

**DESIGN AND DEVELOPMENT OF AGRICULTURAL
EQUIPMENT FOR MARGINAL RICE FARMERS**

INDUSTRIAL DESIGN PROJECT II

IDP602

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Design Project - II

Design and development of agricultural equipment for marginal
rice farmers

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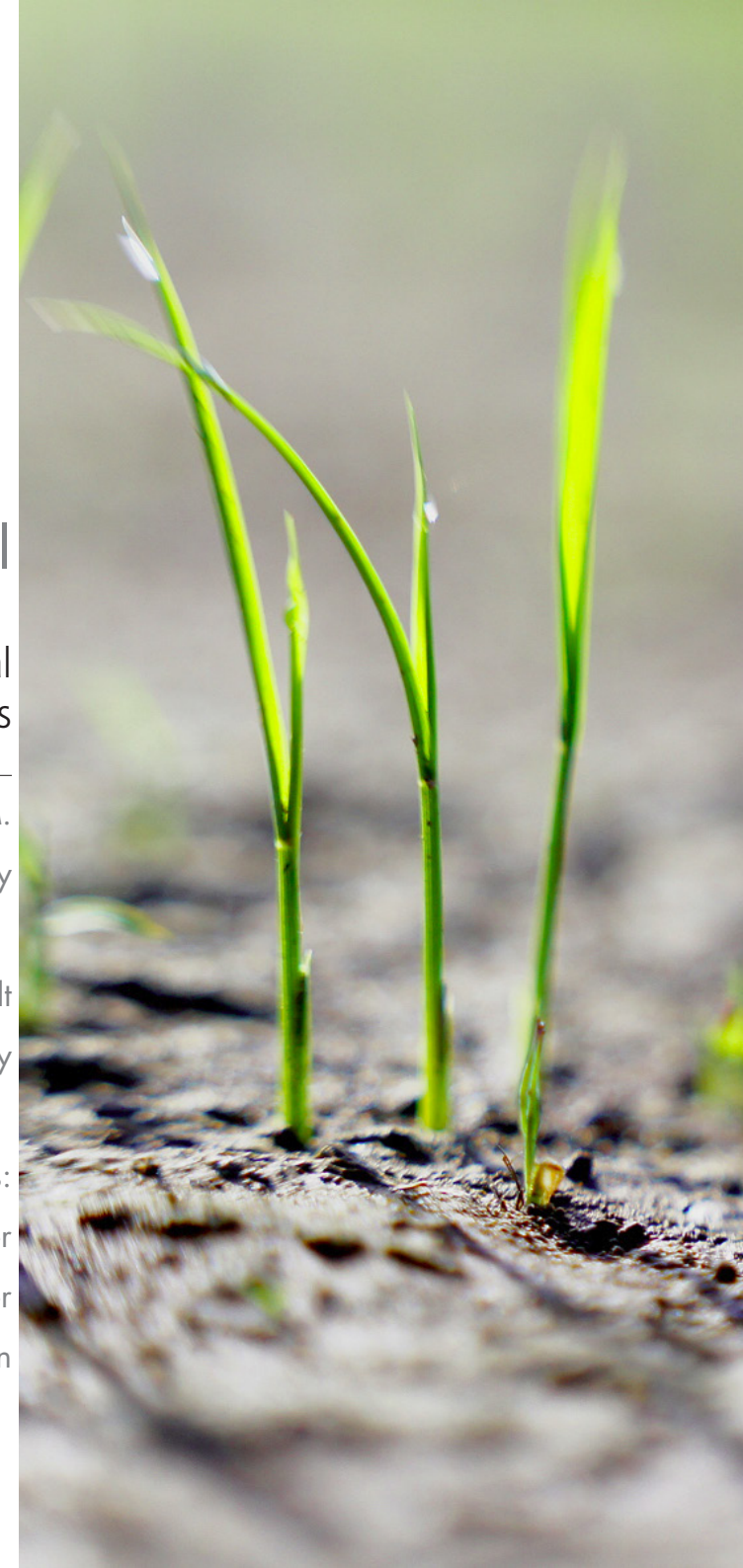
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Approval Sheet

The project titled as "Design and development of agricultural equipment for the marginal rice farmers" by Midhun K.M. is approved in partial fulfilment of the requirement for the degree of 'Master of Design' in Industrial Design.

Gu Guide: *Ralph Bonda*

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Int Internal Examiner: *[Signature]*

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Declaration

I hereby declare that this written submission represents my idea in my own words and where others' ideas have been included; it has been adequately cited and referenced with the original source. I declare that I have adhered to all principles of academic honesty and integrity and have not fabricated or falsified any data/idea/facts/sources in my submission. I understand that any violation of the above entitles the institute to take disciplinary action against me to which I shall be answerable to.

Name Midhun K. M.

Place Darmstadt

Date 28-11-2014

Signature

A handwritten signature in black ink, appearing to read 'Midhun K. M.', written over a light-colored rectangular background.

Acknowledgement

My thanks to my parents and my brother.

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Abstract

The present study is an attempt to understand the current scenario in marginal rice farming in the state of Kerala in India which is deficit in production of its staple grain, rice. The focus is on understanding the context and the requirements of the community for sustaining rice cultivation and their livelihoods. The research carried out showcases the various challenges faced by the farmers to sustain the cultivation due to the higher production cost and lack of solutions to cater to the needs arising from the shortage or unavailability of resources to carry out the operations in the field. The study is concluded by proposing the requirements of the farmers by analysing the data collected during primary and secondary research for designing a solution in the next phase of the work.

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1. Motivation

The republic of India, located in South Asia is the seventh largest country in terms of area and second most populous country with a population of more than 1.2 billion (India, 2014). It is estimated that the labour force of the country is 457.5 million workers distributed among the organized and unorganized working sectors. Out of this 86.2 percent of the workers are employed in the unorganized sector (National commission for enterprises in the unorganized sector, 2008).

The unorganized sector is defined as the following: “The unorganized sector consists of all unincorporated private enterprises owned by individuals or households engaged in the sale and production of goods and services operated on a proprietary or partnership basis and with less than ten total workers” (Report on conditions of work and promotion of livelihoods in the unorganized sector, 2008).

Social security and sustained human development of the workers in the unorganized sector is a matter of concern. The sector is affected by various problems and results into poor and undesirable working conditions. Some of the common issues in the sector are low and irregular income, unequal wages for male and female workers, no payment for overtime work, no job security, lack of dignity, lack of proper health care and the poor working conditions (Surbhi Kapur, 2014).

Considering the fact that a large percentage of the working

population of the country is employed in the unorganized sector with the poor working conditions, the requirement is to focus on the needs arising from this sector for the well being and overall development of the condition of the workers. Around 64 percent of the unorganized sector is from the agriculture which provides employment for farmers and agricultural labourers (National commission for enterprises in the unorganized sector, 2008). The distribution of a large number of working population and its contribution to the economy of the nation makes agriculture very important in the context of India.

1.1 Agriculture in India

As discussed, India is an agrarian economy with half of the working population relying on the agriculture sector for their livelihood. The sector accounts for 14 percent of the GDP and 11 percent of the exports. Being a country with the 17 percent of the world population, 2.5 percent of global land and 4 percent of water resources, the core of India's agricultural strategy is to provide food security by increasing the production. The country produces a wide variety of crops, horticultural products and livestock and is the world's second largest producer of rice and wheat which are the major staple food for many countries (Government of India, 2013).

1.2 Rice and its importance

Rice is a type of grass belonging to the genus *oryza* with many varieties and grown by different ways of cultivating. The plant undergoes three main stages of growth namely vegetative, reproductive and ripening, for the seed to be harvested (Ricepedia, 2014). The crop is cultivated in dry or semi-dry upland and in wet or lowlands (Rice, 2014)

In India, rice is one of the important food crops in terms of area, production and consumer preference. 22.3% of the global pro-

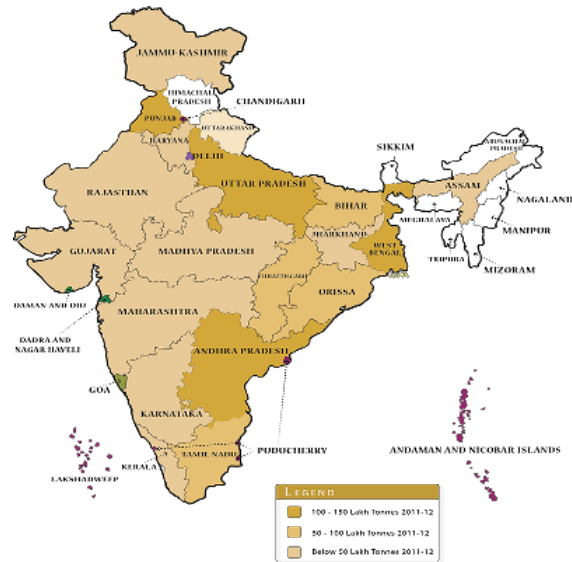


Figure 1-1: Rice producing states of India [1]

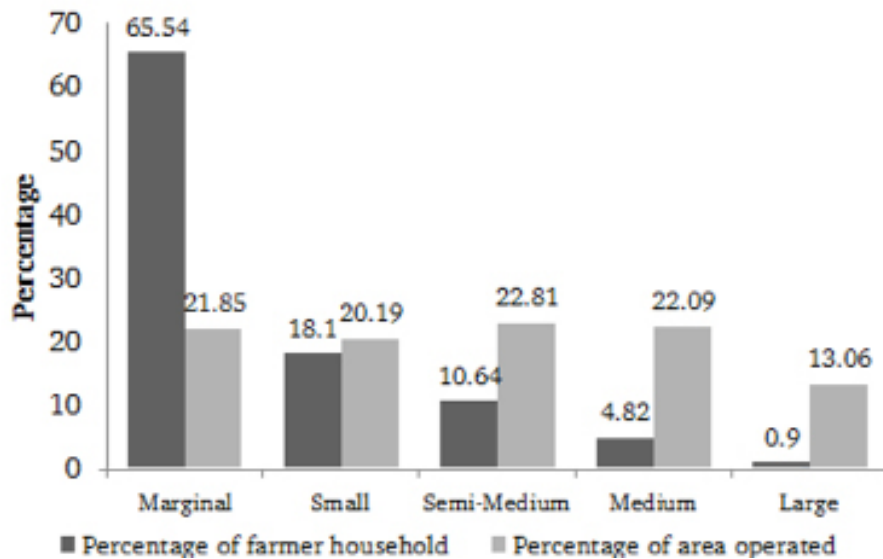


Figure 1-2: Percentage of various farmer household and area operated by each category in Indian agriculture (National commission for enterprises in the unorganized sector, 2008).

duction of rice is from India (Government of India, 2013). It is the staple food of the people from eastern and southern part of India.

Even though statistics shows an increase in the overall production of rice in the country, there are cases reported about the gradual shrinkage of rice cultivation in some parts of India. The issues associated with the procurement system and the unpredictable weather has resulted in farmers scaling down the cultivation (Roy, 2012). A study conducted indicates that the issues associated to rice cultivation are much more and ranges from unavailability of labourers during peak season, less profit, slow pace of mechanization, lack of credit, uneconomic size of land holding and so on (Thomas, 2002). This demand for a need to study this area considering the importance of the rice in India and farming community involved in this sector.

1.3 Marginal Farmers in India

Marginal farmers are those cultivating in agricultural land more than 0.01 hectares and up to 1 hectare. 65.54 percent of farmer household in India is in marginal farming and the area operated by them is 21.85 percent of the agriculture land (Figure 2). The major reason for this majority in marginal farming is due to sub-division of land and also due to the land distribution processes. In the current scenario, this marginal and small holding of land is more prominent and pertinent. The value of output per hectare from marginal farms is higher and contributes a major share in to the national crop output even when the operated land area is much smaller. But these higher yields are not enough to compensate for the higher production cost for these marginal land holdings and causes disparities in the earnings for these farm sizes in the current scenario (National commission for enterprises in the unorganized sector, 2008). Considering the advantages arising out of the higher yield, the large number of farmers engaged in this group and the

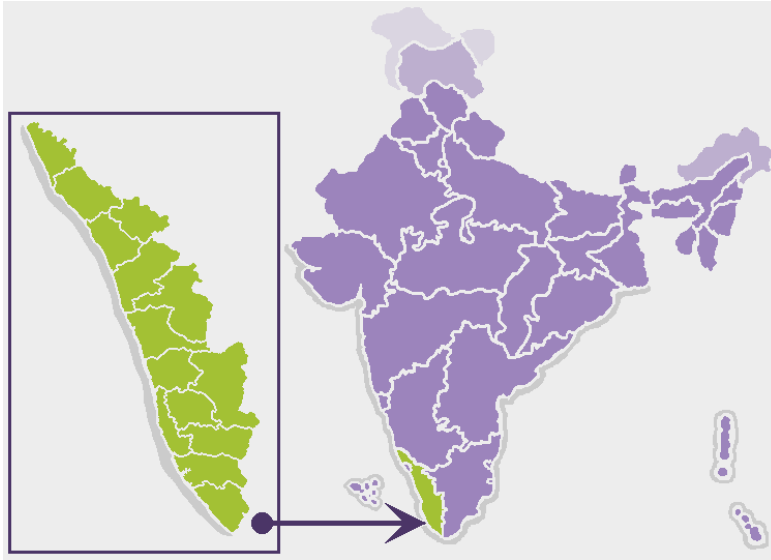


Figure 1-5: Location of Kerala at the south-western tip [2].



Figure 1-4: A landscape of rice fields in Kerala.[3]

poor working conditions of being in an unorganized working sector, marginal farming is an area which needs to be focused on for reducing the disparities in income and to offer a better living condition for the marginal farmers.

1.4 The Indian state, Kerala

Kerala is a state of India located on the south western tip of the country. The state is spread across a narrow strip of land with three different layers of highland, midland and lowland and a large number of rivers, lagoons, backwaters and estuaries. Looking at the agriculture sector of Kerala, the average size of land holding are small and declining (Kerala development report, 2008). Report suggests that over 95 percent are marginal farmers in the state of Kerala (Singh, 2012). The state grows mainly tradable commodities dependent on the international market. Rice is the staple food of the state and being food deficient in production of the required amount of food, the state relies on imports to compensate for the shortage (Kerala development report, 2008). Being a state with rice as the staple food and with deficit production and also the maximum of farmers falling under the marginal segment, the situation demands more attention.

The current investigation will be focused on understanding the scenario in unorganized sector of marginal farming and the challenges faced by the marginal rice farmers in the state of Kerala where the shortage in the production of food has always been predominant.

This report is divided in to 5 chapters. Chapter 1 discusses about the motivation for the project and discusses about the relevance of the topic. Chapter 2 discusses about the methodology adopted to realise the project. Chapter 3 discusses the results from the secondary and primary research conducted to understand the scenario. In chapter 4, the discussions based on the results are reported

with the final user needs. Chapter 5 concludes the report with an overview of the project and the future scope of work intended for the phase-2 of the project.

In this current phase of the project, the understanding of the user context and the user requirements are carried out. The process involves conducting the secondary and primary research to accomplish the task.

2.1.1. Secondary Research

Secondary research is carried out to understand the current scenario existing in rice cultivation sector. The process is carried out by conducting literature survey, internet survey, collecting information from books, articles and various other resources available. The idea is to understand the activities in rice farming and the related topics such as the occupational health hazards, the scenario in marginal farming, the role of mechanization and the available machines for rice cultivation. This will provide an overall understanding of the existing scenario in the sector and a beginning for the primary research which will be carried out next.

2.1.2. Primary Research

Objective of the Primary Research

The focus of the primary research is to understand the user and user context much closely to find the requirements for any design intervention. The primary research is carried out by interviewing the appropriate participants from the state of Kerala in India and associated to rice cultivation.

Participants Chosen for Interview

Choosing appropriate participants is crucial for a qualitative survey to understand the real needs of the users. The user segment for the present study involves marginal rice farmers, farmers who have quit rice farming, farm machine operators and the solution providers for the agriculture related problems.

The marginal rice farmers are the primary users for the study as they take up the ownership of the whole activities and risks associated. The choice of farmers who have quit rice cultivation is made to understand the reasons behind quitting and to ensure if any complexities involved in the system are taken into account for any interventions to be made. Considering the highly intense activities in rice farming and the shortage of labourers, the rise in usage of machines is predominant and this brings in the need to include the farm machine operator to the survey. The issues associated to farming is brought into notice and addressed by the various solution providers working in the government and private sector related to agriculture. The need to understand the real challenges through different perspectives is crucial to understand the entire system and the factors revolving around, and that makes the inclusion of solution providers into this primary research crucial.

User Interview Method

General interview guide approach was chosen to conduct the interview. The choice of this type of interview is to ensure that the same general areas of information are collected from each interviewee with a degree of freedom and adaptability to extract the information. The idea behind understanding the context and the experiences from interviewees in the current scenario also led in to choosing this method of interview. Considering the fact that the users for the current project are located in India, a telephonic interview is planned and the conversations will be recorded for analysis and interpretation of the user needs.

Scope of User Interview

The set of questions prepared for the different user groups are added in the appendix at the end of the report. The questionnaire was also supported with pictures of various machines used in rice cultivation and shown to farmers using the help of friends and

family in India during the interview. A brief overview of the scope of the interview is discussed below.

The scope of the interview for the farmers is to mainly understand the following points:

- Motivation to continue rice cultivation
- Rice cultivation for livelihood
- Activities involved in rice cultivation
- The various issues related to each of the activity ranging from health risks, arranging for additional labour or machines, risks involved and the expenses.

The farmers those who have quit rice farming are enquired mainly to understand the reasons to quit and to understand the scenario which prevailed in those days.

The scope of the interview with the farm machine operator is the following:

- The livelihood and the various source of income.
- Work load and associated health issues.
- The process involved in using the machine and the associated usability issues.

The solution providers are interviewed to understand the current challenges in the marginal farming and the design process adopted to solve the problems locally.

Analysis of Data Collected from Interviews

The data collected from the interviews are added into a mind

map as per the user segment and the specific activities or the areas related to them in the phase 1 of data analysis. The approach adopted here is to analyse the data individually as received and later to form groups in the phase 2 of data analysis. In phase 3, the groups formed are analysed individually and also the relationship between the data from different groups are studied. The needs arising from each group is then interpreted and these are discussed with the existing solutions or practices available in the current scenario before the final user needs are proposed.

2.2 Project Plan

The current project titled ‘Master thesis Phase-1’ is focused on understanding the context and the requirements of the user’s in the study. The phase -2 of the project will be dealing with the designing of products or solution for the requirements proposed here in this study. Phase-3 of the project will be dealing with the prototyping of the solution.

The following are the tasks within the scope of the phase-1 of the project in the order of completion:

1. Project management: Understanding the tasks and management of time.
2. Secondary research: Activities in rice farming, occupational health hazards, and product study.
3. Primary research: Design and execution of interviews with appropriate user segment.
4. Data analysis: Analyse the data and interpret the user needs.

The time line of the phase-1 is shown in Table 1

3. Results of the research



Figure 3-1. Rice plant with grains

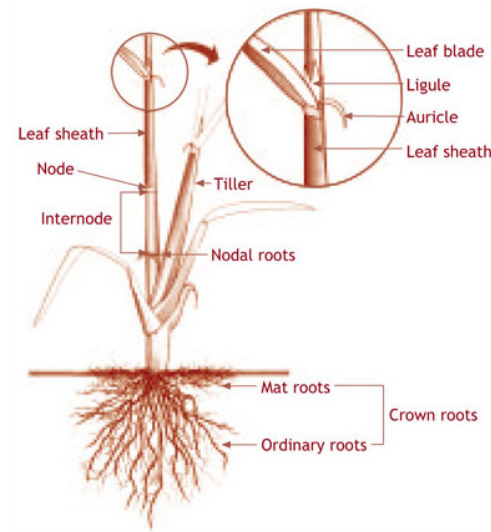


Figure 3-2. Different parts of a rice plant [4]

3.1 Secondary Research on Rice Cultivation

The present study is focused on understanding the practices followed in rice cultivation and the various factors associated to this field which can then help in understanding the complexities involved and the directions in which the research should be proceeded.

3.1.1. Rice Cultivation; the Process

Rice plants are similar in nature to other grains like oats and wheat. The major difference is the ability of rice plant to grow in standing water or in wet soil. The plant develops clusters of small flowers called panicle by wind pollination. These flowers are then developed in to rice grains. When matured, the plant has a main stem and several tillers attached to it. The flowering head or the panicles are grown on the terminals of these tillers (Ricepedia, 2014).

The height of the plant varies based on the variety and environmental conditions. The heights can range from 0.4m to 5m in some floating rice. Even though rice plant can grow from one season to the next, the plant is treated as annuals by planting new seeds for each season for better yields. The growth cycle of the rice is divided into vegetative phase including the germination, seedling and tillering and the reproductive phase during which the panicles are formed and later mature into grains (Ricepedia, 2014).

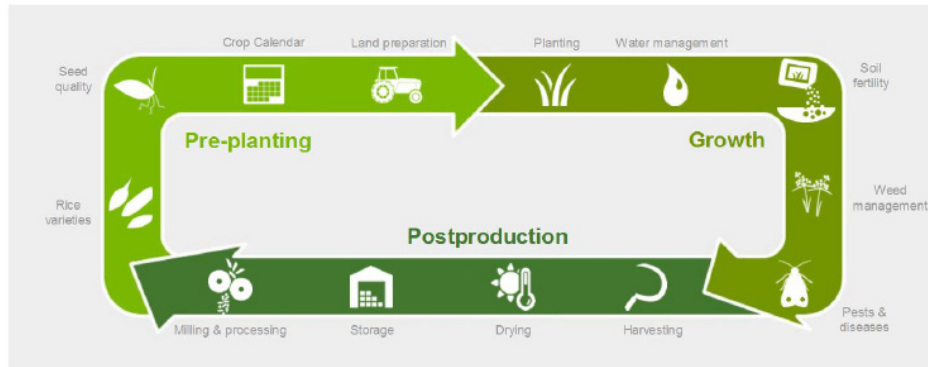


Figure 3-3. An overview of activities in rice cultivation and processing of rice [5]



Figure 3-4. Tilling of land in flooded condition [6]

The various activities in rice cultivation can be categorised in to three stages; pre-planting, growth and post production. A detailed analysis of the activities is necessary to understand the intensiveness of the cultivation method.

Seed Variety

The selection of proper variety of seed is important. The various criteria considered for selecting the seeds are good quality of grain, high market price, higher yield potential, resistance to diseases, pests and other local conditions of the growing region and the right maturity period matching with the season (Rice knowledge bank, 2014).

Crop Calendar

A crop calendar helps in planning of all farm activities like estimating the labour requirements and peak usage time, organizing contractors for various machinery aids, arranging for credits and to understand the schedule for crop establishment and the nurturing of the crop (Rice knowledge bank, 2014).

Land Preparation

Land preparation is necessary before planting. It helps in controlling weeds, recycling of plant nutrients and facilitates for a suitable soil surface for transplanting or direct seeding. The typical process involves mixing and overturning of soil, breaking of soil clods into smaller mass and levelling of field. The process is carried out after the previous harvest or during the fallow period and takes 3-4 weeks (Rice knowledge bank, 2014).

Wet preparation methods are adopted for lowlands by tilling the land in flooded or saturated conditions. The process starts with construction of highly compacted bunds to enable water retention in the field. The field is then irrigated with 2-3 cm of water for 3-7



Figure 3-5. Ploughing of dry soil [7]



Figure 3-6. Transplanting using transplanter[8]

days for it to become soft. Then the primary tillage is carried out which dig up and mix the soil and ensures the weeds are uprooted and buried in the soil. The tilling process is carried out in various patterns. The field is again flooded for 10-14 days until the secondary tillage operations. The secondary tillage carries out puddling of the soil to muddy or water tight paste for retention of water and nutrients. The last stage is levelling of the field using laser leveller or a wooden plank attached to the tractor or draft animal. Levelling ensures uniform water distribution and higher yield and quality (Rice knowledge bank, 2014).

Dry preparation method is used in uplands and requires lesser water. In this process, the puddling is not carried out and rest of the processes are similar to wetland except for leaving the field for 2 weeks for the weeds to re-emerge after levelling. These weeds are then killed by spraying herbicide before planting the crop (Rice knowledge bank, 2014).

Planting

Direct seeding or transplanting is the two different methods for planting. Direct seeding requires more seeds than transplanting but it matures faster than transplanting as in the former the plant do not experience any stresses of pulling out from soil and replanting. The growth of weeds is more predominant in direct seeded fields. Dry and wet direct seeding methods are practised and in wet condition, the pre-germinated seeds are either broadcast or drilled using a drum seeder. The drum seeder requires a well levelled smooth soil. In the case of dry condition, the seed is sown on the field and then incorporated by ploughing (Rice knowledge bank, 2014).

Transplanting is another method where the seedlings are grown in a nursery and transplanted into the field at regular interval of spaces. The process is carried out both manually and using machines. Manual transplanting requires 25-30 man days for 1



Figure 3-7. Manual transplanting of seedlings[9]



Figure 3-8. Weeds in rice fields[10]

hectare. The proper spacing of plant can yield 20-40 percent more yield and also facilitates easy management of weeds and fertilizer application (Rice knowledge bank, 2014).

Water Management and Soil Fertility

Rice is grown in flooded fields to ensure sufficient water availability and to control the weeds. A puddled and levelled field can ensure a better water management. The bunds should be strong and without any holes or cracks to ensure no loss of water. In case of lowland rice cultivation, the plant is highly sensitive to water shortage. In case of direct seeded field, the field will be flooded only after plants are grown large enough to withstand the water. Soil fertility needs to be maintained for the plants to grow and develop. An imbalance in the nutrients can cause lots of problems to the crops (Rice knowledge bank, 2014).

Weed and Pest Management

For a better and good quality yield the weeds and pests should be controlled. The weeds decrease the crop yield by sharing the nutrients and water. The removal of weeds increases the production cost and also the existence of weed seeds in grains can reduce the buyer price. Weeds can be controlled by spraying herbicides and also by ensuring proper land preparation is carried out. Around 37 percent of crop is lost every year due to pests and diseases. Usage of clean seeds and equipment, cultivating at the same time as neighbours, application of right amount of fertilizers and encouragement of natural enemies of pests are the best practices to be followed for pest control (Rice knowledge bank, 2014).

Harvesting and storage

Harvesting is the process of gathering crop from the field after it is matured. The process includes reaping, stacking, handling, threshing, cleaning and transporting. There are various methods of



Figure 3-9. Pests on rice plant[11]



Figure 3-10. Reaping of paddy [12]

harvesting and proper methods yield maximum grain and minimize grain damage. The time of harvesting is important as the crop needs to be harvested with the right moisture content. An early harvest can result into immature grains and late harvesting can cause excessive loss or breakage of grain. The germination potential of seed is also affected by the harvesting time. The various system of harvesting are manual reaping and threshing, manual reaping and mechanical threshing, mechanical cutting and mechanical threshing and the combine harvesters. The choice of an appropriate harvest depends on the availability of labour, economic conditions, time and other factors such as farm by products (Rice knowledge bank, 2014).

The harvested rice needs to be immediately dried to reduce the moisture in the grain for safe storage. At the time of harvesting, the grain consists of 20-25% moisture which increases the natural respiration and causes deterioration of the grain during storage. The grains are dried under sun or by using heated air drying systems (Rice knowledge bank, 2014).

3.1.2. Marginal Farming and Mechanization

The size of marginal farming community in India is already discussed in chapter 1. An understanding of the issues faced by marginal farmers and the challenges in mechanization for marginal farmers is to be probed. The inadequate income of marginal farmers due to the small land holdings and assets are compounded by various other factors. The lack of access to proper market, proper human resource base, credits, public irrigation and poor knowledge of technology are other factors affecting them. The prevalence of informal tenancy in the country is a major issue for the farmers as there is no security and certainty in the land they cultivate since many of them cannot afford for own land. The lack of documents due to the verbal agreement process in this informal system has kept them away from accessing the credits through the formal de-



Figure 3-11. Combine harvester[13]

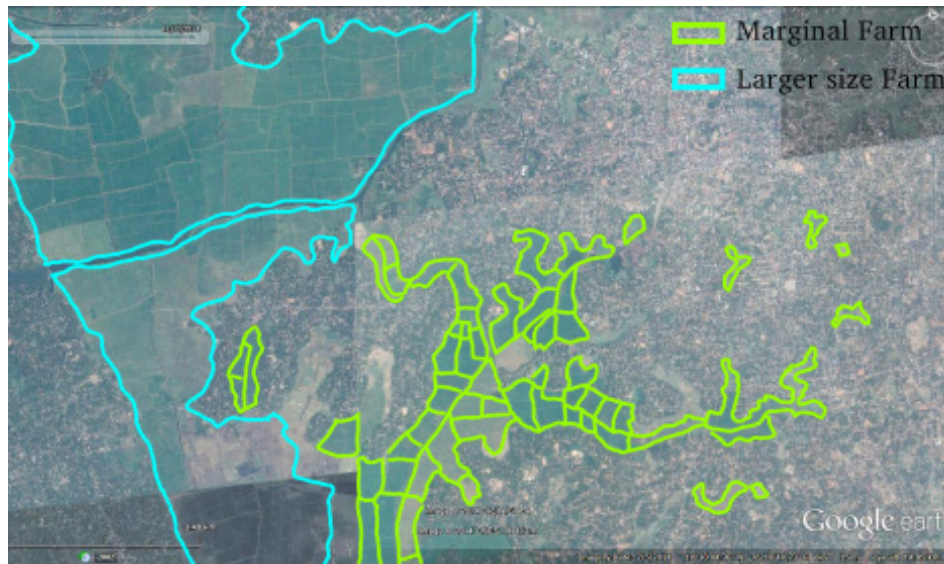


Figure 3-12. Cluster of marginal rice field in comparison to larger area field[14]

livery system. The lack of literacy and formal education has also resulted in leading them to be not aware of many of the available credit schemes, technology usage and the government's support initiatives. The increasing production cost and the indebtedness of the farmers to private money lenders have witnessed a series of suicides in distress. The income from non-farm business and animal farming is required for a marginal farmer to sustain in the current scenario due to the various factors discussed so far and the high production cost of farming. Surveys conducted suggest 44% of marginal farmers disliked farming in the current scenario (National commission for enterprises in the unorganized sector, 2008).

Looking at the developments in mechanization in agriculture, it has been proven that the states with higher farm power have a higher productivity. The demand for adequate farm power is crucial in agriculture considering the scarcity of farm labour and rising demand for food grains. Further, the study carried out on the effect of mechanization on socio-economic conditions of farmers and the impact on employment of labour proves that the mechanization, apart from high rate of production also has helped in building new secondary and tertiary employment opportunities than before. But the decreasing trend of operational land holding has obstructed growth of agricultural mechanization. The high cost and the non-availability of machines which suits to the small scale farms, forces the farmers to follow the traditional operations. The other issues like the highly diverse farm sizes and the seasonal usage of machines makes the process challenging. (Government of India, 2013).

3.1.3. Machines used in rice cultivation

This section explores the various machines and equipment used in different stages of rice cultivation.



Figure 3-13. Bund former[15]



Figure 3-14. Bund former[16]

Land preparation

As discussed in section 3.1.1, the major tasks in land preparation are bund construction and soil preparation. The machines used for these activities are power tillers and tractors with various attachment fitted on to these.

Bund formers: These are the attachment attached to rear of tractors to build or strengthen the existing bunds. The basic process involves collecting of soil and aligning it in heaps as the tractor moves forward. Figure 9 shows a bund former which is simple in operation and gathers soil to form the bunds. The Figure 10 shows a bund former with a roller which strengthens the existing bund. This device is suitable for both wet and dry conditions (Soil preparation).

Power tiller: This machine is widely used in many of the rice producing countries. It is mounted with a 6-12kW gasoline or diesel engines in the front and counter balanced by the attachments at the rear. The operator walks behind the machine to control. These machines are fitted with rubber tires for dry land ploughing and cage wheels for wet working conditions. These are multipurpose machines which can be used for ploughing, land levelling, transportation and water pumping purposes. Mouldboards plough, disc plough, harrows and rotovators are the attachments commonly used with this. The simple mechanical design and compatibility with wet and dry soil conditions make it a popular machine. The cost of owning and the fatigue caused to operator are the downsides of this machine (Farm power, 2014).

Four wheel tractors: The 3 major category of these are two wheel drive, unequal four wheel drive and equal four wheel drive tractors. The two wheel drive tractors are the commonly used tractors in dry or upland farming. The power of the tractor ranges from 4-150kW. The advantages of this tractor over 4 wheel drive tractors

are in terms of the manoeuvrability, simple design and the lower cost. The use of cage wheels is required for this machine to operate in very wet and muddy conditions (Farm power, 2014).

Planting

The various methods of planting are transplanting and direct seeding. The equipment used for these different methods are discussed below.

Transplanting: The transplanting can be carried out using mechanical transplanters which can save time and labour. The most common types of transplanters are the walk behind models and the ride-on models. The condition of the soil should be well suited for the machine as the parts or wheels of transplanter should not stick on to soil. The advantages of the machine are fast and efficient, reduce stress and health risks, maintain uniform spacing and density of plant and results into vigorously growing tillers and uniform maturing of the plant (Rice knowledge bank, 2014).

The limitations of the machine are the requirement for special nursery management, accessibility to the field, expensive and need for expertise in using the machine. The machines also require well puddled and levelled fields and demands for hard sub surface soils to operate (Rice knowledge bank, 2014).

Dry direct seeding: The turbo happy seeder is used to drill seeds into soil. The device is attached to tractor and places the seed into both dry and moist soil. The machine requires a smooth and levelled seedbed to maintain an optimum depth. The use of this machine makes manual weeding easier than in broadcasting (Rice knowledge bank, 2014).



Figure 3-15. Power tiller[17]



Figure 3-16. Four wheel tractor[18]

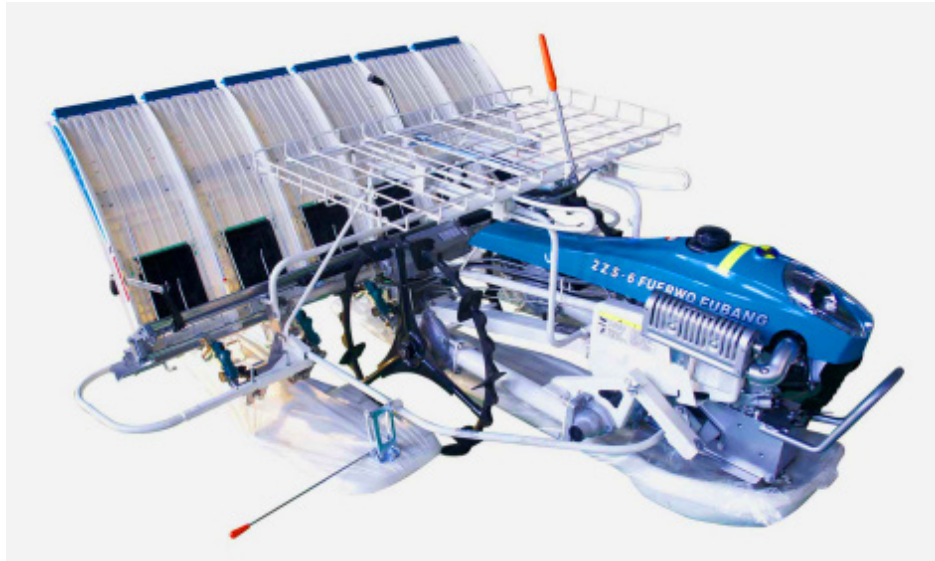


Figure 3-17. Walk behind transplanter [19]



Figure 3-18. Ride on transplanter [20]

Wet direct seeding: Drum seeder is the device available for this operation. The device is simple in design and effectively carries out row seeding of pre-germinated paddy on puddled soils. The device also saves up to 50 to 70% of seeds compared to manual broadcasting. The machine is available up to 8 and 12 row seeding models and is economical to operate and maintain. The device is operated by pulling and requires very less effort of around 9kg (IRRI running farm machinery, equipment and tools).

Weed Management

The equipment available for removal of weeds and the application of pesticides are available in manual and mechanical operated modes.

Cono-weeder: The device is manually operated and consists of a pair of conical shaper rotors with serrated blades. The device uproots and buries weeds in a single pass. The skid provided on the front aids in floatation of the device in soft field. It can be operated by both women and children and the handle height can be adjusted (IRRI running farm machinery, equipment and tools).

Harvesting

As discussed in section 3.1.1, the usage of machines for harvesting are for reaping, threshing and for the combine harvesting method.

Reaper: The reaper cuts and gathers the straw and lays the crop on the field. The device has a cutting width of 1.5m and was popular once. The device is currently being replaced by combine harvesters (Mejia).



Figure 3-19. Reaper to cut the plant[21]



Figure 3-20. Thresher to separate the grain [22]

Thresher: Threshers are stationary machines with peg-toothed threshing drums. The crop is fed in to the thresher for separating the grains. The pegs on the drum hit the material and separate the grain from the straw. The impact of the hitting causes the removal of the grain. The threshed grains with the impurities like fragments of straw are then passed on to the oscillating screen to separate the grain (Rice knowledge bank, 2014).

Combine harvester: These are the machines which can carry out reaping, threshing and cleaning of grains. The machine is broadly classified into standard combines, stripper header combines, head-feed combines and axial flow combines. The technology and the method used in reaping and processing of the crop differentiate them into these categories. The various categories of these machines have their own advantages and disadvantages (Rice knowledge bank, 2014). The major advantages of using a combine is faster harvesting, less labour, minimal grain loss and lower harvesting cost for farmers. The limitation is the higher costs of the machine (A.R.M. Mahrouf). The combine harvesters are available in market from mini to heavy duty machines.

3.1.4. Occupational Health Hazards

Severe environment conditions, longer working hours, strenuous work and use of improper equipment make the working condition of agricultural workers extremely difficult. The condition is worsened by the ignorance of ergonomic conditions in the design of tools and equipment. Work posture is an important aspect which limits the time and effectiveness of the performance of workers (Sanjit K. Kar, 2012). The major conditions which cause occupational diseases among rice farmers are from pesticide exposure, musculoskeletal disorders and the injuries due to different farm operations. The change of the system of the agriculture from past and the higher competition for yield has increased the use of pesticides



Figure 3-21. A mini and compact combine harvester[23]



Figure 3-22. Stripper header combine[24]

aided with the faulty spraying equipment and lack of attention to safety precautions resulting into illness from pesticide exposure. Sprains and strains and back injuries are common to rice farmers (Sapsatree Santaweesuk, 2014).

A study conducted on the analysis of manual rice transplanting suggests that the farmers experience and suffers from musculoskeletal disorder on lower back, upper back, legs, and shoulder regions. This is due to the prolonged awkward working postures (Pragya Ojha, 2014). The manual reaping and binding jobs in the harvesting stage of cultivation has resulted into pain in the upper arm due to the frequent contraction of biceps and triceps. The workers also reported pain in the wrist joints due to the static load of holding the straw during reaping and the repeated movement of other wrist while reaping with the sickle. The food habit and hygiene affected by the working conditions also result in to digestive problems. This is mainly due to the long gap between the meals due to the prolonged work hours. The workers also face problems with their eyes due to the prolonged exposure to dust particle and fragments of straw in the field (Sanjit K. Kar, 2012).

Power tiller is one of the most widely used machinery in India due to the small holdings of land. The operators of this machine get exposed to high level of vibration transmitted from the machine. The increased exposure of this results in to hand arm vibration syndrome. The speed of travel of the machine and the terrain also makes the problem severe (Bini Sam, 2009). The issues due to vibration are also prevalent in tractors. The occurrence of resonance conditions due to the forced frequency from tractor and the natural frequency of human tissues results in to dislocation of internal organs of the body. The three basic ways in which the vibration is transmitted to operator in a tractor are through seat, controls and steering wheel and from the floor and the foot control (B. Cvetanovic, 2013).



Figure 3-23. Area under rice cultivation and annual rice production in Kerala[25]

3.1.5. State of Rice Cultivation in Kerala

Rice is grown in diverse conditions at various regions in the state of Kerala. The location ranges from 3m below mean sea level to 1400m in the high ranges. The crop is grown in standing water as well as in purely rain-fed uplands with no standing water. The three main season of rice growing in Kerala are:

- *Virippu season* (autumn) – April-May to September-October
- *Mundakan season* (winter) – September-October to December-January
- *Puncha season* (summer) – December-January to March-April (Kumari, 2011).

The wet and humid tropical climate of the state is highly conducive for the cultivation of rice. Apart from the hybrid varieties of rice, the state also grows rice which has medicinal values such as njavara which is used in the Ayurvedic treatments (Kumari, 2011).

Even though rice is the major staple crop of the state, there is a decline in the area and production. These are due to various reasons and one among them is the high cost of production when compared to other states (Kumari, 2011).

The decline of the production is alarming majorly for two reasons. One is, Kerala produces only 15% of the food grains for its total consumption and the rest is imported from neighbouring states. The second reason is the importance of rice fields for the environment and ecological systems. The rice fields are crucial for the survival of the flora and fauna and it also acts a natural drainage path for flood water and replenishes the ground water (Thomas J. J.).

Along with the high production costs, the farmers also loss their crops due to the unexpected climatic conditions. The com-

Operations/Labourer	Wages in Kerala (Men)	All India average wage (Men)	Wages in Kerala (Women)	All India average wage (Women)
Harvesting/Winnowing/Threshing workers	INR 519.14	INR 229.28	INR 404.62	INR 192.77
Ploughing or tilling workers	INR 675.14	INR 261.03	-	-

Table 3-1. The comparison of wages for labourers in Kerala to all India average wages (Labour Bureau, Government of India, 2014)

Farmer ID	Area of Land in acres	District in Kerala	Number of crops per year
Farmer 1	2	Palakkad	2
Farmer 2	0.45	Thrissur	1
Farmer 3	1	Thrissur	1
Farmer 4	2	Thrissur	1
Farmer 5	2.5	Thrissur	1

Table 3-2. List of marginal farmers interviewed

petition from cash crops such as banana, coffee, pepper has also constraint the expansion of area under rice cultivation. Over the years a large area of paddy fields got converted to grow these crops (Thomas J. J.).

Rice cultivation requires timely availability of labourers during transplanting and harvesting and farmers are finding it difficult to get labourers in peak seasons. The expansion in mass education and the growth of construction sector and service industry is one of the reasons for the shortage of labours (Thomas J. J.).

The production costs are higher in the state due to the higher wages for the labourers in the state. The comparison between the all the India average wage and the wages in Kerala for the same operation is shown in the table below.

3.2 Primary Research on Marginal Rice Farming Community

The interview is conducted with 5 marginal rice farmers, 2 rice farmers who have quit the cultivation, 1 operator and 1 solution provider. The details of the stakeholders interviewed are shown in Table 3-2, Table 3-3, Table 3-4 and Table 3-5.

3.2.1. Phase 1: Raw Data Analysis

The user interviews conducted with each segment of users showcases the various processes and the issues associated to marginal rice cultivation in the state of Kerala. In the phase 1 of the analysis process, the inputs from the marginal farmers are listed in a tabular format with the data next to the specific participant. The table is attached for reference in the appendix of the report. To enhance the visualization and the ease of data handling considering the constraints in the time, it was decided to project the data on a mind map.

The raw data is projected on the mind map (Figure 1) with

Farmer ID	Area of Land in acres	District in Kerala
Farmer quit 1	1.5	Palakkad
Farmer quit 2	2	Thrissur

Table 3-3. List of farmers who have quit

Operator ID	Machines owned	Number of years of experience
Operator 1	Tractor	15

Table 3-4. Details of machine operator interviewed

ID	Area of interest	Number of years of experience	Organization
SP 1	Farm mechanization	12	Governmental

Table 3-5. Details of solution provider interviewed

the marginal rice farmer as the centre point and the following topics attached to the centre.

- Motivation for rice cultivation
- Activities in rice cultivation
- Rice cultivation for livelihood
- Issues related to labourers
- Reasons to quit rice cultivation
- Machines owned by the farmers
- Issues and feedback from machine operator
- Feedback and challenges provided by solution providers

The detailed discussion on the various topics listed above is necessary to understand the real scenario of marginal rice farming.

Motivation for rice cultivation

The motivation to continue cultivation of rice is based on several factors. The farmers are interested in agriculture and few of them have taken farming as a profession. The advantage of the shorter cultivation period of 3-4 months makes rice a favourable crop for most of the farmers interviewed. The benefits of community farming where the cultivation is carried out with the support of committees formed locally making availability of labourers and farm machines easily is also a motivating factor. But this method is not available for marginal farmers located away from the interconnected network of fields. It is also to be noted that rice is not the primary source of income and the farmers have various other source of income from cash crops, vegetables and other jobs like steel structural works and gold smith.

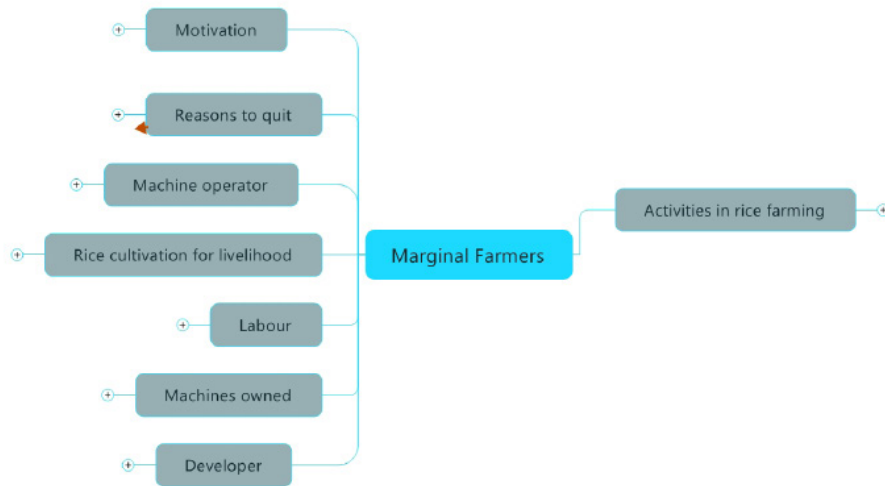


Figure 3-24. Mind map for Phase 1 of data analysis



Figure 3-25. Tractor sinks in muddy soil [26]

Activities in rice cultivation

The various activities involved in rice cultivation are already discussed in the secondary research and the issues and the methods adopted by marginal farmers are discussed here.

Land preparation: The puddling of land is carried out by tractors as it is faster and more efficient than power tiller. There are instances where the tractors are not used as it sinks in the highly muddy soil and replaced by power tiller. The machines are available with operator on payment on hourly basis. The bund preparation is carried out by the farmer by himself or with the help of labourers using the traditional tools like hoes. The unavailability and unaffordability of labourers demands farmers to carry out the operation by themselves most of the time.

Planting: The farmers interviewed follows both broadcasting and transplanting depending on the season or the availability of labourers. The transplanting process is carried out manually or by using the transplanting machine available at some of the locations. But at the moment even though the machine has widely acclaimed success, it is not available to various marginal farmers. The reasons are various for the unavailability. Those who use the machines are the beneficiaries of various on-contract machine availability schemes where the farmers pay a sum of INR3500 and provide seed and the whole process of transplanting from preparation of seedling to transplanting is carried out by a group of 3 people who come along with the transplanting machine. The farmer who uses this on contract basis system says it is economically viable for him and requires fewer amounts of seed. Whereas those farmers who has no such machines available adopts to the manual labour and says it is unaffordable for him to buy such a machine to make it available for his seasonal usage on his smaller piece of land. The other case of not using the machine is due to the incompatibility of the machine to the highly muddy soil conditions as the movement of the wheels



Figure 3-26. Manual bund preparation[27]



Figure 3-27. Broadcasting of seeds[28]

disturbs the loose muddy soil and causes the undesired sinking of the planted seedling or causes the mud to cover the seedling during the process of transplanting the second row. The unavailability of machines and shortage as well as unaffordability of labourers is a crisis many of them face.

Water management and soil fertility: The farmers take care of the water management and soil fertility by themselves. The usage of water pumps facilitates the water management and the fertilizers are added based on the soil conditions of the field and the type of the seed. The fertilizers at subsidized cost are available for some and the irrigation canals and own water resources like wells aid for the availability of water.

Weed and pest management: The process adopted for this activity by the farmers is manual. The farmers use weedicides to remove the weeds or manually pluck the weeds by self and at times with the help of family members. There are also issues like allergy to pesticides which has caused one farmer to refrain from doing that activity by self and seeks help from others.

Harvesting: The process of harvesting is carried out both manually and by using combine rice harvesters. The farmers suggest the manual mode of harvesting is expensive and difficult in the current scenario due to the unavailability and unaffordability of labourers. The issues faced in manual mode of harvesting vary with season. In rainy season the plants are heavier unlike the summer crop and the field is wet and demands the farmer to carry the reaped bundle to home for threshing which otherwise is carried out in the field itself if it was a summer crop. This scenario demands for more number of labourers to be employed. The delay in the harvesting of the crop reduces yield and finding labourers and completing the task on time is one of the difficulty farmer faces. The farmers spend a good time in negotiating with the available labourers and also carry out extra work by self to complete the task as the current



Figure 3-28. Contract basis transplanting using machine [29]



Figure 3-29. Reaping in a wet field [30]

labourers are inefficient. The additional amount of work and the awkward work posture causes sprains to which they do not heed much.

Most of the farmers who have interconnected paddy fields with another group of cultivators and belonging to the community-cultivation mode resorts to the usage of combine harvesters which are available on payment for hourly basis. But there are also cases where even with interconnected field the farmers have to resort to manual mode of harvesting. The reasons are many. The combine rice harvesters refuse to take up work on smaller land holdings like marginal sized fields. The farmers also have the practice of cultivating the land at their own available time and enjoy the flexibility available in the marginal farming system. Also the growing of different variety of crops like “navara” which requires lesser number of days causes different seasons for harvesting when compared to the neighbour. This is another cause of unavailability of combine harvesters. The other factor such as the size of the combine harvesters causes it to be not compatible for some of the farmers. Bigger machines are unable to access the field as the village roads are narrow and there are electric lanes which touches the harvesters as they are big machines. The medium sized combine harvesters which can reach the fields are unable to traverse across the bunds separating the fields which are up to 1m high.

The uncertainty in the arrival of combine harvesters is also a problem faced by the farmers as they are worried about the loss of yield if the machine does not arrive. The marginal farmers are also concerned about the charges as they have to pay on hourly basis and the machine requires more time in muddy field as in the smaller plots due to the manoeuvrability issues. The number of unloading trips in medium sized machines is also a concern for the farmers as it consumes more time. The other factors such as the profits from by products such as straw are also a concern for the farmers. In the



Figure 3-30. More number of labourers for carrying heavy straw [31]



Figure 3-31. Electric lines in narrow road [32]

current scenario, the longer the hay, the higher the cost it yields and the medium sized combines process the straw into smaller sizes. The bigger sized combine harvester which provides longer hay works only in dry land and is of no use during the rainy season harvesting. The unavailability of government owned machines due to poor maintenance is also cited as problem as the private operated machines charges more money for the process.

Apart from the combine rice harvesters, the reaper which was widely used in the state is no more utilized as the machine depends on labourers for collecting and threshing and also do not cut the paddy on the edges of the bund.

Storage: The shift from the old system of harvesting to combine harvesters makes it possible for selling the rice directly from the field as the machine is capable of reaping and threshing the grain from the plant. But the farmer faces problems in drying the seeds as they have no access to any facilities if the harvesting is in rainy season. The facility and effort required for parboiling the rice is also not feasible as in there olden days and the farmers resort to sell the paddy to industry and buy the parboiled rice for their everyday meal from the shops.

Rice cultivation for livelihood

The feedback from farmers suggests that it is not possible to survive on rice cultivation alone as the income is insufficient for the inflated day to day expenses. The seasonal cultivation method of rice is also another reason they pointed out making rice not a constant source of income. There are also risk factors from climate which makes the returns unpredictable. The other issues like the soil conditions and methods of cultivation play a major role in the yield of the crop making it different for each farmer. The farmers also face financial issues due to the delay in getting the returns from selling the grain.

Issues related to labour

The unavailability and unaffordability of labourers as discussed in the activity based feedback from farmers is severe. The farmers have to pay a large share of money for the labourers and that results into lesser profit. The labourers available currently are inefficient compared to the labourers from the past. This as per the farmers is due to the change in the old system of agriculture where people were paid with grains unlike the current system of daily wages. In current scenario the sincerity and responsibility of labourers is drastically reduced as the crop yield is not a factor for their income. The lack of interest among youth and the heavy physical work with no scheduled time is a cause for the shortage of labourers.

Reasons to quit rice farming

The farmers who have quit rice farming cite shortage and unaffordability of labourers, shortage of water and the undesired and unplanned development of roads and bunds by the government as the major reasons. A farmer cites that with the change from the old system of agriculture as described in the previous topic, has resulted in the depreciation of the healthy relationship that existed between the farmer and labourers. The demand for higher wages by the labourers even when the returns from selling of the crop were minimal was a reason to quit rice cultivation. The shortage of water for those with no access to irrigation canal has caused some of the farmers to quit as there is always an uncertainty in the rainfall on which they relied in the past. The government projects without much planning and thoughts have also resulted in making the rice fields uncultivable and forced the farmers to quit rice cultivation forever.

Machines owned by the farmers

None of the marginal farmers interviewed owns any kind of

machines for rice cultivation. The reasons they cited were the higher costs, seasonal usage of machine and also suggested that the machines cannot be afforded if it is not a source of income apart from the work it can carry out in the rice field. Many of the machines are also not aware to the farmers in the current scenario.

Issues and feedback from machine operator

The operator interviewed owns the tractor that he operates and pointed out that the job is seasonal and he finds work only for 6 months in a year even after he carries out work other than those related to rice cultivation. During the offseason he tries for other jobs like auto rickshaw riding for his daily expenses. The charges for the service are on hourly basis and vary with the type of work and the attachment that needs to be fixed on the tractor to carry out the work. Considering the work level he said it is demanding and suggested that a minimum of 2 to 3 years of experience is required to efficiently operate the machine, which otherwise will affect the crop yield and results in losses for the farmer.

The work environment is polluted with dirt and exposed to high temperature from machine as well as from the environment depending on the climate. The latest models with air-conditioned cabins are not preferred as the cost of the machine and the operating costs are higher and are not affordable for all. The delays or uncertainties in availability of machines are due to the breakdown of the machine or due to the additional work proposed by the farmer apart from the previously quoted work. There was an instance where the tractor sank into the muddy soil and the operator had a major repair as water surged into the major components. Instances such as this cost them a huge amount of money to repair. There are loans available and cost of the machine was repaid in a period of 5.5 years.

Feedback and challenges provided by solution providers



Figure 3-32. Dirty work environment [33]



Figure 3-33. Cage wheels as an attachment for wetland [34]

The responses from solution provider suggested the various challenges in the mechanization for the marginal farms in the current scenario. The major factors which pose the challenges are affordability, seasonal usage, diverse soil conditions, resistance to change traditional requirements by farmers, user friendly and women focused designs. The imported machines which are efficient in operation was pointed out to have poor after sales service which is highly demanding in agriculture field as the delay in availability of machine can result into the loss of crop. The difference in the standards of spare parts and the unavailability in the local markets are the reasons for this poor maintenance.

The process of design starts when a need is identified and the initial stages are focused on developing or adapting the relevant mechanism to carry out the required function. The user safety and other factors such as choice of materials and power source are considered and the machine is developed for a specific area or work condition. The feedback from the initial prototype and demand for other functionalities is taken into account and the machine is further refined.

3.2.2. Phase 2: Grouping of Raw Data

The raw data collected from the interviews are reported and the phase 2 deals with grouping of the data. The marginal farmers deal with machines and man power to cultivate rice. The climate and land conditions are other factors which affect them. The current scenario of rice cultivation as a livelihood is also an important factor in this context of marginal farming and is grouped separately. The four groups of data are shown below

The points or issues raised in the interview are considered and it is grouped by associating it to the respective topic. The vari-

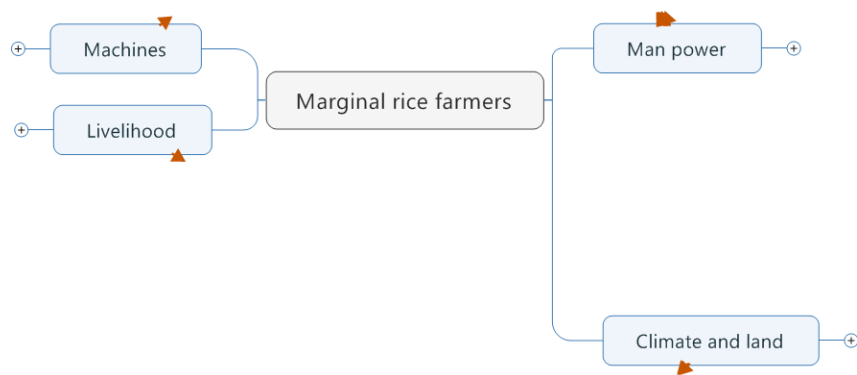


Figure 3-34. Grouping of data in phase - 2

ous issues associated to machines across the different activities are grouped together and it is made easy to understand what are the problems faced in the usage of machine for marginal farms. Likewise the problems associated to manpower, climate and livelihood are discussed. The interconnections between various points in different groups are also found out in the process.

For detailed study, the complete mindmap for phase-2 is attached in the appendix at the end of the report. The various issues and the points associated to each group and the interconnection will be discussed now.

The issues associates to machines are listed below:

- The machines are unaffordable due to various reasons. One among them being the cost and other factors such as seasonal usage makes it not affordable for marginal farm lands. The other factor pointed out is that as long as a machine is not used to make additional income and used only for own farms then it is unaffordable.
- Available on rent or on contract by hourly payment. The time taken to complete the activity matters here as the farmers want services which are of low cost.
- Diverse soil conditions causes sinking and making some machines not compatible to such terrains.
- The fragmented or the smaller land holding does not make some machines economically feasible to take up the work.
- Even though the machines are available in market, it is not available to the farmers through the various governmental or private owners nearby.
- There is an uncertainty in the time of availability of machines which the farmers find very risky as it can affect the yield of the crop.

- Some of the efficiently operating machines are unable to access the fields and others which can access the field have manoeuvrability issues while traversing across the fields.
- Farmers are not aware of many of the machines. These are due to various reasons such as the poor marketing of the agricultural products and the unavailability of proper media coverage.
- The various machines used affect the prices available for the farm by-products in the local market due to the processing techniques adopted in the machine.
- The delay in servicing and spare parts availability is a concern for many of the machines used.
- The use of small machines for marginal farm sizes such as reapers for harvesting depend on the labourers for further processing and is not a feasible solution in the current scenario.
- The operators dealing with the machine is also facing the problems with seasonal job availability.
- The demand for experience to efficiently process the activity is a matter of concern in the current scenario.
- The difficulties faced in operating the machine in dirty and hot environments and dealing with the breakdown and repair is a problem for the operators.

Now looking at the issues and points related to manpower, we can see that in the current scenario farmers rely on man power when machine is not compatible or available. The various points to be discussed on man power are:

- Shortage in labourers is highly prevalent and the fewer number and the demand in peak season worsen the scenario.

- The wages are high and the farmers get lesser profits from the crop. The issue gets affected more with the inefficiency of labourers in completing the work on time.
- The manual labour involves heavy physical work as there is no fixed work hours for the farmers as they have to ensure the crop never fails. This causes the farmer to work more to compensate for the shortage in labourers.
- The heavy work load causes various health issues and the use of pesticides manually is also not healthy.

The issues due to climate are mainly concerned with water. The water shortage due to poor rainfalls or the floods due to heavy rainfall are a cause of concern for the farmers. Both can negatively affect the crop. The various soil conditions affect the yield of the crop for the same area of cultivation.

The livelihood related points are already discussed in the phase 1 and in the phase 2. The inter connection between the loss of crop which affects the livelihood of farmers due to climate is considered as a major concern.

3.2.3. Phase 3: User need analysis for each group

After citing the issues arising from various groups in phase 2 the next phase is to interpret the needs from each group.

Needs arising out of man power issues:

- The need to process the activities efficiently is crucial.
- The manual power if to be used should be available in sufficient quantity at the required time.
- The workloads should be safer for humans.
- The activities should be carried out with minimum cost for higher

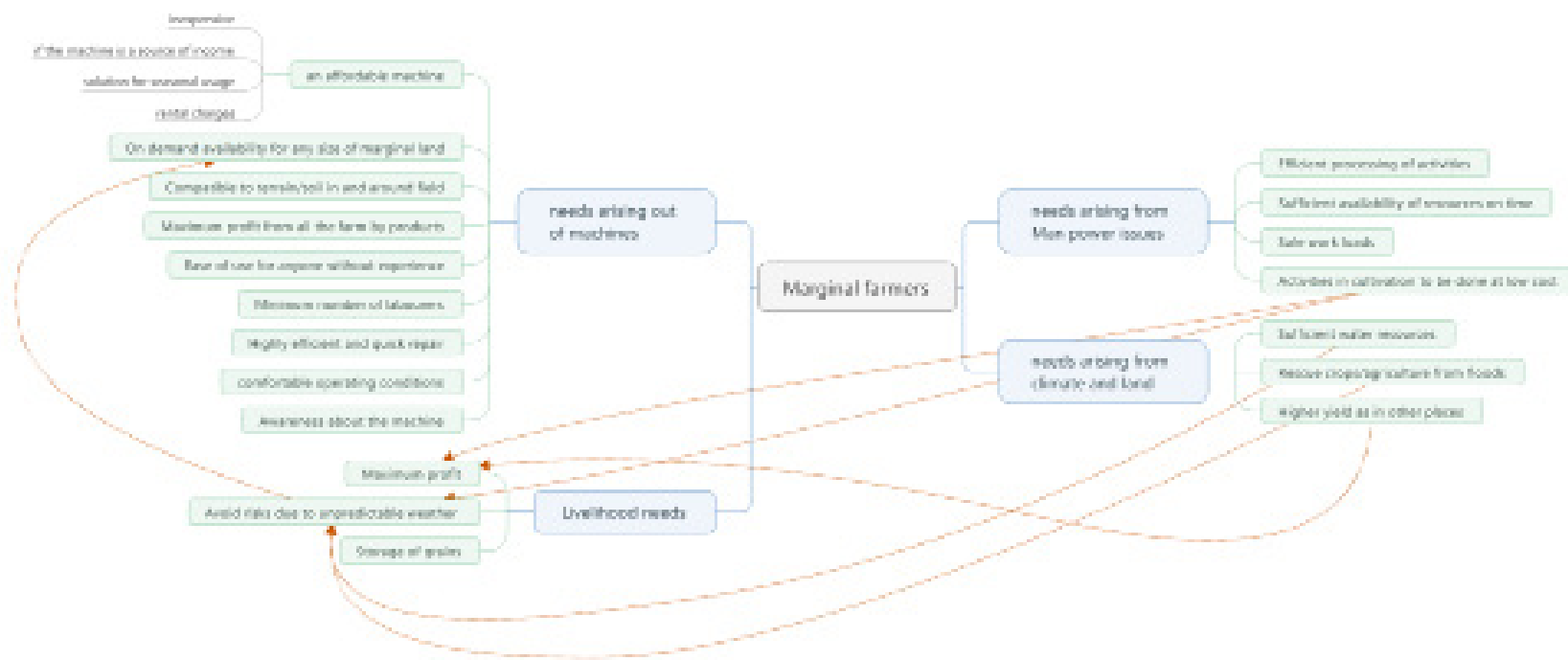


Figure 3-35. Phase-3- Mindmap for user needs from each group. (scaled image included in appendix)

profit.

Needs arising out of machines:

- An affordable machine which are in accordance with the requirements of a marginal farm or farmer.
- The flexibility in time of cultivation followed by the marginal farmers needs to be addressed by the machine by being available at any point of time for any size of the marginal farm land.
- The machine should be compatible to the diverse soil conditions and terrain related to the cultivation area.
- The machines should yield maximum profit from all the farm by-products.
- The machine should be easy to use efficiently without much experience.
- The machine should complete the task with minimum number of labourers.
- The machine should be highly efficient and easy to maintain.
- The machine should ensure comfortable operating conditions at affordable cost to operator.
- The various machines in the market need to be made popular and aware among the farming community to find use of it.

The livelihood needs are:

- To attain maximum profit from rice by carrying out activities at lower cost.
- Avoid risks due to unpredictable weather by making use of resources at the required time.

- The farmers needs to store grains or rice for future use which is not possible now due to the lack of facility and conditions to dry or boil rice.

The needs arising from climate and land issues are:

- Ensure sufficient availability of water for the crops regardless of the climate and the terrain.
- The need to develop a system which can save the crop from heavy rains which causes floods due to the recent development of roads and other structures.
- The need to get higher yield as in other regions for the same area of cultivation.

4. Discussions

The poor social and economic security of the unorganized working sector is a matter of concern due to the majority of the working population engaged in it. And agriculture being a major contributor to the Indian economy and being in this unorganized sector calls for immediate attention. The marginal farmers being the majority of the Indian agriculture sector faces a series of issues due to the disadvantages arising out of small land holdings combined with the hardships of working in the unorganized sector. Being a food production deficit state and housing 95% of marginal farmers, the state of Kerala cries for attention for the declined cultivation of their staple crop, rice. The need to achieve higher food production and the contribution of rice cultivation to sustain the ecosystem of the rich flora and fauna and the water resources in the state is evident. Considering the importance of rice cultivation and the combined issues of unorganized sector and marginal farming, the understanding of needs of marginal rice farmers of Kerala are crucial in the current scenario for the overall development of rice and marginal farmers of the deficient food production state.

The study conducted in understanding the activities in rice farming makes it clear that it is a highly intensive process. Even though every stage is highly demanding and important, the effort and dependency on external resources are found to be more in the

land preparation, transplanting and the harvesting stages. This is clear from the primary and secondary research. In the current scenario, the shortage of labourers in peak season and due to the higher wages, farmers are battling with higher production cost as the solutions to mechanization for seasonal cultivation and small holdings are left as a challenge unresolved. The available unaffordable solutions have led farmers to struggle with the traditional manual labour which take a toll on the health of farmers and labourers due to the occupational health hazards arising from the awkward working postures. The design of equipment or machines without ergonomic factors worsens the situation.

A study carried out on the machines used in rice cultivation showcases a wide variety of products for various activities. Correlating this database of the products with the needs arising from the primary research and some of the challenges in the mechanization of marginal farming as discussed in secondary research, these machines do not meet the real needs of the user group of the current study. The reason is majorly due to the complexity in the marginal farming due to the factors such as small size of land, different harvesting time, the diverse soil conditions and the inaccessible locations, which make it not economically viable for many of the machines and many of the machines not affordable and suited for the genuine and unique needs of the farmers.

The current investigation reveals that the requirements of the marginal rice farming community based on the research carried out is to ensure maximum profit in rice farming through a solution which will be:

- highly efficient in carrying out the activities in the field
- available for any soil, terrain and size of land below 1 hectare
- available at the desired time

- affordable
- ensuring maximum profit from farm by products
- operated without any expertise
- quick at maintenance or replacement

The high efficiency of the solution is arising from the need for minimal production cost which is missing out due to the inefficient manual labour and lack of compatibility and affordability of existing efficient technology for these marginal fields. The diversity in the soil conditions and terrain demands for a solution which is compatible to these conditions as well as economically viable for the smaller land holdings. The flexibility in the cropping time due to the commitments of the farmers to other source of income demands for a solution which is available at the desired time and also to ensure that there is no loss of yield due to delay in activities. The solution should be affordable considering the usage, cost and the economic conditions of the farmers. The value of farm by products is dependent on various market scenarios and the solutions should cater to these needs of earning maximum profit. The need for experience in operating the existing machines and the effect of this on the yield of the crop along with the unavailability of experienced operators demand for a solution which is independent of expertise for usage. Timing of each activity being a crucial factor in agriculture demands for the solution to be quick at maintenance and replacement.

5. Conclusion and future scope of work

The idea behind the project was to understand the concerns and issues of the marginal rice farmers in the state of Kerala in India and to define the specific requirement to resolve the crisis if any found. The project carried out secondary and primary research extensively to understand the context and the issues of the marginal farmers and other associated members of the farming community. The data collected was analysed and has yielded the true needs of the marginal farmers as discussed in the previous chapter of the report. Apart from the findings of the user needs the importance and relevance of user centric design process is also understood. The process undergone has also resulted into an understanding of the interview methods and interpretation of the user needs from the data.

The future scope of the work takes the project to phase-2 where the needs of the users will be prioritized and the solutions will be designed to satisfy the requirements.

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1. Farmer Interview

Self-Introduction

Hello, ‘m Midhun and ‘m currently doing a project related to rice cultivation as a part of my studies. I would like to know about activities in rice cultivation.

Information about the farmer.

Name: Age: Location

Kindly tell me where do you live? Who all are there in your family?

How many years have you been cultivating rice?

How much land do you cultivate?

What was the motivation to pick or continue in this field?

Is it inherited from parents?

Activities in cultivation of rice

Can you briefly tell me about the various activities in rice cultivation?

How many crops/seasons do you cultivate in a year?

Can you please describe each activities in detail (Time required, number of workers, skill of workers, machines used)

Physical and mental stress.

Have you ever been injured during any of the activities?

Do you have any general health problems?

Economic conditions

Do you receive any benefits from the government?

Where do you sell rice? How easy is it?

How much will you earn? Is it sufficient for livelihood?

Do you have any additional source of income?

Machines

How do you get the machines to the field? Is it easy to access?

Do you own any machines?

Do you operate it yourself?

What is the cost? How did you finance?

2. Farmer (quit) Interview

Self-Introduction

Hello, ‘m Midhun and ‘m currently doing a project related to rice cultivation as a part of my studies. I would like to know about rice cultivation in your time and reasons to quit.

Information about the farmer

Name: Age:
Number of years of experience in rice cultivation:

When did you stop cultivating rice?
What was the primary reason?
What was mode of cultivation? (Manual or mechanical)
How much land did you have?
What was the investment?
How much was the profit?
Do you plan to cultivate rice with the new development seen in rice cultivation?
What is your current source of income?

3. Operator Interview

Self-Introduction

Hello, “m Midhun and ‘m currently doing a project related to rice cultivation as a part of my studies. I would like to know about some of the machines used in rice cultivation and the related activities.

Information about the operator.

Name: Age: Location
What machines do you use specific to rice cultivation? Is it a seated type of machine or walking type?
How many years have you been in the field?
How did you get into this field for the first time?

What was the major reason for you to stick to this field?
What is your educational background?

Usage of machine

Can you explain the activities in using the machine from the start?
How are the controls of the machine in understanding for a first time user?
How do you transport the machine to field? Explain the difficulties during the process. (Walking, driving, towed or freight.)
Is there anyone to assist during operating and transportation? How it helps? (Issues in using the machine alone maybe pointed out)
I heard some machines sink in the field? Did you have any such experience? What did you do in such situation?
Did you have any problems in moving the machine from one field to another? Crossing the bunds as in some regions there are bunds as high as 1m.
Is there any specific pattern of movement during the activity? How do you feel while taking turns at the end of the field? How does the machine handle the edges of the field?
Is the machine easy to use by women and aged people?
What is the power source used? How is the machine in terms fuel efficiency, efficiency in processing (time and productivity)? (No. of hours of work and the area completed)
Have you noticed any exposed part posing a threat to user safety?
Have you ever felt the need to modify or modified the machine to suit for any of your specific needs for usage or ease of repair? Have you ever seen any such modified machines or used it?
Any bad experience in using this machine? What do you find interesting in using

this machine?

Have you used the sitting type of machine? How did you feel the difference from walking type? What was your experience? (Also ask vice versa if the operator is using walking type machine)

How was the experience in transporting it? How was the experience in crossing the bunds which are taller? How did you manage?

Physical and mental stress.

How many hours do you work on an average? How do you feel the work?

What was the longest period of work in a day? How did you feel the work? Did you have any sprain or injuries? Did you face any problem standing in wet soil or water for long time? Do you use safety shoes?

Economic conditions

Is the job seasonal? What do you do during offseason? Do you use this machine for any other purposes other than this? Or is it possible to use?

Do you own any machine? What is the cost? How did you finance?

How do you charge for the services? Hourly, daily or quantity of grain or any other measure? What are the charges? Is the income from this sufficient to take care of your family and expenses? Do you have any other source of income? What is that?

How do you manage the time and commitments to the appointments made to farmers? (As farmers were mentioning about the uncertainty in the availability of machines) What is the reason for this? Can you share an experience of yours in dealing with such a situation?

Training

Have you received any formal training in operating the machine? What was the duration of training? Who provided the training? How expensive was the training?

Based on your experience how do you feel about the need for training? What was the advantage?

If no training received, how did you first learn to use the machine? How long did it take?

Do you remember any incidents of confusion in using the machine during those beginning days?

4. Solution Provider - Agriculture mechanization Interview

Self-Introduction

Hello, "m Midhun and 'm currently doing a project related to rice cultivation as a part of my studies. I would like to know about the mechanization in rice cultivation and the processes involved in solving the challenges in mechanization of farms with less than 2.47 acres of land.

Information about the solution provider.

Name: Title of job: Organization:

Experience:

Area of interest: (marginal, small scale, large scale) (Reason)

Previous work experience if any:

What are the challenges in finding solutions through mechanization for farms with less than 2.47 acre?

The design process

Please explain the typical process in the development of a machine.

What criteria do you take into account during the design? (Ease of use of the machine, safety of operators, local terrain and soil conditions, Affordability)

How do you choose the mechanism? Material? Manufacturing?

How do you evaluate the machine after the design?

What is your opinion about innovators from villages? What are their contributions in development of new products?

The current scenario

What could possibly be the reason for some machines not being popular and not even known to farmers?

What is the pace of mechanization in rice cultivation in fragmented land holdings and less than 2.47 acres?

What is your opinion about using the machines imported from other countries in rice farming? Do we face any problems with that? (Soil conditions, Anthropometric, safety issues due to cultural differences, spare parts etc.)

Personal experiences

Would you like to share any memorable projects? What were the challenges? How did you crack it?

Can you please tell about the nature of the development team? Are there experts from different fields? Who all?

Appendix 2

Sl. No.	Name, Age	Experience (years)	Area of cultivation	No. of crops/year	Motivation	Other source of income or crops	Land preparation	Sowing and Transplantation	Fertilizer and irrigation	Deweeding	Harvesting	Machines owned by farmer	General issues	Transportation and maneuverability	Health injuries	Rice cultivation for livelihood
1	Balan, 55	30	2	2	Farming as a profession, rice cultivation is seasonal and only for 4 months and aided by machines now.	Banana, Chinese potato(Plectranthus rotundifolius)	Power tiller used if the soil condition causes sinking of tractor.	Pays Rs. 3500/acre for transplantor (1 driver and 2 helpers). Contract basis, seed provided by farmer.	Manual irrigation and fertilizer based on soil type	Manual and uses weedicide	1st crop: rainy season, muddy soil, reaps and transfer onto bunds and later taken away for threshing. 2nd crop: summer, threshing done in field itself, less weight, less no. of workers. Currently manual labour.	Nil	Shortage of labourers, uncertainty in availability during some season. If number of people are less then the days of harvesting extents. Machines are unaffordable if it is not a source of income. Loss of crop due to attack from wild animals	combine harvester can't traverse across bunds high as 1m and bigger combines touch electric lines.	Disappointment due to crop loss, long time work postures results in sprains and gets alright by next day.	Can't survive with rice cultivation alone
2	Babu, 35	17	0.45	1	Interested in farming. Feels good to eat self grown rice which is of better quality.	Goldsmith, Banana cultivation	Tractor	Manual sowing.	Fertilizer applied manually. For pesticide depends on other farmer since allergic to pesticide.	Manually done by self	Manually done as the land is fragmented and farmers not always sow at the same time resulting in different harvesting season and making combine harvesters not feasible for a single plot. At times shortage of labour experienced and delays harvest.	Nil	Shortage of labourers, uncertainty or delay in getting the machine on right time. Pointed out the problems with hay collected in small combines being not similar to traditional stock. But also said the problem is escalated by the uncertainty in timely availability of machine.	There are no problems in moving around and into the field.	No physical problems till now. But worries about climate	Not feasible to live from agriculture alone.
3	Sivaraman, 59	3	1	1	Interested in farming, availability of machines and support by society. Only 3.5 months required for cultivation.	Structural works	Only power tiller can be used as the fields are muddy and loose. Only pays for the job and no confusion. Bunds done by self, not very big and not strongly made.	No transplanting. Only sowing. Testing going on with transplantor this year as previous experience failed as during the second trip the mud went down on the transplanted area as it got loose.	Manual and fertilizer provided by society	Stays back from welding work and work with wife in field to manually pluck away the weed.	Done with combine harvesters. Tracked harvesters. Operators intentionally delay by not going in optimal pattern. Rice sold from field itself and no transportation worries.	Nil	The expenses incurred for labourers are one reason for less profit as compared to olden days. Not possible to parboil the rice as no facilities available like firewood and availability of people. The shortage of labourers have resulted in not cultivating 2 seasons like olden days. The decisions are taken collectively and even if anyone wants to cultivate 2 season the society may not do it.	The transfer of combine harvester across the irrigation canals or streams demand for layering of hay to make path for the harvester	No problems	Not feasible to live from small land like his and also one season crop pays off less.
4	Jose, 70		2		The need for a life sustaining ecosystem and self interest	Coconut, rice, cash crops	Tractor			Pesticide applied manually	Harvester used and comes only when a minimum of 50-100acre land ready. At times when combines are not rarely available, then reaper used. But now they have formed union and cultivating together. Do not have facility to boil and store rice for self use	Nil	problems with rain, drying of harvested crop is not possible, awareness about different machines are poor, adjusts with others and get machines from them for timely activities			Delay in getting money after sale
5	Unni, 42	20	2.5	1	Inherited from previous generation, and interest in farming, short duration of crop	Cow, money lending, construction machinery supplier	manual bund preparation and tiller	transplantor used due to labour shortage	Manual	Weedicide applied manually	combine harvester used.		Muddy soil demands more effort and labourer but higher yield possible.	Fields are dried thoroughly before harvesting. No problems		
6	Jayaprakashan, 70	50	30	2	Inherited from previous generation, better quality food for self		Uses tractor. Power tiller not available as no operator available for walking type	manually done	manually done	manually done	uses combine harvesters. Big combine harvester provides full length hay and earns more money. But works only in dry soil. Medium sized machine is good for muddy soil but hay is not as good as other machines output. Smaller plots requires more time and bigger plots requires lesser time. Muddy soil requires more time (almost double)	Have a tractor but no operator is available, so hires another tractor	1st season crop is difficult due heavy rain and shortage of labour. Requires more labourers during transplanting after sowing. The machines owned by government offices are not operating due to poor maintenance. Depends on machines from neighbouring state. The current labourers from kerala are not efficient.			Government support to rice farmers are not good enough. Delay in giving money after selling rice to govt.

