11. The significant F ratio of 61.49 proved that the 11^{th} step could explain maximum percentage variation.

Even though there were 11 regression coefficients, only that of three constraints namely, inadequate repair and service facilities (X_{15}), opposition from farm labourers (X_{22}) and lack of credit facilities (X_{18}) were significant as indicated by the 't' values presented in Table 4.3.12.

The following form of step-wise regression equation is significant in predicting the adoption behaviour of rice farmers of the Problem Region with respect to rice farm mechanization.

$$\hat{Y} = 80.659 - 1.580^{**} X_{15} - 0.248^{*} X_{22} - 0.148^{**} X_{18}$$

The data presented in table 4.3.11 indicated that as high as 93 per cent of the variation in the extent of adoption of rice farm mechanization in the Problem Region was explained by the 11 constraints – X_{10}, X_{18}, X_5, X_1, X_{22}, X_{15}, X_3, X_{12}, X_8, X_{23} and X_{24}. A perusal of Table 4.3.12 indicated that out of the above 11 constraints only three ,viz. inadequate repair and service facilities were found to be significant. The partial regression coefficients indicated that a unit increase in the constraint inadequate repair and service facilities would decrease the extent of adoption by 1.580 units, while unit decreases in the constraints viz.opposition from farm labourers and lack of credit facilities would effect reduction in adoption to the tune of 0.248 and 0.148 units respectively *ceteris paribus*.

4.3.4 Adoption prediction model for rice farm mechanization in Kerala - Results of the step-wise Regression analysis of the pooled sample

Step-wise regression analysis was done with the pooled sample comprising of 320 respondents belonging to the five NARP regions for working out the adoption prediction model for rice farm mechanization in Kerala State as a whole. The results are presented in Table 4.3.13 and 4.3.14.

As shown in Table 4.3.13 the step-wise regression process contained 10 steps when the pooled data of the 320 farmers was analysed. The first and most important constraint to enter the regression equation was negative attitude towards farm mechanization (X_{10}), followed by low cropping intensity (X_5). The first step could explain 29.05 per cent variation in adoption behaviour. Sequential entry of each constraint ultimately reached a maximum of 74.48 per cent when the constraint cheap labour availability entered the regression equation in the 10^{10} step. The significant F

Table 4.3.13 Step-wise Regression Analysis of constraints to rice farm mechanization in the pooled sample of five NARP regions

(N = 320)

Step No.	Constraints included in the step-wise Regression analysis	F ratio	% variation explained	Step-wise increase in % variation
1	X_{10}	130.17	29.05	
2	X_{10}, X_5	171.18	51.92	22.87
3	X_{10}, X_5, X_6	231.49	68.73	16.81
4	X_{10}, X_5, X_6, X_1	187.62	70.44	1.71
5	$X_{10}, X_5, X_6, X_1, X_3$	161.16	71.96	1.52
6	$X_{10}, X_5, X_6, X_1, X_3, X_{17}$	138.76	72.68	0.72
7	$X_{10}, X_5, X_6, X_1, X_3, X_{17}, X_{23}$	122.70	73.35	0.67
8	$X_{10}, X_5, X_6, X_1, X_3, X_{17}, X_{23}, X_2$	110.26	73.93	0.58
9	$X_{10}, X_5, X_6, X_1, X_3, X_{17}, X_{23}, X_2, X_4$	99.25	74.24	0.31
10	$X_{10}, X_5, X_6, X_1, X_3, X_{17}, X_{23}, X_2, X_4, X_{21}$	90.19	74.48	0.24

Table 4.3.14 Test of significance of Regression Coefficients (Pooled sample)

Constraint No.	Name of constraint	Regression coefficient (b)	S.E. of b	't' value
X_{21}	Cheap labour availability	-0.574594	0.334373	-1.7184
X_4	Conversion of paddy lands	-6.757836	3.310453	-2.0414*
X_2	Fragmentation	-1.681981	0.673426	-2.4976*
X_{23}	Low level of entrepreneurship	-0.1393028	4.074410	-0.0342
X_{17}	Low custom hire facilities	-1.823020	0.689555	-2.6438*
X_3	Unevenness	-0.055567	2.100651	-0.0264
X_1	Small farm size	-0.563374	0.153259	-3.6760**
X_6	Conveyance inaccessibility	-0.126306	1.166764	-0.1083
X_5	Low cropping intensit	-0.154355	0.448974	-0.0163
X_{10}	Negative attitude	-0.404555	0.082039	-4.9313**

* Significant at 5% level.
** Significant at 1% level.

ratio (90.19) corroborated that step-wise regression equation with all the 10 steps included was significant in explaining the percentage variation in adoption behaviour to the tune of 74.48 per cent.

A critical examination of the 't' values presented in Table 4.3.14 indicated that out of the 10 regression coefficients, coefficients of only five constraints were individually significant in prediction.

Thus the following form of step-wise regression equation is capable of predicting the adoption behaviour of rice farmers of Kerala with respect to rice farm mechanization.

$$\hat{Y} = 71.945 - 6.158^{*} X_{4} - 1.682^{*} X_{2} - 1.823^{*} X_{17} - 0.563^{**} X_{1} - 0.405^{**} X_{10}$$

As evidenced by the data in Table 4.3.13 nearly 75 per cent of the variation in the extent of adoption of farm implements and machinery by the pooled sample of rice farmers of Kerala was explained by the 10 constraints viz. X_{21}, X_{4}, X_{2}, X_{23}, X_{7}, X_{3}, X_{1}, X_{6}, X_{5} and X_{10}.

A glance at the Table 4.3.14 established that out of the 10 constraints, only five were significant. They were : conversion of paddy lands, fragmentation of holdings, low custom hire facilities, small farm size and negative attitude. As evidenced by the partial regression coefficients, unit increases in the constraints namely, conversion of paddy lands, fragmentation of holdings and low custom hire facilities would effect decreases in the extent of adoption of rice farm mechanization technology to the tune of 6.158, 1.682 and 1.823 units respectively ceteris paribus. Decreasing effects of unit increases in the constraints small farm size and negative attitude towards rice farm mechanization on extent of adoption would be in the order of 0.563 and 0.405 units respectively _ceteris paribus_.

4.4 Result tests with the three packages of farm implements and machinery : low mechanization package (LMP), medium mechanization package (MMP), and high mechanization package (HMP)

Effect of the LMP, MMP and HMP on labour input, yield, cost of cultivation, net returns, and benefit-cost ratio - Results of the Analysis of Variance

4.4.1.1 Labour input (Table 4.4.1.1 and Fig. 4.4)

The HMP required the lowest quantity of human labour input (108 d/ha) as against that for the MMP (127 d/ha), and for the LMP (136 d/ha).

Table 4.4.1.1 Labour input as affected by level of mechanization

Sl. No.	Mechanization Package[a]	Labour input (man d/ha)[b]	Computed F
1	LMP	136.44	
2	MMP	127.22	177.34**
3	HMP	107.88	

Cv = 2.65%

LSD (0.05) = 3.19

** Significant at 0.01 level

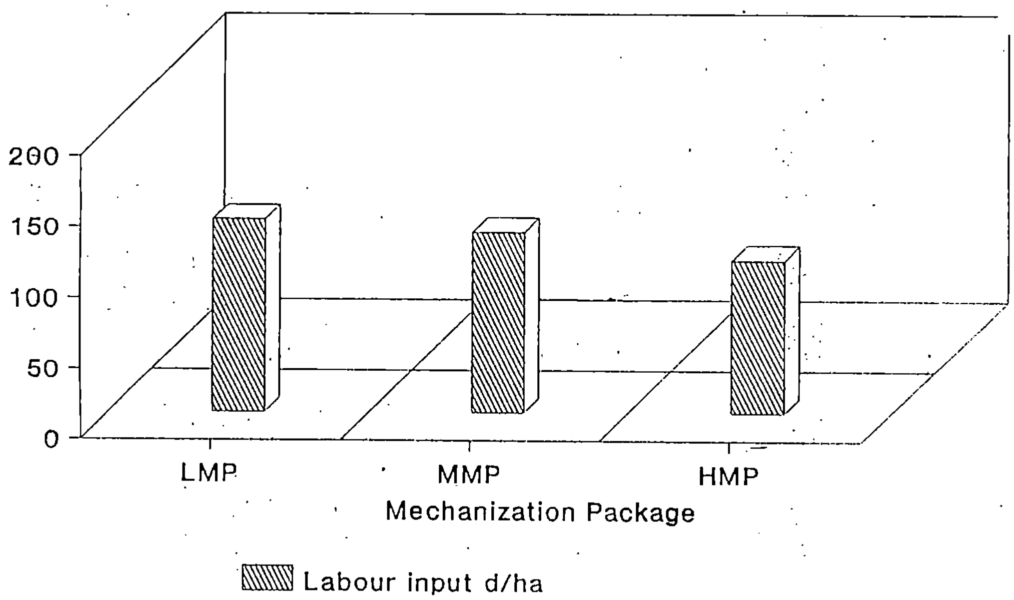
[a] LMP = Low mechanization package

MMP = Medium mechanization package

HMP = High mechanization package

[b] Man days per hectare

Fig.4.4 Labour input for rice cultivation by level of mechanization package in result test plots



LMP = Low mechanization package MMP = Medium mechanization package
HMP = High mechanization package

When compared to the LMP, there was a reduction in labour input to the tune of about 9 d/ha (7.35 per cent) and 28 d/ha (26.47 per cent) for the MMP and the HMP respectively. The MMP used about 19 man days (18 per cent) more than that of the HMP to raise one hectare of rice crop.

The computed F ratio proved that the differences in labour input amongst the three packages were highly significant. As indicated by the LSD value each package differed significantly from the other in terms of labour use for rice cultivation.

The foregoing results revealed that as the level of mechanization increased, the total quantity of human labour input required to perform a unit piece of work decreased. The significant differences among the three packages with respect to labour input (Table 4.4.1.1) could be discussed with the support of the data on work capacity and the resultant saving in time as presented in section 4.1 of this thesis. All the conventional implements/or methods listed in the LMP had the lowest work capacity when compared to that of MMP and HMP. The improved implements and machinery in the MMP and HMP by virtue of their higher work capacity might have warranted lesser time for field and post harvest operations thereby requiring lesser number of labour days when compared to the LMP. This differential trend is quite an encouraging one to the farmers as the costliest single input in rice cultivation is the labour wages. Similar findings have been reported by Motilal (1971), Saefudin et al. (1983), Maamum (1983) and Nandal (1988).

In the light of the above discussion the hypothesis that the three mechanization packages would be on par with respect to labour input was summarily rejected indicating significantly differential labour requirement.

4.4.1.2 Yield (Table 4.4.1.2)

The MMP achieved the highest per hectare yield of 3.23t, followed by the HMP (3.23 t). Cultivation with the LMP registered the lowest yield of 3.15 t/ha. As is evident from the non significant F ratio, the yield per hectare did not differ significantly in the plots employing different packages of farm implements and machinery.

It is interesting to find from Table 4.4.1.2 that the level of mechanization had no significant influence on yield of rice. Though studies of Aguilar et al. (1963), Saefudin et al. (1983), Bansal and Jain (1986), Patil (1986) and Bhan (1987) have reported yield increase due to mechanization or observed higher yields in mechanised farms, they have concluded that the increase in yield was not directly due to mechanization. The reason might be the fact that farm equipment is usually only one of many exceedingly

Table 4.4.1.2 Yield of rice as affected by level of mechanization

Sl. No.	Mechanization package [a]	Grain yield (t/ha)	Computed F
1	LMP	3.15	
2	MMP	3.23	2.29^{NS}
3	HMP	3.22	

Cv = 8.03%

LSD (0.05) = NS

NS. Not significant

[a] LMP = Low mechanization package

MMP = Medium mechanization package

HMP = High mechanization package

complex interacting inputs within a cropping system. Thus any increase in yield reported might more likely be associated with the timely farm operations facilitated by the improved farm implements and machinery, and adoption of improved technologies like use of good seeds, application of fertilizers, weedicides, plant protection chemicals, scientific water management and reduction in crop loss (both on and off the field).

The foregoing discussion narrows down to the opinion of Giles (1975) that one cannot always validate a claim that the use of an implement or machine in the production, harvesting and processing of field crops is a lone contributor to a demonstrated yield increase. Hence the hypothesis that the three mechanization packages would be on par with respect to per hectare yield of rice is accepted.

4.4.1.3. Cost of cultivation (Table 4.4.1.3 and Fig.4.5)

Rice cultivation with the HMP required the lowest per hectare cost of Rs.6,568/-. The HMP required Rs.7,004/- to raise one hectare of rice crop. Cost of cultivation employing the LMP was the highest (Rs.7,390/ha).

As depicted in Fig. 4.5 when compared to the LMP, there was a reduction in cost of cultivation to tune of Rs.386/ha (5.51 per cent), and Rs.822/ha (12.51 per cent) for the MMP and HMP respectively. Usage of the HMP had a

Sl. No.	Mechanization package[a]	Cost of cultivation (Rs/ha)	Computed F
1	LMP	7,390	
2	MMP	7,004	67.34**
3	HMP	6,568	

Cv = 2.6%

LSD (0.05) = 114.41

** Significant at 0.01 level

[a]LMP = Low mechanization package

MMP = Medium mechanization package

HMP = High mechanization package

Table 4.4.1.3 Cost of cultivation of rice as affected by level of mechanization

Sl. No.	Mechanization package[a]	Cost of cultivation (Rs/ha)	Computed F
1	LMP	,390	
2	MMP	,004	67.34**
3	HMP	[illegible],568	

Cv = 2.6%

LSD (0.05) = 114.41

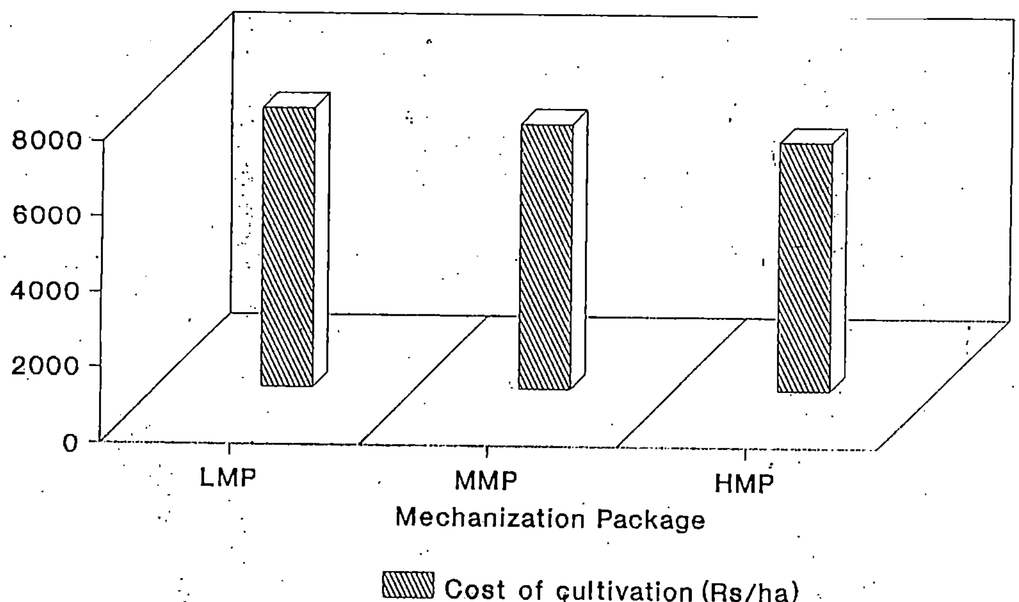
** Significant at 0.01 level

[a]LMP = Low mechanization package

MMP = Medium mechanization package

HMP : High mechanization package

Fig.4.5 Cost of cultivation of rice by level of mechanization package in result test plots



LMP = Low mechanization package MMP = Medium mechanization package
HMP = High mechanization package

cost advantage of Rs.436/ha (6.64 per cent) over the MMP.

The computed F ratio suggested that the differences in the per hectare cost of cultivation existing amongst the three packages were highly significant. As indicated by the LSD value, each of the three packages differed significantly from the other in terms of cost of cultivation of rice crop.

It is encouraging to find that the more the level of mechanization package, lesser was the per hectare cost of cultivation of rice. The saving in cost of cultivation due to the mechanization package could be discussed in the light of the data presented in sections 4.1 and 4.4.1.1 of this thesis where it has been stated that the MMP and HMP had significant advantages like lesser labour input, saving in time, higher work capacity and the like over the LMP. It could be seen from Table 4.4.1.1 there was a reduction in labour input in the order of 9 d/ha and 28 d/ha for the MMP and HMP respectively when compared to the LMP. If such a saving in labour days are translated to monetary terms at the present wage rates, there was a saving of Rs.360/- and Rs.1,120/- for the MMP and HMP respectively. Apart from the saving in cost of labour the increased work capacity and the resultant saving in time might be the other reasons for the effect of mechanization package on cost of cultivation. Studies of Bansal and Jain (1986),Rao (1986), Gupta and Ram

(1989), *Sinha et al.* (1989) and *Sivaswamy et al.* (1990) lend support to the above finding.

With the support of the above discussion the hypothesis that the three mechanization packages would be on par with respect to cost of cultivation of rice was rejected.

4.4.1.4 Net returns (Table 4.4.1.4 and Fig. 4.6)

The net returns (margin between gross revenue and total cost) obtained was the highest in plots employing the HMP (Rs.4,662/ha). The net returns obtained from the MMP plots was Rs.4,305/ha., and that from the LMP plots was Rs.3,264/ha.

A perusal of Table 4.4.1.4 revealed that the per hectare net returns of the MMP and the HMP were higher by Rs.1,041/- (31.9 per cent) and Rs.1,398/- (42.83 per cent) respectively than that of the LMP. The HMP had a per hectare net returns advantage of Rs.357/- (8.29 per cent) over the MMP.

The computed F ratio presented in Table 4.4.1 proved that the differences in net returns obtained by employing the three packages were significant at 0.05 level. As indicated by the LSD value, each package differed significantly from the other in terms of net returns from rice cultivation.

Table 4.4.1.4 Net returns from rice production as affected bylevel of mechanization

Sl. No.	Mechanization Package[a]	Net returns (Rs/ha)[b]	Computed F
1	LMP	3,264	
2	MMP	4,305	3.58*
3	HMP	4,662	

Cv = 16.13%

LSD (0.05) = 338.50

*Significant at 0.05 level

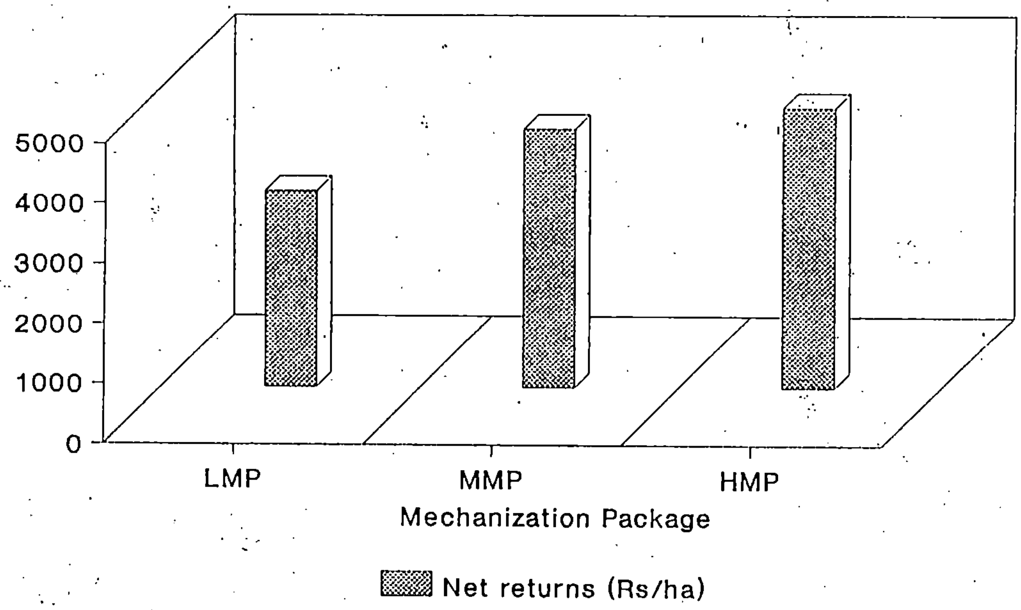
[a]LMP = Low machanization package

MMP = Medium mechanization package

HMP = High mechanization package

[b]Net returns = Cross returns - Cost of cultivation

Fig.4.6 Net returns from rice cultivation by level of mechanization package in result test plots



LMP - Low mechanization package MMP - Medium mechanization package
HMP - High mechanization package

The results revealed that as the level of mechanization increased, the net returns obtained from each hectare of rice crop raised also increased. The significant differences among the three packages with respect to net returns could be discussed in the light of the data on labour input (Table4.4.1.1) and cost of cultivation (Table 4.4.1.3). All the improved implements and machinery in the MMP and HMP required lesser quantity of labour input when compared to the LMP. The MMP and HMP required 7.35 per cent and 26.47 per cent lesser labour days respectively than the LMP on per hectare basis. As discussed in section 4.4.1.3, there was a saving of labour wages to the tune of Rs.360/- and Rs.1,120/- for the MMP and HMP respectively. Similarly, regarding per hectare cost of cultivation, as the level of mechanization increased, the cost of cultivation decreased (Table 4.4.1.3). When compared to the LMP, there was a reduction in cost of cultivation in the order of Rs.[illegible]/ha (5.51per cent) and Rs.822/ha (12.51 per cent) for the MMP and HMP respectively. Naturally, the reductions in labour input and cost of cultivation might have jointly resulted in getting high net returns per hectare when the MMP and HMP were employed for rice cultivation and post harvest operations. Studies of Bansal and Jain (1986) and Sinha <u>et al.</u> (1989) lend support to this finding.

Hence, the hypothesis that the three mechanization packages would be on par with respect to net returns per hectare was rejected.

4.4.1.5. Benefit-cost ratio (Table 4.4.1.5 and Fig.4.7)

Rice cultivation with the HMP resulted in getting the highest benefit-cost ratio (B:C) of 1.72 followed by the MMP (1.62). Cultivation with the MMP could claim a B:C of 1.49.

Results of the Analysis of Variance proved that the three packages differed significantly with respect to the B:C. Further, the LSD value at 0.01 level of probability suggested that each one of the three packages significantly differed from the other in terms of their B:C. Both the MMP and HMP were able to give benefit-cost ratios which were significantly higher than that of the LMP.

As evidenced by Table 4.4.1.2 and Table 4.4.1.3 the MMP and HMP could claim advantages over the LMP with respect to labour input and cost of cultivation. These might have influenced the result that higher the level of mechanization, hire would be the benefit-cost ratio enjoyed by the crop-implement system.

Hence the hypothesis that the three mechanization packages would be on par with respect to benefit-cost ratio would be on par was rejected.

Table 4.4.1.5 Benefit - Cost ratio of rice production as affected by level of mechanization

Sl. No.	Mechanization Package[a]	B:C[b]	Computed F
1	LMP	1.49	
2	MMP	1.62	4.60**
3	HMP	1.72	

Cv = 8.33%

LSD (0.04) = 0.05

**Significant at 0.01 level

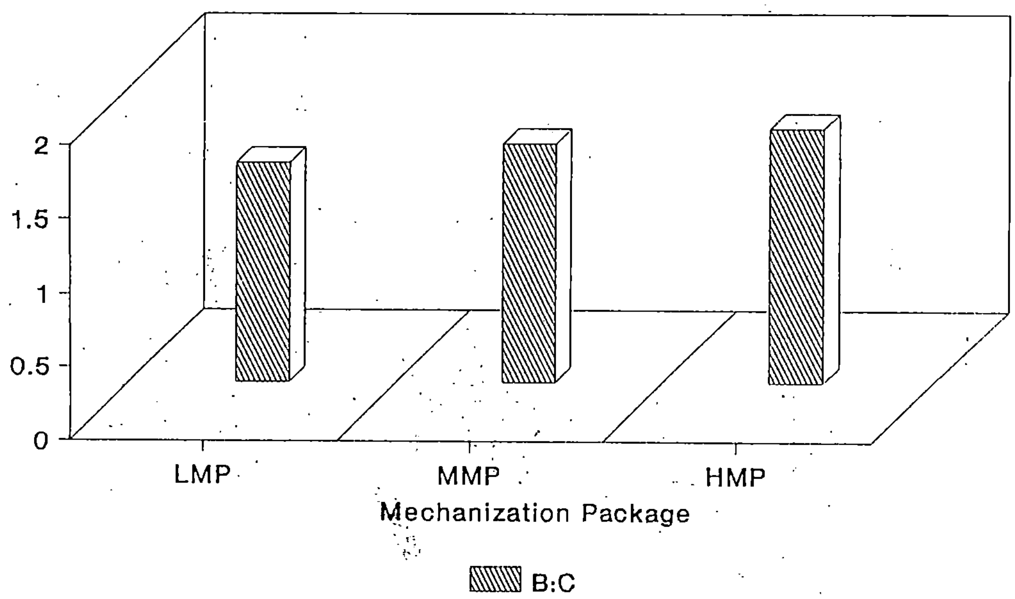
[a]LMP = Low mehanization package

MMP = Medium mechanization package

HMP = High mechanization package

[b]B:C = Present value of gross benefits/present value of gross costs

Fig.4.7 Benefit-cost ratio from rice cultivation by level of mechanization package in result test plots



LMP = Low mechanization package MMP = Medium mechanization package
HMP = High mechanization package

4.4.2 Selective perception of farm mechanization attributes related to the three packages of farm implements and machinery (Table 4.4.2.1 and Table 4.4.2.2)

The nine farmers who participated in the result tests were asked to give their perception on the five attributes viz. 'scope for use', 'simplicity in use', 'quality of work done', 'time saving in use', and 'cost reduction in use' of each implement/machine included under the three packages- LMP, MMP and HMP.

Results of the inter-package comparative perception and the rank position of each attribute amongst the three packages are furnished in Table 4.4.2.1.

• The mean scores and inter-package rank positions revealed that to the MMP, the farmers assigned first ranks to the attributes 'scope for use' and 'quality of work done', and second ranks to the remaining attributes viz. 'simplicity in use' 'time saving in use', and 'cost reduction in use'. The HMP obtained first ranks for two attributes – 'time saving in use', and 'cost reduction in use', second rank for 'scope for use', and third ranks for 'simplicity in use' and 'quality of work done'. The LMP could fetch only one first rank by virtue of the attribute 'simplicity in use', one second rank for 'quality of work done', whereas it was pushed back to the third rank position

Table 4.4.2.1 Comparative perception of farm mechanization attributes about the low, medium, and high packages of farm implements and machinery

Sl. No.	Attributes	Mechanization packages					
		L M P		M M P		H M P	
		Mean Score	Inter package rank	Mean Score	Inter package rank	Mean Score	Inter package rank
1	Scope for use	3.07	3	4.28	1	3.80	2
2	Simplicity in use	4.10	1	3.65	2	2.28	3
3	Quality of work done	3.74	2	3.76	1	3.33	3
4	Time saving in use	2.33	3	3.54	2	4.47	1
5	Cost reduction in use	2.78	3	3.15	2	3.65	1

LMP = Low mechanization package

MMP = Medium mechanization package

HMP = High mechanization package

with respect to 'scope for use', 'time saving in use', and cost reduction in use'.

To test whether the three packages differed significantly from each other in terms of the cumulative perception scores assigned to them, the 't' test of significance (for small samples) was employed forming all possible pairs with the three mechanization packages. Thus comparisons could be made between LMP-MMP, MMP-HMP and LMP-HMP. The comparison of the pairs are presented in Table 4.4.2.2.

All the three pairs under comparison differed significantly from each other with respect to all the five attributes as perceived by the participating farmers. Barring the attributes - 'quality of work done' in the LMP-MMP comparison, and 'time saving in use', and 'cost reduction in use' in the MMP-HMP comparison, 't' values of all the pair comparisons were significant at 0.01 level of probability. This indicated that all the attributes under study had a very high selective bearing on the level of mechanization package.

The forthcoming paragraphs discuss the results on the selective perception of farm mechanization attributes emitted from the study.

Table 4.4.2.2 Test of significance of differential perception of farm mechanization attributes

Sl. No.	Attributes	Computed 't' values			Table values of 't'	
		LMP vs MMP	MMP vs HMP	LMP vs HMP	0.05	0.01
1	Scope for use	4.159**	4.005**	2.859**		
2	Simplicity in use	3.380**	3.423**	3.317**		
3	Quality of work done	2.439*	2.989**	2.657**	1.746	2.583
4	Time saving in use	2.811**	1.982*	3.329**		
5	Cost reduction in use	2.172**	1.767*	2.848**		

* Significant at 0.05 level.

* Significant at 0.01 level.

LMP = Low mechanization package.
MMP = Medium mechanization package.
HMP = High mechanization package.

4.4.2.1 Scope for use

As is evident from Table 4.4.2.1 the farmers perceived high scope for use on the MMP. This might be due to the fact that the implements/machinery contained in the MMP were of middle level with respect to capital cost and mechanical complexity when compared to those in the HMP. When compared to the LMP, the MMP was more time saving and drudgery alleviating. The farmers of Kerala have experienced the difficulty to get sufficient hired labour for rice cultivation especially during peak periods of operations like land preparation, sowing/transplanting, harvesting and threshing. Moreover now-a-days farmers are reluctant to maintain work animals due to high cost of maintenance and also that the animals have to be kept idle during off seasons. These might have prompted the farmers to assign first rank to the MMP when they perceived the attribute 'scope for use

In the light of the [illegible]ssion the hypothesis that the three mechanization packages would be on par with respect to the [illegible] the attribute 'scope for use' by the farmers was rejected

4.4.2.2 Simplicity in use

The LMP was assigned first rank and HMP third rank with respect to this attribute by the farmers. It is quite natural that higher the level of mechanization, higher will the level of complexity. For example, when compared to the country plough or Bose plough the power tiller or tractor are complicated machinery. Similar is the case of all implements/machinery in the HMP. The results presented in Table 4.4.2.1 corroborated that MMP was more complicated than the LMP and the HMP the most complicated among the three packages. None of the implements/methods used in the LMP, as expected, were complicated. They did not use any extra power than the human or animal power. Moreover farmers due to their long experience with the conventional implements and methods could perceive simplicity easily on the LMP. Since they lacked exposure to the implements and machinery included in the MMP and HMP, it was quite natural that farmers assigned first rank and third rank for the LMP and HMP respectively with regard to the attribute 'simplicity in use'.

With the support of the above discussion the hypothesis that the three mechanization package would be on par with respect to the perception of the attribute 'simplicity in use' by the farmers was rejected.

4.4.2.3 Quality of work done

It is encouraging to find from the data in Table 4.4.2.1 that the MMP secured first rank with respect to the attribute 'quality of work done'. Incidentally the HMP could secure only third rank in this regard. This differentiation could be discussed in the light of the qualitative performance of the individual implements/ machinery included in the MMP. For example, when compared to the country plough in the LMP and the straight tilling blade of power tiller and tractor cultivator included in the HMP, the Bose plough used in the MMP showed superiority in the quality of work.Its curved shoe inverted the soil like a mould board plough. Similarly the helical geometry in the case of helical blade puddler facilitated better churning and slicing than the puddling implements used in the LMP and HMP. It is quite natural that the pumpset, power sprayer, improved sickle, motorised mini thresher and blower for winnowing were not only efficient and drudgery alleviating, but also superior in work quality. These might be the reasons which prompted the farmers to assign first rank to the HMP with regard to the attribute 'quality of work done'.

In the light of the above discussion the hypothesis that the three mechanization packages would be on par with respect to the perception of the attribute 'quality of work done' by the farmers was rejected.

4.4.2.4 Time saving in use

The farmers assigned first rank to the HMP with regard to the attribute 'time saving in use'. All the implements/machinery included in the HMP had high work capacity (section 4.1). So it is quite natural that farmers ould see and experience how fast was each operation done by he HMP. High work capacity of an equipment facilitates the completion of operations with lesser time. Hence the result obtained in the present study.

With the support of the above discussion the hypothesis that the three mechanization packages would be on par with respect to the perception of the attribute 'time saving in use' by the farmers was rejected.

4.4.2.5 Cost reduction in use

It is encouraging to find from Table 4.4.2.1 that the HMP was assigned first rank by the farmers in their perception of the attribute 'cost reduction in use'. As discussed in section 4.4.1.3 and as seen in Table 4.4.1.1 and 4.4.1.3, the HMP by virtue of its highest work capacity required the least labour input and time to complete a unit piece of operation, thus resulting in the least cost of operation. The farmers while observing various field operations might have rightly perceived this. Hence the result obtained in the present study.

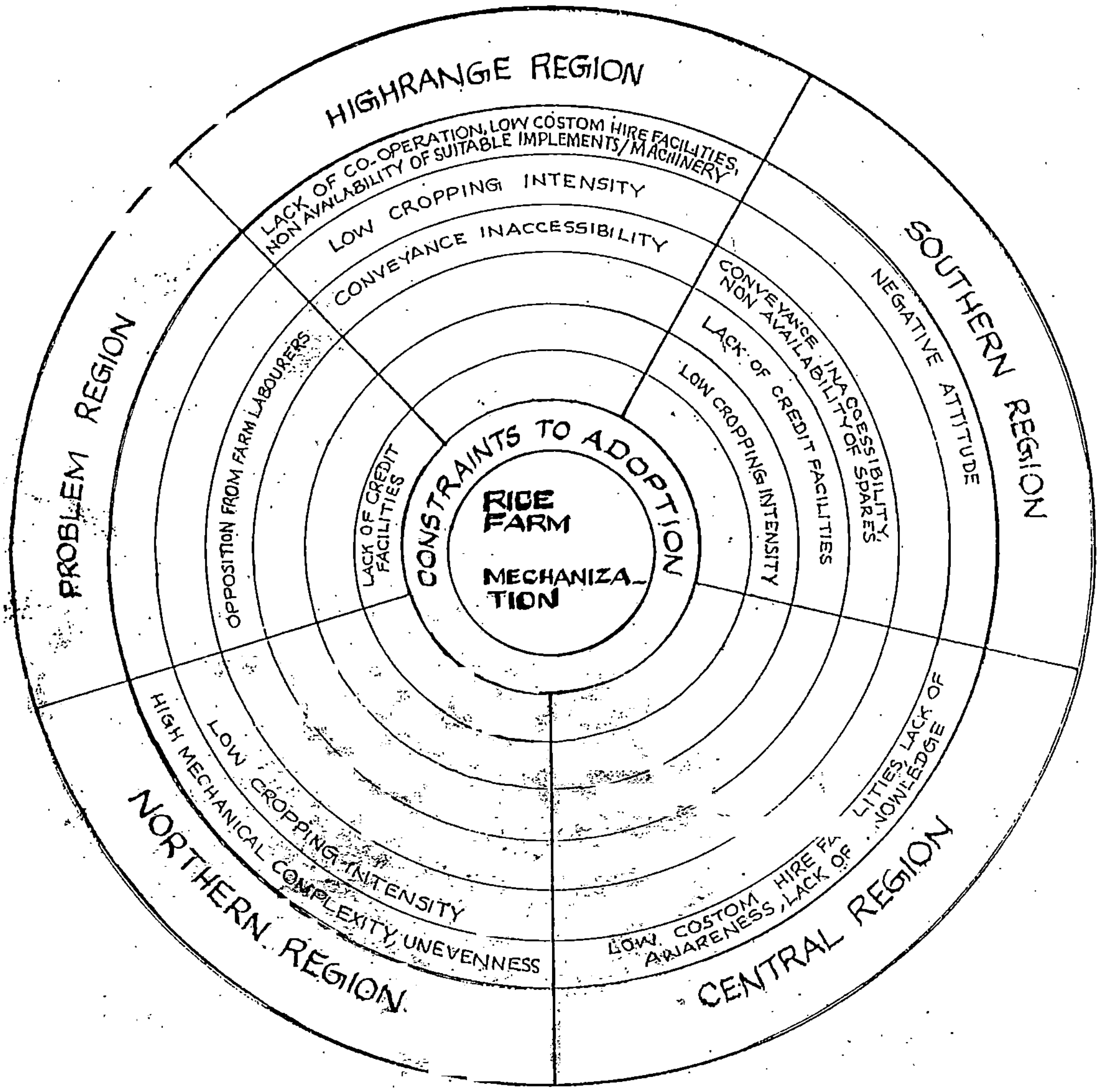
Therefore, the hypothesis that the three mechanization packages would be on par with respect to the perception of the attribute 'cost reduction in use' by the farmers was rejected.

4.5 Empirical model for predicting adoption behaviour of farmers with respect to rice farm mechanization

In the light of the results emerged from the step-wise regression analysis of constraints to adoption of rice farm mechanization technology, the empirical model suggested is shown in Fig.4.1.

As seen in the figure, the model is given in a circular form. The central portion of the circle depicts the main theme of the model viz. constraints to the adoption of rice farm mechanization technology in Kerala. The constraints capable of predicting the adoption behaviour of farmers are located in concentric rings around the central portion. Closeness of the rings to the central portion indicates higher level of significance of the partial regression coefficients in the step-wise regression equation. As depicted in the circle shaped model there are five sectors for this circular model, each sector representing one NARP region. Within each sector, the constraint having the highest partial regression coefficient in the step-wise regression equation is located closest to the central circle. The NARP regions are identified in the circle by five arrows pointing towards the central portion indicating that within each NARP region the closer a constraint is located near the central circle, the higher is its contribution in influencing the adoption behaviour. Similarly farther a constraint is located from the central

Fig. 4. 8 EMPIRICAL MODEL FOR PREDICTING ADOPTION BEHAVIOUR OF FARMERS WITH RESPECT TO RICE FARM MECHANIZATION



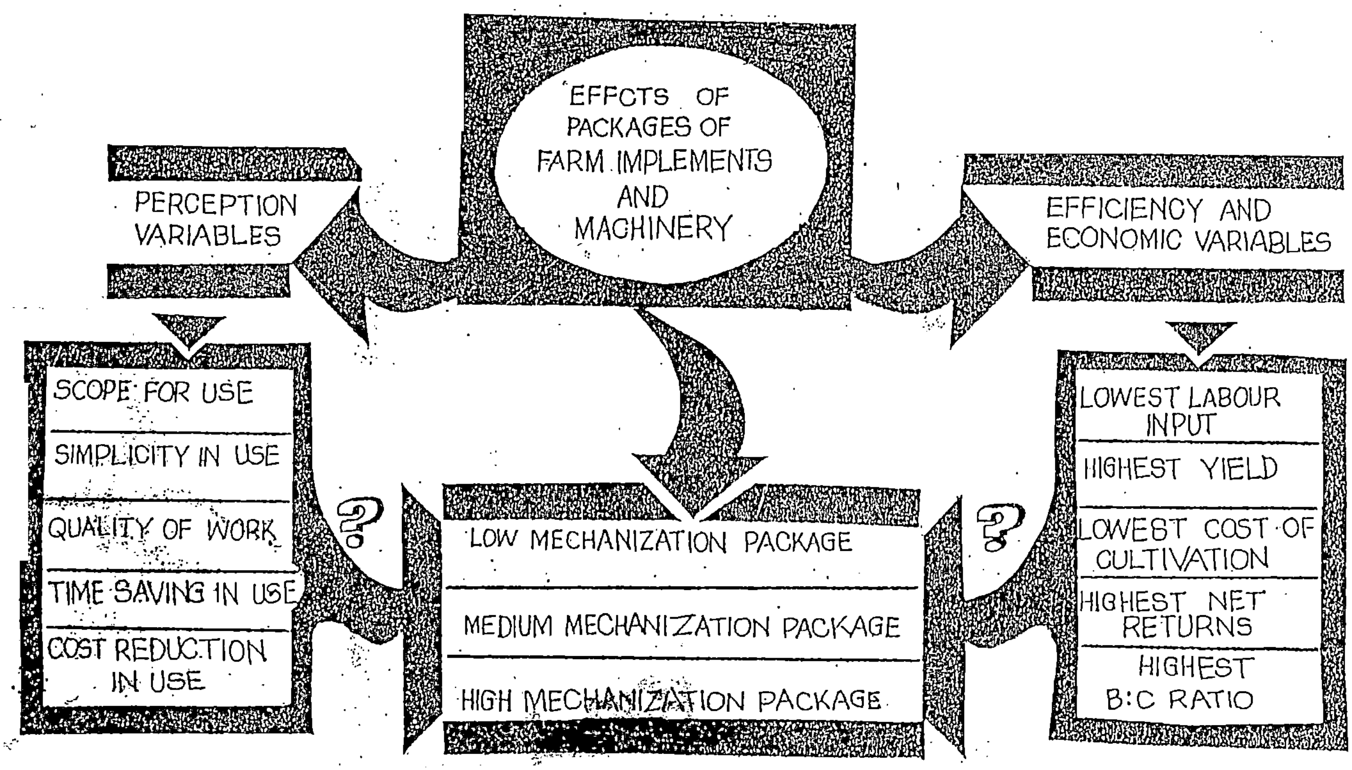
circle, lesser is its contribution in influencing the extent of adoption of farm implements and machinery.

The first ring contains the constraint lack of credit facilities (Problem Region) indicating its importance as a highly significant constraint to adoption of rice farm mechanization technology. The second ring contains the constraint low cropping intensity (Southern Region). The third ring contains 'lack of credit facilities' (Southern Region). The fourth ring contains 'conveyance inaccessibility' and 'non availability of spares' (Southern Region), 'conveyance inaccessibility' (Highrange Region) and 'opposition from farm labourers' (Problem Region). The fifth ring contains 'low cropping intensity' (Highrange Region and Northern Region). The sixth ring, which is the outermost, contains 'negative attitude'(Southern Region), 'lack of co-operation among farmers', 'low custom hire facilities', 'non availability of suitable farm implements and machinery' (Highrange Region), 'high mechanical complexity' and 'unevenness' (Northern Region) and 'low custom hire facilities', 'lack of awareness' and 'lack of knowledge' (Central Region).

4.6 Empirical model of result tests with selected packages of farm implements and machinery

The model showing the effect of the three packages of farm implements and machinery, viz. LMP, MMP and HMP is shown in Fig. 4.2.

Fig. 2.3 CONCEPTUAL MODEL OF RESULT TESTS WITH SELECTED PACKAGES OF FARM IMPLEMENTS AND MACHINERY



The arrows pointed towards the 'packages' indicate the first choice in farmers' perception of the attribute from where the arrows start. Thus the farmers perceived 'high scope for use' and 'quality of work done' on the MMP. The LMP is shown to have the assignment of the attribute 'simplicity in use' by the farmers. Farmers perceived the attribute time saving in use and cost reduction in use on the HMP.

Regarding the efficiency and economic variables, four arrows are pointed towards the HMP, indicating that rice cultivation with the HMP resulted in having the lowest quantity of labour input, the lowest cost of cultivation, the highest net returns and the highest benefit - cost ratio. The dotted arrows represent non significant effects indicating that though cultivation with the MMP recorded the highest per hectare yield, the effect is not significant. The model suggests that from the angle of view of efficiency and economic aspects related to rice farm mechanization, the HMP has the distinct advantages over the LMP and MMP.

SUMMARY

5. SUMMARY

Labour is the costliest single input in rice cultivation contributing to about 60 per cent of the total cost of production. The seasonal nature of the crop does not permit to utilise the hired labour force continuously and effectively all through the year consequent to which labour scarcity especially during peak periods of rice farm operations has been a major problem in the rice front of Kerala. For carrying out the timely and season bound operations and more over to bring down the cost of labour, cost of cultivation, to reduce drudgery and to increase labour use efficiency, improved farm implements and machinery are of great value.

Systematic comprehensive research works on the assessment of current status of use, extent of adoption, constraints to the adoption of farm implements and machinery and their field application have not been done so far in Kerala. For conducting such a study a detailed survey was undertaken in the five NARP regions of Kerala. To measure the extent of adoption of rice farm mechanization and to identify the intensity of constraints to adoption new measuring tools were developed and applied. Result tests using selected packages of farm implements and machinery were also conducted to identify the worth of the improved farm implements and machinery in the socio-economic context of the state.

The specific objectives of the study were:

1. To conduct a survey of the farm implements and machinery used by the rice farmers of Kerala and to collect basic information on their functions, specifications, costs, availability and custom-service details.

2. To study the extent of adoption of improved farm implements and machinery by rice farmers of Kerala.

3. To identify the constraints to the use of farm implements and machinery as perceived by the rice farmers of Kerala.

4. To conduct result demonstrations with the selected fa implements and machinery for rice cultivation.

The study was conducted as a phased programme in two stages. The first three objectives listed above were accomplished by Stage I. The fourth objective related to the conduct of result tests in farmers' fields was achieved by Stage II.

For undertaking stage I of the study, a five stage sampling design was adopted with NARP regions of Kerala as the first stage units, Krishibhavans (Panchayat level agricultural officers) as the third stage units, padasekharams (group of paddy fields in a village) as the fourth stage units and rice farmers as the fifth stage units. The first four stage units were selected based on the criteria of highest net cropped area under rice and highest production of rice recorded during the year 1989-'90. From each NARP region 64 rice farmers were selected.

Thus the total sample size of the study for Stage I was 320. As Stage II of the study, result tests were conducted in farmers' fields with three selected packages of farm implements and machinery, viz. 'Low Mechanization Package' (LMP), 'Medium Mechanization Package'(MMP) and 'High Mechanization Package' (HMP). Nine farmers from nine locations of the Central Region were purposively selected to participate in the result tests.

A survey on the farm implements and machinery used by the rice farmers of Kerala to study the details like salient features, present status of use, costs, availability, custom service details and field application was conducted. To study the extent of adoption of farm implements and machinery, a Farm Mechanization Quotient

(FMQ) was developed and applied in the study. Twenty four constraints to adoption of improved farm implements and machinery were selected for the study through review of literature followed by pilot study and judges' relevancy rating. Out of the 24 constraints four were measured by adopting the methods developed by others and 20 were measured by using the methods developed for the study.

The data for the Stage I of the study were collected from the respondents by using interview schedule. The data on result tests (Stage II) were directly measured by the researcher by taking observations in the field and by interviewing the participating farmers with the help of a structured schedule.

The collected data were analysed using appropriate statistical techniques including percentage analysis, simple linear correlation analysis, step-wise regression analysis, analysis of variance and paired t-test.

The salient findings of the study are as follows:

1. Among the animal drawn ploughs, barring the Southern Region, the country plough had the highest percentage of respondents as owner-users and custom-hirers. The Bose plough was more popular in the Southern Region. Bose plough by virtue of its high work capacity and quality of work and the lowest operational cost was found to be an efficient

animal drawn plough, followed by the improved country plough.

2. The use of animal drawn puddlers was confined to the Central Region. The helical blade puddler due to its high work capacity, quality of puddling and suitability to all types of soils, was found to be an efficient puddler for all regions.

3. The country wet land leveller now under common use in Kerala was found to be inferior in all respects to the modified wet land leveller as it could cover about three fold area with just half the operational cost of country leveller.

4. As to the power tiller and various implements operated by it, the Problem Region had distinctly higher percentage of owner-users and custom-hirers. The straight tilling blade of power tiller now popular in Kerala had the limitations of shallow tilling and poor soil inversion. The two way plough of power tiller has not gained popularity in the State. But it has got potentiality as an efficient plough by virtue of its deep ploughing and better soil inversion. Puddling and levelling operations done by wet land pudding wheels and wet land leveller of power tiller were found to be distinctly faster and economic when compared to animal drawn implements.

5. Tractor ploughing has gained popularity in all the regions except the Highrange Region. The Central Region had the highest percentage of users of tractor and its implements like cultivator, cage wheel, paddy puddler, rotavator, and wet land leveller. Ploughing with cultivator was fast and economic. Similarly puddling and levelling operations done with cage wheel and leveller were also very quick and less expensive. Tractor drawn rotavator and paddy puddler though highly efficient, due to their high capital cost and very recent introduction have not become popular among the rice farmers.

6. The Problem Region had the highest percentage of owner-users of all the three conventional water lifting devices, namely counterpoise lift, water wheel and swing basket. Their use was very low in all the other NARP regions. The conventional water lifting devices had the limitations of low work capacity, inability to lift water from deep sources and drudgery in operation. Axial flow pumps, locally known as petti and para were found confined to the Problem Region alone. The Central Region had the highest percentage of owner users and custom hirers of kerosene pumpsets/ diesel engine pumpsets and the highest percentage of owner users of electric motor pumpsets. Electric motor pumpsets were more popular than kerosene pumpsets and diesel engine pumpsets in all the regions.

7. Among the three plant protection equipment, hand compression sprayers followed by knapsack sprayers were common in all the regions. Power sprayers were also only selectively owned and used and custom hired. The Problem Region had the highest percentage of owner-users and custom-hirers of knapsack sprayers whereas the Central Region had the highest percentage of owner users and custom hirers of hand compression sprayer and power sprayer. Spraying done with power sprayer was fast and economic. Due to the high capital cost of power sprayer, it would be appropriate to use it on a joint basis or group basis.

8. Preponderant majority of farmers of all regions used the indigenous country sickle for harvesting paddy. There were only negligible and isolated use of improved sickles. The mechanically operated paddy harvester (self propelled vertical conveyor reaper) had also negligible number of users. The use of country sickle was not only time consuming but also the cost of harvesting per hectare was formidably high. The improved sickle, though efficient was not found used by farmers due to lack of experience, the peculiar shape and weight of the sickle. The vertical conveyor reaper windrower though could complete the harvesting in quick time and with less cost, it had the limitations of high capital cost, its difficultly to harvest lodged crops and poor maneuverability in deep and muddy

fields. The potentiality of the reaper can be exploited in areas having non lodging, short and medium statured varieties and in fields which are not too muddy for the easy movement of the machine.

9. In general, mechanical threshing of rice has not gained momentum in Kerala. The Central Region had the highest number of owner-users and custom-hirers of mechanical threshers. The pedal thresher despite having time and cost advantages over conventional threshing, had the limitations of poor work capacity and drudgery in operation. The motorised mini thresher was found to be a prospectful machine especially for small scale operations due to its high work capacity, low capital cost, less cost of operation and portable nature. Among the two big type mechanical threshers used for large scale operations, the rasp-bar type was found distinctly better than the peg tooth type. It would be appropriate to use mechanical threshers on a joint basis or group basis.

10. The mechanical winnowers viz. the motorised simple winnowing fan and big type motorised paddy winnowers were found to be selectively used, that too, by a very few percentage of farmers of the Central Region and Problem Region. The motorised simple winnowing fan had three fold work capacity and one-third cost of operation when compared to the conventional method of winnowing. The big type

motorised paddy winnower had five to six fold work capacity and less than one third cost of operation as against that of conventional winnowing. Both the two types of mechanical winnowers had the advantage of drudgery alleviation. For small scale winnowing, farmers can own and use the motorised simple winnowing fan. For large scale operations the big type motorised paddy winnower can be used as joint/group owner-users or joint/group custom-hirers.

11. With a view to study the extent of adoption of farm implements and machinery, a formula was developed to compute farm mechanization quotient (FMQ). Weightage scores were assigned to 32 types of improved farm implements and machinery following a step-by-step systematic procedure under both situations of use namely, 'owner-user' and 'custom-hirer'

The results are summarised hereunder:

11.1 As to the extent of adoption of rice farm mechanization, the Central Region occupied the first position followed by the Problem Region. The Highrange Region had the lowest FMQ.

11.2 In general the extent of adoption of rice farm mechanization was low in Kerala. Central Region had distinctly higher percentage of respondents belonging to the 'medium' and 'medium to high' categories of adopters followed by Problem Region. Preponderant majority of respondents of Highrange Region belonged to the lowest class of FMQ indicating the lowest status of the region with respect to rice farm mechanization.

11.3 None of the NARP regions could come under the 'high category' class with respect to rice farm mechanization.

11.4 The differences among the five NARP regions with respect to rice farm mechanization were significant.

12. With a view to study the constraints to rice farm mechanization, the intensity of adoption constraints, relationship of the identified constraints to rice farm mechanization, and adoption prediction models (for each NARP region and for the State as a whole) were worked out in this study.

The results are summarised below:

12.1 Intensity of adoption constraints to rice farm mechanization as present in the NARP regions:

12.1.1 Among the five regions the Highrange Region was studded with multifarious constraints with high level of intensity. The constraints were: unevenness of fields, conveyance inaccessibility, lack of awareness, lack of knowledge, negative attitude, high capital cost, high cost of operation, non availability of suitable farm implements and machinery, plentiful availability of labour, cheap labour availability, low level of entrepreneurship and low use of information sources.

12.1.2 The Southern Region was characterised by high levels of intensity of constraints namely, fragmentation, non availability of spares and low profitability of rice cultivation.

12.1.3 In the Northern Region, the constraints namely, small farm size, low cropping intensity and inadequate repair and service facilities prevailed as most intensely felt constraints.

12.1.4 In the Problem Region the intensity of constraints namely, high mechanical complexity, lack of credit facilities and opposition from farm labourers was the highest when compared to the other regions.

12.1.5 When compared to the other regions, the intensity of constraints present in the Central Region was low. The lone constraint having the highest intensity noticed was low custom hire facilities.

12.1.6 The Highrange Region had a high cumulative constraint score of 513.8. The scores for the other regions were distinctly lesser: Northern Region (446.54); Southern Region (426.43); Central Region (388.677); Problem Region (360.53).

12.2 Intensity of adoption constraints as perceived by the farmers:

12.2.1 Out of the 24 constraints studied, the Highrange Region had the highest percentage of farmers perceiving 11 constraints: unevenness, low cropping intensity, conveyance inaccessibility, high capital cost, high cost of operation, non availability of suitable farm implements and machinery, non availability of spares, inadequate repair and service facilities, low custom hire facilities, plentiful availability of labour and cheap labour availability.

12.2.2 The specific constraints to rice farm mechanization perceived by the farmers of the Southern Region were: fragmentation, lack of co-operation among farmers, non availability of spares and low profitability of rice cultivation.

12.2.3 A high proportion of farmers of the Northern Region perceived 'small farm size' as a major constraint.

12.2.4 Considerable proportion of farmers of the Problem Region perceived the constraints namely, lack of credit facilities and opposition from farm labourers as the most intensely felt ones.

12.2.5 When compared to the other regions, the intensity of constraints perceived by the farmers of the Central Region was low. The lone constraint having the highest intensity experienced by them was low custom hire facilities.

12.3 Relationship of the constraints with the extent of adoption of improved farm implements and machinery (Pooled sample of 320 respondents).

Simple linear correlation analysis was employed to establish the relationship of the 24 constraints with the extent of adoption. The pooled 'r' values indicated that 10 constraints under study established significant negative correlation with adoption. They were: Small farm size, conveyance inaccessibility to the field, lack of co-operation among farmers, lack of knowledge, negative attitude, high capital cost, high mechanical complexity, low custom hire facilities, lack of credit facilities and low level of entrepreneurship.

12.4 The 24 constraints when subjected to step-wise regression analysis emitted the following results as summarised below:

12.4.1 In the Northern Region, the constraints namely, low cropping intensity, high mechanical complexity of farm implements and machinery and unevenness of fields were found to be individually significant in predicting the adoption of rice farm mechanization.

12.4.2 'Lack of knowledge on farm implements and machinery', 'lack of awareness of farm implements and machinery', 'negative attitude towards rice farm mechanization', and 'low custom hire facilities' were the constraints found to be individually significant in predicting the adoption behaviour of farmers in the Central Region.

12.4.3 In the Southern Region, the constraints namely, high capital cost of farm implements and machinery, non availability of spares, lack of credit facilities, conveyance inaccessibility, low cropping intensity and negative attitude towards rice farm mechanization were found to be individually significant in predicting the adoption of farm implements and machinery.

12.4.4 'Non availability of suitable farm implements and machinery', 'low custom hire facilities', lack of co-operation among farmers', 'low cropping intensity' and conveyance inaccessibility' were found to be individually significant in predicting the adoption of rice farm mechanization in the Highrange Region.

12.4.5 In the Problem Region the constraints found to be individually significant in predicting the extent of adoption were inadequate repair and service facilities, opposition from farm labourers and lack of credit facilities.

12.4.6 When the pooled sample of 320 respondents of the study was step-wise regressed, 10 constraints were found to explain nearly 75 per cent of the variation in the extent of adoption. The partial regression coefficients on testing for their significance revealed that the best prediction equation was with five constraints namely, conversion of paddy lands, fragmentation of holdings, low custom hire facilities, small farm size and negative attitude towards rice farm mechanization.

13. In Stage II of the study, result tests were conducted in nine locations of the Central Region with three packages of farm implements and machinery namely, 'low mechanization packages' (LMP), 'medium mechanization package' (MMP, and 'high mechanization package' (HMP).

Effect of these packages on labour input, yield, cost of cultivation, net returns and benefit-cost ratio were found out by the ANOVA technique. Selective perception of the respondents on the attributes viz. scope for use, simplicity in use, quality of work done, time saving in use, and cost reduction in use were also measured.

The results are summarised as follows:-

13.1 The HMP required the lowest quantity of human labour input followed by MMP. It was the highest for the LMP. The differences among the packages were highly significant.

13.2 Cultivation with the MMP achieved the highest per hectare yield. But the three packages did not differ significantly with respect to per hectare yield of paddy.

13.3 Rice cultivation with the HMP required the lowest per hectare cost followed by the MMP. Cost of cultivation of the plots where the LMP was used, was the highest. The differences in per hectare cost of cultivation existing among the three packages were highly significant.

13.4 The net returns obtained was the highest in the plots employing the HMP followed by the MMP. Those differences were significant as revealed by the ANOVA.

13.5 Rice cultivation with the HMP resulted in giving the highest benefit-cost ratio followed by the MMP. The three package significantly differed from one another with respect to benefit-cost ratio.

13.6 The farmers perceived significantly high 'scope for use' on the MMP. The three packages significantly differed on this attribute.

13.7 The LMP was assigned first rank and the HMP third rank with respect to the attribute 'simplicity in use'. The differences among the packages were significant.

13.8 The MMP secured first rank with respect to the attribute 'quality of work done'. The differences were significant.

13.9 The HMP was assigned first rank by the farmers in their perception on the attribute 'cost reduction in use'. The three packages differed from one another on this attribute.

14. Empirical model was suggested for predicting the adoption behaviour of farmers, with respect to r farm mechanization, in the background of the constraints.

15. Empirical model was designed highlighting the effect of the farm mechanization packages on selected quantitative, qualitative and perception attributes related to rice farm mechanization.

Implications of the study

1. The survey conducted in the NARP regions on the farm implements and machinery revealed that the State of Kerala is in its infancy with respect to the status of rice farm mechanization. This should serve as an eye opener to the farm machinery researchers to develop appropriate farm implements and machinery, and to the extension personnel to popularise the use of labour saving, cost reducing and drudgery alleviating farm implements and machinery.

2. The farm mechanization quotient developed in the study to quantity adoption behaviour of farmers regarding farm mechanization holds out definite scope for improvement and for use in future research studies of similar nature.

3. The results on the differential status of adoption behaviour of farmers of different NARP regions regarding improved farm implements and machinery, being the first of its kind in Kerala, would definitely open new vistas for future research programmes of similar nature.

4. The various methodological approaches to identify and measure the constraints to adoption of farm mechanization technologies also would help researchers to pursue further research programmes on socio-economic aspects of farm mecnanization.

5. The structural and access constraints to rice farm mechanization technologies identified in the study imply multifarious considerations at the policy making level.

6. The study has convincingly demonstrated the effect of adoption constraints on the use of farm implements and machinery in the State. Efforts to popularise innovative farm mechanization technologies must be based on region specific analysis of adoption constraints and their field level manifestations.

7. The diversity of constraints identified, their relative importance and their impact on extent of adoption of rice farm mechanization in the five NARP regions also substantiate region specific research and extension programmes based on an inter disciplinary approach.

8. The results of the study also imply much diversed and multifaceted considerations at the policy making level. The major suggestions emitted on analyses of the various results of the study such as: strengthening the agricultural

engineering wing of the state department of agriculture to cater to the needs of imparting technical advice, providing custom hiring of important implements and machinery at public sector level, establishment and promotion of viable systems of ownership and use like 'private custom hire service', 'co-operative ownership', 'informal joint ownership', 'group use' and the like; promoting dealership and repair and service network; providing adequate and timely credits and subsidies for purchase of farm implements and machinery; training programmes to impart skill to the farmers for operating and undertaking minor repair and maintenance; propaganda through mass media and result demonstrations to make farmers convinced of the potentialities of farm mechanization; providing remunerative prices for the produce - have all policy implications for the concerned.

9. The result tests conducted with the selected packages of farm implements and machinery provide a systematic <u>modes operandi</u> for conducting farm mechanization trials in farmers' fields. Besides, the findings emerged from the result tests of the study have brought into limelight the potentialities and benefits, and farmers' perception on rice farm mechanization as the study had the background of actual field level situation.

10. The farm mechanization quotient, and the other tools and structural schedules developed in the study, the empirical models for predicting adoption behaviour, and the outcome of the result tests proving the worth of innovative farm mechanization technologies could be used with suitable modifications in other rice growing States of India.

Suggested lines for future research

1. A multidisciplinary team may undertake a more detailed and concentrated survey in all the districts of Kerala to study the current status and actual field level problems of rice farm mechanization.

2. Indepth studies on farm mechanization in general rather than confining to rice farm mechanization alone, may be taken up.

3. The farm mechanization quotient developed in the study may be applied in studies of similar nature and re-validated.

4. Action research studies to identify the adoption constraints, solutions to overcome them, and evaluation of the solutions may be taken up on a multi locational and multidisciplinary basis.

5. Case studies of mechanized and non mechanized farms

may be taken up to probe into the intricacies of constraints and benefit at the micro level.

6. Co-ordinated research projects involving teams of scientists with specialization in agronomy, agricultural economics, agricultural engineering and social sciences need to be initiated to make a detailed analysis of each of the constraint at micro level.

7. Realisation of the important fact that adoption behaviour of the farmers is not influenced by the 'individual-blame hypothesis' alone, more focussed attention may be given on the 'system-blame hypothesis' which states that characteristics of the technology and the contextual and access conditions of the farmers affect adoption decision.

8. While analysing the constraints to adoption of high level technologies like farm mechanization, more attention may be given to the diverse physico-biological and social requirements of the technology, and to variations in farming environments as factors influencing farmers' adoption behaiour.

9. The issue of farm mechanization in Kerala has been subjected to many debates, criticisms and myths such as: prevalence of small and fragmented holdings, massive human

labour and animal labour displacement, negative attitude of labourers and trade unions towards mechanization, poor investing capacity of farmers, costly nature of the technology, low technical know how and poor mechanical skill of the farmers, inappropriate nature of available technology and doubts on the contribution of mechanization towards increased yield and cost reduction. These and similar controversies and debates have to be subjected to rigorous scientific investigation through an inter disciplinary approach.

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* Original not seen.

APPENDICES

CHECK LIST OF FARM IMPLEMENTS/MACHINERY

Sl. No.	Implements/Machinery	OWNING AND USING					USING BY HIRING FROM OTHERS				
		Very difficult	Difficult	Moderately difficult	Less difficult	Least difficult	Very difficult	Difficult	Moderately difficult	Less difficult	Least difficult
1	2	3	4	5	6	7	8	9	10	11	12
1	Spade (Chopping hoe)										
2	Pick axe										
3	Digging hoe ('Kunthali')										
4	Hand Shovel										
5	Long handled hand rake (for clod crushing)										
6	Wooden stick for clod crushing										
7	Country plough										
8	Bose plough										
9	Mould Board Ploug (KAER-II)										
10	Wooden leveller (country-small)										

		OWNING AND USING					USING BY HIRING FROM OTHERS				
1	2	3 (VD)	4 (D)	5 (MD)	6 (LD)	7 Least dif.	8 (VD)	(D) 9	(MD) 10	(LD) 11	12 Least dif.
11	Larger Modified Wooden Leveller										
12	Helical blade puddler										
13	Channel cum Bund former										
14	Animal drawn clod crusher										
15	Power tiller										
16	Straight tilling blade (Rotor) of Power tiller										
17	Single way plough of Power tiller										
18	Tiller cage wheel										
19	Special slat type Two-way plough of power tiller										
20	Wooden levelling board of power tiller										
21	Steel levelling board of power tiller										
22	Bund former of power tiller										
23	Trailer of Power Tiller										
24	Pumpset attachable with power tiller										

		OWNING AND USING					USING BY HIRING FROM OTHERS				
1	2	(VD) 3	(D) 4	(MD) 5	(LD) 6	Least dif. 7	(VD) 8	(D) 9	MD 10	(LD) 11	Least dif. 12
25	Four Wheel Tractor										
26	Tractor cultivator										
27	Tractor cage wheel										
28	Multi-bottom iron plough of tractor (Mould board)										
29	Tractor disc plough										
30	Levelling board of Tractor										
31	Trailer of Tractor										
32	Dibbling stick with metallic cone tip										
33	Hand operated seed drill										
34	Bullock drawn seed drill										
35	Single row seed dibbler										
36	Multi-row seed dibbler										
37	Hand fork for weeding/inter-culture										
38	Three pronged hoe for weeding										
39	Star weeder										
40	Peg type weeder										
41	Seed dressing drum										

1	2	3 (VD)	4 (D)	(MD) 5	(LD) 6	Least dif. 7	8 (VD)	9 (D)	(MD) 10	11 (LD)	Least dif. 12
		OWNING AND USING					USING BY HIRING FROM OTHERS				
42	Seed-cum-Fertilizer drill										
43	Fertilizer drill for puddled soils										
44	Hand Compression sprayer										
45	Rocker sprayer										
46	Knapsack sprayer										
47	Power sprayer										
48	Power sprayer-cum-Power Duster										
49	Counterpoise lift ('Etham')										
50	Swing basket										
51	Water Wheel										
52	Animal operated mote										
53	Kerosene pumpset										
54	Diesel pumpset										
55	Electric motor pumpset										
56	Axial flow pump ('Petti & Para')										
57	Country sickle										
58	Improved sickle										

		OWNING AND USING					USING BY HIRING FROM OTHERS				
1	2	V.D. 3	D 4	5 MD	6 L.D	7 Least Diff.	8 VD	9 D	MD 10	L.D 11	Least Dif 12
59	Paddy harvester (Power operated reaper)										
60	Pedal Thresher (Manual operated)										
61	Axial Flow Thresher (Motorised or Engine)										
62	Thresher-cum-winnower (Motorised or Engine)										
63.	Winnower using simple electric fans										
64	Paddy winnower (Motorised or Engine)										
65	Hand operated Winnower										