

SUSTAINABILITY OF RICE-BASED FARMING SYSTEM IN MANIPUR: A CRITICAL ANALYSIS

Thesis
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NAGALAND UNIVERSITY

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of
Doctor of Philosophy
in
Agricultural Extension Education
By

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2024

DEDICATED
TO
MY BELOVED
PARENTS
&
My Brothers

DECLARATION

I, **Bidyapati Thangjam**, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else and that the thesis had not been submitted by me for any research degree in any other university/institute.

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The result of the investigation reported in the thesis has not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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(Bidyapati Thangjam)

CONTENTS

CHAPTER	TITLE	PAGE NO.
1.	INTRODUCTION	1-13
	1.1 Concept of sustainability and sustainable agriculture	2-3
	1.2 Importance of sustainable farming	3-4
	1.3 Rice based farming system: Perspective on sustainable practice	5-6
	1.4 Perspective of agriculture in Manipur	6-8
	1.5 Statement of the problem	9-11
	1.6 Objectives	11
	1.7 Scope and importance of the study	11-12
	1.8 Limitations of the study	12
	1.9 Organization of the thesis	13
2.	REVIEW OF LITERATURE	14-63
	2.1 Concept of sustainability	15-17
	2.2 Dimensions of sustainability and the indicators for sustainability measurement	17-19
	2.3 Socio-economic and psychological characteristics of rice-based cultivation farmers	19-50
	2.4 Cropping pattern and farm resources management under rice-based farming system	51-53
	2.5 Attitude of farmers towards the adoption of sustainable agricultural practices	54-55
	2.6 Extent of adoption and factors determining sustainable agricultural practices	55-58
	2.7 Employment generation (mandays) under sustainable agricultural practices	58-61
	2.8 Constraints faced by farmers in adoption of sustainable agricultural practices	61-63

3.	RESEARCH METHODOLOGY	64-102
	3.1 Research design	64
	3.2 Locale of research	64-65
	3.3 Sampling procedure	66-71
	3.4 Selection of variables and their empirical measurements	72-98
	3.5 Hypothesis formulation	98-99
	3.6 Tools and technique of data collection	99-100
	3.7 Analysis of data	100-102
4.	RESULTS AND DISCUSSION	103- 302
	4.1 Socio-economic and psychological characteristics of rice-based cultivation farmers	103-173
	4.2 Examine the cropping pattern and farm resource management under rice-based farming system followed by the respondents	174-203
	4.3 Attitude of farmers and extent of adoption of sustainable agricultural practices under rice-based farming system	204-258
	4.4 Factors determining the sustainability of rice-based farming system	259-276
	4.5 Income and employment generation from livelihood enterprises under rice-based farming system	277-294
	4.6 Constraints faced by farmers in adoption of sustainable farming system	294-299
5.	SUMMARY AND CONCLUSIONS	300-359
	5.1 Introduction	300
	5.2 Objectives	300-301
	5.3 Research Methodology	301-302
	5.4 Results	302-312
	5.5 Conclusions	312-314
	5.6 Policy implications and recommendations	314-316
	REFERENCES	i-xxvi
	APPENDICES	i-xxvii

LIST OF TABLES

TABLE NO.	TITLE	PAGES
3.4.21.1	Selection of respondents under cropping pattern and resource management	85
3.4.22.1	List of final statements for the scale of attitude of farmers towards adoption of sustainable agricultural practices	89
3.4.24.1	Selection of indicators of sustainability	93
4.1.1.1	Distribution of respondents according to the category of age group	103
4.1.1.2	Comparative account of age of respondents	105
4.1.2.1	Distribution of respondents based on sex	106
4.1.3.1	Distribution of respondents based on the family type	107
4.1.4.1	Distribution of respondents based on the family size	108
4.1.4.2	Comparative account of family size of respondent	109
4.1.5.1	Distribution of respondents based on their educational level	110
4.1.5.2	Comparative account of educational level of respondents	112
4.1.6.1	Distribution of respondents based on their experience in rice-based farming	113
4.1.6.2	Comparative account of experience of respondents	114
4.1.7.1	Distribution of respondents based on total landholding area	115
4.1.7.2	Comparative account of total land holding area	116
4.1.8.1	Distribution of respondents based on the area under rice-based farming system	117
4.1.8.2	Comparative account of area under rice-based farming system	118
4.1.9.1	Distribution of respondents based on the annual income	119
4.1.9.2	Comparative account of annual income	121

4.1.10.1	Distribution of respondents based on income from rice-based farming system	122
4.1.11.1	Distribution of respondents based on training exposure	124
4.1.12.1	Distribution of respondents based on the training needs	126
4.1.13.1	Distribution of respondents based on the level of extension contact	128
4.1.13.2	Comparative account on the level of extension	130
4.1.14.1.1	Distribution of respondents based on formal information sources	131
4.1.14.1.2	Distribution of respondents based on the overall utilization of formal information sources	133
4.1.14.2.1	Distribution of respondents based on the utilization of informal information sources	134
4.1.14.2.2	Distribution of respondents based on the overall utilization of informal information sources	136
4.1.14.3.1	Distribution of respondents based on the utilization of mass media information sources	137
4.1.14.3.2	Distribution of respondents based on the overall utilization of mass-media information sources	139
4.1.14.4.1	Distribution of respondents based on the utilization of social-media information sources	140
4.1.14.4.2	Distribution of respondents based on the overall utilization of social media of information sources	141
4.1.14.5	Distribution of overall respondents based on the level of information sources utilization pattern	142
4.1.14.6	Comparative account of information sources utilized by the respondents	143
4.1.15.1	Distribution of respondents based on the knowledge level of sustainable agricultural practices in valley districts	145
4.1.15.2	Distribution of respondents based on the knowledge level of sustainable agricultural practices in hill districts	148
4.1.15.3	Overall knowledge index on the sustainable agricultural practices	151

4.1.15.4	Distribution of overall respondents based on the knowledge level of sustainable agricultural practice	153
4.1.15.5	Comparative account of knowledge level on sustainable agricultural practices	155
4.1.15.6	Correlation of socio-economic and psychological characteristics with their knowledge on sustainable agricultural practices	156
4.1.16.1	Distribution of respondents based on scientific orientation	158
4.1.16.2	Comparative account of scientific orientation on rice based farming system	159
4.1.17.1	Distribution of farmers based on the innovativeness	160
4.1.17.2	Comparative account of innovativeness on sustainable agricultural practices	161
4.1.18.1	Distribution of respondents based on risk orientation	162
4.1.18.2	Comparative account of risk orientation	163
4.1.19.1	Distribution of respondents based on the production orientation	164
4.1.19.2	Comparative account of production orientation	165
4.1.20.1	Distribution of respondents based on market orientation	166
4.1.20.2	Comparative account of market orientation	167
4.1.21.1	Distribution of farmers based on perception towards climate change in valley districts	168
4.1.21.2	Distribution of farmers based on perception towards climate change in hill districts	170
4.1.21.3	Distribution of overall respondents based on the perception towards the impact of climate change	171
4.1.21.4	Comparative account on perception towards the impact of climate change	173
4.2.1	Crop calendar indicating the major rice-based cropping pattern found in the four selected districts of Manipur	174
4.2.2	Distribution of respondents based on the major cropping pattern of rice-based farming system	177

4.2.3.1	Distribution of respondents based on the farm management practices under rice based farming system (RBFS) of Thoubal district	179
4.2.3.2	Distribution of respondents based on the farm management practices under rice based farming system (RBFS) of Imphal East district	182
4.2.3.3	Distribution of respondents based on the farm management practices under rice based farming system (RBFS) of Churachandpur district	184
4.2.3.4	Distribution of respondents based on the farm management practices under rice based farming system (RBFS) of Senapati district	186
4.3.1.1	Distribution of respondents based on their attitude towards the adoption of sustainable agricultural practices	204
4.3.1.2	Comparative account on attitude towards adoption of sustainable agricultural practices	206
4.3.1.3	Correlation of socio-economic and personal variables with attitude towards adoption of sustainable agricultural practices	207
4.3.2.1	Distribution of respondents based on the extent of adoption of sustainable agricultural practices in valley districts	209-210
4.3.2.2	Distribution of respondents based on the extent of adoption of sustainable agriculture practices in hill districts	213-214
4.3.2.3	Distribution of overall respondents based on the adoption under sustainable agricultural practices	217
4.3.2.4	Ranking of adoption on sustainable agricultural practices based on mean score	219
4.3.2.5	Distribution of overall respondents based on the adoption level of sustainable agricultural practices	221
4.3.2.6	Comparative account on response of adoption on the sustainable agricultural practices	222
4.3.2.2.1	Distribution of respondents based on the extent of adoption of sustainable practices under rice-fish farming system in Thoubal district	223

4.3.2.2.2	Distribution of respondents based on the extent of adoption of sustainable practices under rice-fish farming system in Imphal East district	225
4.3.2.2.3	Distribution of respondents based on the extent of adoption of sustainable practices under rice-fish farming system in Senapati district	227
4.3.2.2.4	Distribution of overall respondents based on the extent of adoption of sustainable practices under rice-fish farming system	229
4.3.2.2.5	Distribution of overall respondents based on the level of adoption of rice-fish farming system	231
4.3.2.2.6	Comparative account on adoption of sustainable practices under rice-fish farming system	232
4.3.2.3.1	Distribution of respondents based on the extent of adoption of rice-mustard farming system in Thoubal district	233
4.3.2.3.2	Distribution of respondents based on the extent of adoption of rice-mustard farming system in Imphal East district	235
4.3.2.3.3	Distribution of respondents based on the extent of adoption of sustainable practices under rice-mustard farming system in Churachandpur district	237
4.3.2.3.4	Distribution of overall respondents based on the extent of adoption of sustainable practices under rice-mustard farming system	239
4.3.2.3.5	Distribution of overall respondents based on the level of adoption under rice-mustard farming system	241
4.3.2.3.6	Comparative account on response of adoption of rice-mustard farming system	242
4.3.2.4.1	Distribution of respondents based on the extent of adoption of rice-vegetables farming system	243
4.3.2.4.2	Distribution of overall respondents based on extent of adoption under rice-vegetables farming system	246
4.3.2.4.3	Distribution of overall respondents based on the level of adoption under rice-vegetable farming system	247
4.3.2.4.4	Comparative account of adoption under rice-vegetable farming system	248

4.3.3	Correlation of socio-economic and personal characteristics of farmers with their adoption of rice-based farming system	249
4.3.4	Path coefficients of selected variables with respect to adoption of rice-based farming system	251
4.3.5	Socio-economic and personnel factors explaining variance towards adoption of sustainable rice based farming	254-255
4.4.1	Sustainable index of rice-based farming systems in the selected districts of Manipur	259
4.4.2	Sustainable index of the selected rice-based farming system in Manipur	261
4.4.3	Distribution of respondents based on sustainability of rice based farming system practiced by the farmers of Thoubal district	263
4.4.4	Distribution of respondents based on the sustainability of rice-based farming system practiced by the farmers of Imphal East district	264
4.4.5	Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Churachandpur district	265
4.4.6	Distribution of respondents based on sustainability of rice base farming system practiced by the farmers of Senapati district	266
4.4.7	Distribution of overall respondents based on sustainability of rice-based farming system	267
4.4.8	Predictors of environmental sustainability of rice-based farming system	268
4.4.8.1	Model of environmental sustainability on rice-based farming system showing the effectiveness of variables	269
4.4.9	Predictors of social sustainability of rice-based farming systems	271
4.4.9.1	Model of social sustainability on rice-based farming system showing the effectiveness of variables	272
4.4.10	Predictors of economic sustainability of rice-based farming system	274
4.4.10.1	Model of economic sustainability on rice-based farming system showing the effectiveness of variables	275

4.5.1	Employment generation in mandays (per hectare per year) under the rice-based farming system	277
4.5.2	Cost of cultivation and income generated under rice-based farming system (RBFS) in Thoubal district	280
4.5.2.1	Cost of cultivation and income generated under rice-based farming system (RBFS) in Thoubal district per hectare	282
4.5.3	Cost of cultivation and income generated under rice-based farming system (RBFS) in Imphal East district	283
4.5.3.1	Cost of cultivation and income generated under rice-based farming system (RBFS) in Imphal East district per hectare	285
4.5.4	Cost of cultivation and the income generated under rice-based farming system (RBFS) in Senapati district	286
4.5.4.1	Cost of cultivation and income generated under rice-based farming system (RBFS) in Senapati district per hectare	288
4.5.5	Cost of cultivation and the income generated under rice-based farming system (RBFS) in Churachandpur district	289
4.5.5.1	Cost of cultivation and the income generated under rice-based farming system (RBFS) in Churachandpur district per hectare	291
4.5.6	Distribution of average income and yield under the different rice-based farming system (RBFS) in the selected districts	292
4.6.1	Constraints faced by the respondents under sustainable rice-based farming systems	294
4.6.2	Ranking of the constraints faced by the respondents in adopting sustainable rice-fish farming system	297
4.6.3	Constraints faced by the respondents under sustainable rice-mustard farming system (RMFS)	298

LIST OF FIGURES

FIGURE NO.	CAPTION	IN BETWEEN PAGES
3.2.1	Selection of state	65-66
3.3.1.2	Selection of districts	71-72
3.3.1.3	Sampling design	71-72
3.3.1.3	Selected blocks and villages	71-72
4.1.1.1	Distribution of respondents based on age	105-106
4. 1.2.1	Distribution of respondents based on sex	105-106
4.1.3.1	Distribution of respondents based on the family type	109-110
4.1.4.1	Distribution of respondents based on the family size	109-110
4.1.5.1	Distribution of respondents based on their educational level	111-112
4.1.6.1	Distribution of respondents based on their experience in rice-based farming	114-115
4.1.7.1	Distribution of respondents based on total landholding area	116-117
4.1.8.1	Distribution of respondents based on the area under rice-based farming system	118-119
4.1.9.1	Distribution of respondents based on annual income	121-122
4.1.10.1	Distribution of respondents based on income from rice-based farming system	123-124
4.1.11.1	Distribution of respondents based on the training exposure	124-125
4.1.12.1	Distribution of mean based on the training needs	126-127
4.1.13.1	Distribution of respondents based on the level of extension contact	130-131
4.1.14.5	Distribution of respondents based on the overall level of information sources utilization	144-145

4.1.15.4	Distribution of overall respondents based on overall knowledge level of sustainable agricultural practices	154-155
4.1.16.1	Distribution of respondents based on scientific orientation	161-162
4.1.17.1	Distribution of farmers based on the innovativeness	161-162
4.1.18.1	Distribution of respondents based on risk orientation	165-166
4.1.19.1	Distribution of respondents based on the production orientation	165-166
4.1.20.1	Distribution of respondents based on market orientation	167-168
4.1.21.3	Distribution based on the mean (ranking) of perception towards of climate change	173-174
4.2.4.1	Interaction of farm resources components in rice-fish farming system	194-195
4.2.4.2	Interaction of farm resources components in rice-mustard farming system	199-200
4.2.4.3	Interaction of farm resources components in rice-vegetables farming system	203-204
4.3.1.1	Distribution of respondents based on their attitude towards the adoption of sustainable agriculture practices	206-207
4.3.2.4	Ranking of adoption of sustainable agricultural practices based on mean score	220-221
4.3.2.5	Distribution of respondents based on the adoption level of sustainable agricultural practices	222-223
4.3.2.2.5	Distribution of respondents based on the level of adoption of rice-fish farming system	232-233
4.3.2.3.5	Distribution of respondents based on the level of adoption of rice-mustard farming system	242-243
4.3.2.4.3	Distribution of overall respondents based on the level of adoption under rice-vegetable farming system	248-249

4.4.1.1	Sustainable index of rice-based farming systems in the selected districts of Manipur	259-260
4.4.1.2	Overall sustainable index of rice-based farming systems in the selected districts of Manipur	259-260
4.4.1.3	Sustainable index of valley region and hill region of rice-based farming systems	259-260
4.4.2	Sustainable index of the selected rice-based farming system in Manipur	262-263
4.4.2	Overall sustainable index of the selected rice-based farming system in Manipur	262-263
4.4.3	Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Thoubal district	263-264
4.4.4	Distribution of respondents based on the sustainability of rice-based farming system practiced by the farmers of Imphal East district	263-264
4.4.5	Distribution of respondents based on the sustainability of rice-based farming system practiced by the farmers of Churachandpur district	265-266
4.4.6	Distribution of respondents based on the sustainability of rice-based farming system practiced by the farmers of Senapati district	265-266
4.4.7	Distribution of overall respondents based on sustainability of rice-based farming system	267-268
4.5.1.1	Employment generation (mandays) under the different types of farming system	277-278
4.5.1.2	Employment generation (mandays) in activities under the different types of farming system	277-278
4.5.6.1	Distribution of BCR under rice-based farming system (RBFS) in the selected districts	292-293
4.5.6.2	Distribution of rice yield under rice-based farming system (RBFS) in the selected districts	292-293
4.5.6.3	Distribution of net income (Rs/ha) under rice-based farming system (RBFS) in the selected districts	292-293

LIST OF PLATES

PLATE NO.	CAPTION	IN BETWEEN PAGES
1.	Field structure for rice-fish farming system in Imphal East and Thoubal district (Valley district)	187-188
2.	Field structure for rice-fish farming system in Senapati district (Hill district)	187-188
3.	Field of rice-fish farming system	193
4.	Field of a rice-mustard farming system at hill district	195
5.	Field of a rice-mustard farming system in valley district	198
6.	Field of a rice-vegetables farming system	200
7.	Field of a rice-vegetables farming system in Senapati district	201
8.	Data collection activities	xxiii-xxvii
9.	Field visit for observation and records	xxiii-xxvii
10.	Field structure of rice-based farming system	xxiii-xxvii
11.	Farmers activities in the field	xxiii-xxvii

LIST OF APPENDICES

APPENDIX NO.	TITLE	PAGES
A	Interview schedule	i-xxiii

LIST OF ABBREVIATIONS

%	Per cent
&	Ampersand
@	at the rate
₦	Nigerian nairas currency
<	Less-than sign
>	Greater-than sign
°C	Degree Celsius
BCR	Benefit Cost Ratio
cm	Centimeters
<i>et al.</i>	<i>Et alli</i> (and other)
<i>etc.</i>	<i>et cetera</i>
FAO	Food and Agriculture Organization
Fig.	Figure
g	Gram
ha	Hectare
HYV	High Yield Variety
km ²	Square Kilometer
mg	Mili gram
ml	millilitre
MT	Metric ton
R	Rand (South Africa currency)
Rs	Rupee
SFA	Sustainable food and agriculture
t/ha	Tons per hectare
Tk	Taka (Bangladesh currency)
<i>viz.</i>	<i>videlicet</i> (namely)
σ	Standard deviation
$\bar{\chi}$	Mean

ABSTRACT

The present study entitled “**Sustainability of rice-based farming system in Manipur: A critical analysis**” was carried out with an objective to understand the phenomenon of sustainable rice-based farming system, to find out the sustainable resource management practices of farmers, to study the extent of adoption of current technology of rice-based farming systems, to know the employment & income generation, to identify the major constraints faced by farmers in rice-based farming system. The study was conducted in the state of Manipur. Ex-post facto research design and multistage purposive cum random sampling design was followed for the study. Four districts viz., Imphal East and Thoubal district representing valley area and Churachandpur and Senapati district representing the hill area of Manipur. From each of the selected districts, two blocks were selected randomly. Thus, 8 blocks were selected. Two villages from each of the selected blocks were randomly selected comprising a total sixteen villages. Further 20 respondents from each village were selected and a sample of 320 respondents was included for the present study. Findings of the study revealed that majority of the respondents were male, middle aged and had nuclear family having medium family size. Majority respondents were educated upto secondary level, had high experience on rice-based farming, small landholding having less than 1 acre of land under rice-based farming system. Majority of the respondents had an average income of Rs. 55,365.00, no training exposure, had medium level of extension contact, information sources utilized, knowledge level, scientific orientation, innovativeness, risk orientation and market orientation. Major cropping pattern under rice-based farming system were rice-fish farming system (RFFS), rice-mustard farming system (RMFS) and rice-vegetables farming system (RVFS). RFFS was followed in Thoubal district, Imphal East district and Senapati district, RMFS was followed in Thoubal district, Imphal East district and Churachandpur district and RVFS was followed in Senapati district and Churachandpur district. In case of farm resources management, majority of the respondents practice both machine and manual process in land preparation, used both local and HYV variety, used organic nutrient management and rain-fed water management, practice cultural control method of weed management, pest management and disease management. Most of the respondents harvested rice manually and used crop residue for animal feed and recycling of plant nutrients. Majority of the respondents had favourable attitude towards the adoption of sustainable agricultural practices with an attitude index of 65.40. In case of adoption of sustainable rice-based farming system, majority of them had medium level of adoption in RMFS with an attitude index of 63.69 followed by RFFS with an adoption index of 63.42 and RVFS with an adoption index of 58.31. Size of land under rice-based farming, annual income, income from rice-based farming, informal information, mass media information sources, perception towards climate change and risk orientation had found positive and significant association with adoption of sustainable rice-based farming system. The highest total effect on adoption of rice-based farming system was exerted by training exposure, the direct effect exerted by income from rice-based farming system and most highest three largest variables through which indirect effect were channelized included experience in rice based

farming system through experience in agriculture, age and training exposure. In case factor influencing the sustainability of rice based farming system, a total of 21 independent variables were conglomerated and 9 factors were elicited and renamed. The nine factor account for 69.59 per cent variations in explaining the sustainability of rice based farming system. In the context of sustainability, Thoubal district had the highest sustainable index (65.44) followed by Imphal East district (62.05), Senapati district (60.34) and Churachandpur district (58.47). Environmental sustainability had the highest sustainability level (63.32) followed by social sustainability (60.51) and economic sustainability (59.52) under rice-based farming systems in Manipur. Valley region had higher sustainability in rice-based farming system in comparison to the hill region and overall sustainability index of rice-based farming system was found to be 61.58. RFFS had the highest sustainability (65.49) followed by RMFS (59.06) and RVFS (58.89). The predictors of environmental sustainability explained the variations up to 87.90 per cent, social sustainability (9.49%) and economic sustainability up to 9.29 per cent. RVFS generated 251 mandays followed by RFFS (240 mandays) and RMFS (201 mandays). Rice-fish farming system gave higher income and rice productivity. Thoubal district had the highest productivity under rice-based farming system. Thoubal district and Imphal East district representing valley region had higher sustainability score of (63.75) than Churachandpur district and Senapati district, representing hill region with sustainability score (59.41). Overall sustainability index of rice-based farming system was found to be moderate (61.58). In RFFS, Thoubal district had the highest net income (Rs 293468.90/ha) having highest rice productivity (4.6 t/ha with 3.20 BCR followed by Imphal East district and Senapati district. In RMFS, Thoubal district had the highest net income (Rs 140579.00/ha) having rice productivity of 3.84 t/ha with BCR (2.20) followed by Imphal East district and Churachandpur district. In RVFS, Senapati district had higher net income (Rs 89236.11/ha) having rice productivity 2.62 t/ha with BCR 1.50. Farmers faced major constraints in term of lack irrigation sources, lack of improved technology for rice-based cultivation, change in monsoon change and lack of subsidies under rice-based farming system. It may be concluded that rice-based farming system has immense potential to improve the income of farmers, and can also contribute significantly towards sustainable production of rice. However in rice-based farming system hilly region had low sustainability than valley region. Therefore, synergistic interaction of the components of rice-based farming system need to be taken care to enhance the resource use efficiency and recycling of farm resources. Adoption of location specific farming technology may prove instrumental for further improvement of sustainability production under rice based farming system.

Keywords: Sustainability, rice-based farming system, influencing factor, Manipur

CHAPTER I

INTRODUCTION

INTRODUCTION

Food supply comes mostly from agriculture, which also contributes to the growth of the global economy and infrastructure. One of the most effective methods for reducing extreme poverty, fostering wealth, and feeding the world's population is the agricultural sector. In comparison to other sectors, growth in the agriculture sector is two to four times more successful at raising the incomes of 80% of the poor people in rural areas (World Bank, 2023). According to Ministry of Statistics and Programme Implementation (2021), India is the second-most populous nation in the world with 1.39 billion people and is predicted to surpass China by 2027–2030.

The lifestyle, civilization, culture, and heritage of India are all based on agriculture. The majority people in the country make a living from agriculture. India is the seventh-largest country in the world with 3.28 million sq.km (FAO, 2023). According to the Indian Brand Equity Foundation (2022), India has the second-largest arable land of 160 million hectares with access to all 15 notable climates. Additionally, India's landmass contains 46 out of the 60 soil types occupying 50% of its whole geographic area under cultivation. India has more diverse agricultural foundation than any other nation, which increases the likelihood which results in making our nation global agricultural commercial pioneer.

However, due to rising demand and the deterioration of natural resources, there has been a faster decline of natural resources over the past 50 years. The nation is currently dealing with second-generation issues, particularly those pertaining to nutrition and sustainability. Food systems are being impacted by many shocks, from COVID-19 related disruptions to extreme weather, pests, driving up food costs, etc. The resilience and sustainability of agricultural systems are impacted, and climate change ultimately puts further strain on already-stressed resources and threatens the agricultural industry, making rural communities more susceptible (Jia *et al.*, 2019). India needs to address the issue of resource scarcity and embark on a constructive, inclusive, and environmentally sustainable form of development if it is to achieve the

required economic growth along with this expanding population and unsustainable agricultural practices. As a result, sustainability has become essential to agricultural policy and practice going forward. In order to be truly sustainable, agriculture must prioritize two intertwined societal goals: protecting the environment and ensuring access to nutritious food for all (Oberc and Schnell, 2020).

1.1 Concept of sustainability and sustainable agriculture

In October 1987, Our Common Future, also known as the Brundtland Report, was published by the World Commission on Environment and Development. In that report, the term "sustainable development" was officially defined as: "Meeting the needs of the present without compromising the ability of future generations to meet their own needs". Sustainability can be defined as the efficient and equitable distribution of resources for present generation and future generation with the operation of socio-economic activities within the confines of a finite ecosystem (Ben-Eli, 2015). Sustainability brings into focus human activities and their ability to satisfy human needs and without depleting or exhausting the productive resources (Mensah, 2019). In agriculture, sustainable agricultural implies an agricultural production that ensures the ecological stability, economic viability, and socio-cultural permanence (Suresh *et al.*, 2022). Sustainable agriculture act of farming using principles of ecology, the study of relationships between organisms and their environment. It has been defined as an integrated system of plant and animal production practices having a site-specific application that will last over the long term (Das *et al.*, 2020). Sustainability is generally considered to be comprised of three pillars: environmental sustainability, economic sustainability and social sustain. It is a complex idea with many facets which includes social (having a fair deal with its workers as well as a mutually beneficial relationship with the encircling community), economic (should be a profitable business contributing a robust economy) and environmental (having potential to attenuate air, water and climate pollution, build and maintain healthy soil, manage water wisely and promote biodiversity) aspects.

Towards this, the agricultural development strategy has to consider a trade-off between economic benefits and social equity and environmental sustainability (Suresh *et al.*, 2022). Sustainable crop production intensification has become increasingly important as a way of improving use efficiency while conserving resources, minimizing negative inputs on the environment, producing more from the same area of land and improving the flow of natural capital and ecosystem services (Xie, 2019). Sustainable agriculture has been presented as a promising concept that utilizes a wide range of technologies. It aims to increase yields while protecting the environment, land, and other natural resources, as well as promoting a good quality of life and maintaining global food security (Diogo, 2022). This holistic approach has emerged as a promising solution in achieving sustainable food production and safety, primarily through the integration of conservation of the environment, socioeconomic well-being, and food production (Cakmakci, 2023).

1.2 Importance of sustainable farming

Sustainability plays a pivotal role in agriculture, as it aims to balance the need for increased food production with the long-term health of the environment, society, and economic systems. Sustainable agriculture promotes practices that minimize the negative impact of farming on the environment. This includes reducing soil erosion, conserving water resources, preventing pollution from agricultural chemicals, and protecting biodiversity. Sustainable agriculture encourages crop diversity as a means of reducing the risks associated with monoculture (growing a single crop over large areas). A sustainable food system involves minimizing food waste at all stages, from farm to table. Sustainable agriculture seeks to ensure the economic viability of farming operations. It focuses on strategies that can help farmers adapt to the challenges posed by climate change, such as increased temperatures, shifting rainfall patterns, and more frequent extreme weather events.

Sustainable agriculture needs to provide for both present and future generations while maintaining profitability, environmental health, and social and economic equality in order to be sustainable. Sustainable food and agriculture (SFA)

contributes to all four pillars of food security—availability, utilization, stability and the dimensions of sustainability (environmental, social, and economic) (FAO, 2018). Today, the agro biodiversity heritage of the planet is currently in danger. Human pressure on resources and unsustainable land use practices are approaching critical thresholds. Nutrients in the soil are being depleted more quickly than they can be formed. Unsustainable practices used in agriculture that cause ecosystem disruption and soil degradation have made agriculture one of the main sources of pollution. Additionally, in the last decades, harmful contaminants like pesticides and fertilizers used on farms have contaminated the air, land, and water resources (Singh and Craswell, 2021). However, we can improve the technique of agriculture so that it doesn't harm the environment and doesn't release toxins or other pollutants. Many experts agree that sustainable agriculture could be a way to address the current crisis in agriculture (Bekele *et al.*, 2021; Setsoafa *et al.*, 2022). Sustainable agriculture is less expensive; it provides the resources needed for the current human population while preserving the ability of the planet to support future generations (FAO, 2018). Sustainable agriculture is an integrated, systematic method of growing and distributing plants and animals that preserves the environment, increases the amount of the planet's natural resources, and makes the best use of non-renewable resources.

This method of farming adheres to the sustainable development principle, which states that current needs must be met without jeopardizing those of future generations. Sustainable agriculture places an emphasis on growing a variety of crops that are frequently suited to the local climate. Rather than relying on a single crop in industrial monoculture, sustainable agriculture advocates the use of polyculture, in which multiple crops are grown together. Cultivating multiple crops brings significant benefits to society that go far beyond the farm gate. In addition to maintaining biodiversity, enhancing soil and plant health, reducing susceptibility to pests and diseases, diversified agricultural enhance the household nutrition, income generation and creates jobs in the local community. The goal of sustainability in the farming system is to increase the efficient utilization of resources without affecting the natural resources without compromising the ability of future generations to meet their own needs.

1.3 Rice based farming system: Perspective on sustainable practice

Rice (*Oryza sativa* L.) is the second-most significant cereal crop in the world. Asian countries such as China, India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Pakistan, the Philippines, Korea, and Japan produce the majority of the world's rice. The evolution of India's culture and economy is significantly influenced by rice; the country's most important crop is rice (Mohapatra and Sahu, 2022). In comparison to the 510 million metric tons of milled rice produced globally (Shahbandeh, 2023), India is the second largest producer of rice in the world, producing 195 million metric tons, and China record as first with the production of over 212.8 million metric tons. As of 2020–2021, India exported 15.5 million metric tons of rice, which was the most in the world (Venkatesh, 2021). According to International Institute of Import and Export Management (2019), the country's food grain production is made up of rice. So the vast agricultural industry of rice production is essential to India's economic development, employment rates, and foreign exchange earnings in the different rice-related industrial sectors. In India, rice is the main crop that ensures the nation's food security (Nawaz *et al.*, 2019). Rice is one of the major food crops which play a crucial role in reducing the disparity between food grain demand and food supply (Kumar, 2022). Nevertheless, the monoculture of the rice production method results in anthropogenic changes that have a negative influence on the soil's physio-chemical and biochemical indicators, leading to a loss of biodiversity and a deterioration of the natural resource base, ultimately rendering farming unsustainable.

Concerns have been raised about the viability of rice planting systems in the future. First, some major rice-producing regions, including California (USA), China, Indonesia, and South Korea, have seen a slowdown in yield growth rates. Secondly, negative environmental impact is a concern as rice production consumes 30%, 14%, and 10%, respectively, of the global use of irrigation water, fertilizers, and pesticides. Thirdly, the production of rice contributes significantly to anthropogenic greenhouse gas (GHG) emissions, with rice production responsible for 30% and 11%, respectively, of the world's agricultural methane (CH₄) and nitrous oxide (N₂O)

emissions (Yuan *et al.*, 2021). Due to the expansion of crop production, rice cultivation faced a number of agronomic and environmental issues. The rice-based farming system, which has been used for more than a thousand years in Asia, is crucial to the restoration and management of the natural environment. It ensures a regenerative and sustainable agriculture system. The term "rice-based farming system" refers to the following:

- a. Combination of agricultural techniques with rice as the primary crop and the growing of other crops as a secondary crop.
- b. Rice and other crops that grow well together and are frequently inter-planted in various areas

Rice-based agriculture is a form of conservation and regeneration agriculture. This method of farming regenerates soil, eliminates synthetic pesticides and fertilizers, and decreases negative effects by ensuring agriculture is beneficial to the environment. At the same time, it seeks to maintain high levels of productivity. According to (Oberc and Schnell, 2020), rice-based cropping systems are important cropping systems that rotate crops such as cereals, pulses, oilseeds, sugarcane, green manures, vegetables, etc. Diverse rice-based cropping systems, including rice-rice followed by diverse cereals, pulses, oilseeds, vegetables, and fibre crops, have been reported from various parts of India. Diversified agriculture production conserves biodiversity, improves soil and plant health, and reduces exposure to pests, diseases, or extreme weather events. It brings greater rewards to farmers and the local community through improved nutrition and income generation (FAO, 2018). Rice based farming seeks to create a system that will regenerate itself after each harvest, this farming practice allows farmers to harvest other crops throughout the year from the same fields in addition to rice.

1.4 Perspective of agriculture in Manipur

Manipur, the state of India, is located in the north eastern part of the country, where agriculture is the primary economic sector. People's livelihoods and food security depend on the viability, quality, and sustainability of the dominant crops. The

major geographical area of the state is 22,327 sq. km, of which 90% is hilly (Churachandpur district, Senapati district, Ukhrul district, Tamenglong district and Chandel district), and the rest is a central valley (Imphal East district, Imphal West district, Thoubal district and Bishnupur district). Rice is the dominant crop cultivated in the Kharif season in Manipur. Rice is grown on around 65.93% of the total cropped area (Roy *et al.*, 2018). Rice has shaped cultures, diets, and economies, which are the backbone of the state. The agro-climatic condition of the region, Manipur, is very favorable for rice cultivation. The area under rice clearly indicates the importance of rice cultivation. Food security in the state entirely depends on rice, as no other cereals are grown by the farmers due to food habits and agro-climatic situations. Rice is grown in the hill and valley terrains of the state; it is cultivated in almost all the landforms and ecosystems, and they can be grouped into two major ecosystems, i.e., uplands, including jhum and terrace cultivation in the hill region, and lowlands, including jhum and terrace cultivation in the valley region. Four out of nine districts in Manipur are classified as high productivity area, while the remaining five are classified as low productivity area.

As per the report from Department of Agriculture Manipur, 2021-22 among the high-productivity districts, Thoubal district, with 30.15 thousand hectares of rice cultivated area and an average productivity of 3.9 MT/ha, has the highest paddy productivity in the state. Imphal East has the second highest rice productivity of 3.6 MT/ha with an area of 37.61 thousand hectares, followed by Bishnupur district with 29.36 thousand hectares and an average productivity of 3.5 MT/ha, and Imphal West with 39.83 thousand hectares and an average productivity of 3.21 MT/ha. Among the low-productivity districts, Churachandpur has the highest area of rice, with an area of 29.12 thousand hectares and an average productivity of 1.3 MT/ha. Tamenglong district possessed 27.45 thousand hectares of cultivated area with an average productivity of 1.31, followed by Senapati district with a cultivated area of 12.10 thousand hectares and an average yield of 1.34 MT/ha, representing the highest productivity in the hill district of the state, and Tamenglong district with an average productivity of 1.31 MT/ha (Anonymous, 2022).

In India, Manipur holds the 20th rank in terms of rice production and rice cultivation, with a total cultivated area of 175.5 thousand hectares and a total production of 602.2 thousand tons (2021–22) (Singh, *et al.*, 2023). The productivity of rice in the state is 2.2 t/ha, which is far less than in other states and even less than the average productivity (2.8 t/ha) of rice in India. Moreover, 90% of the farmers in the state are small and marginal farmers. The hilly region has low productivity, which is 50% lower than the average productivity of the state (Thangjam and Jha, 2020). Additionally, the long-term practice of mono-cropping and continuous rice cultivation with traditional methods posed serious threats to natural resources and the agricultural sustainability of the state. To enhance sustainability and productivity, the rice-base farming system is an alternative to replace the unsustainable practices of humans. Rice-based farming systems are practiced both in the hills and valley of Manipur. It has largely been adopted in a traditional way. Among the north-eastern states, Manipur is the most suitable site for a rice-based farming system, as the region has 79,360 hectares of water. Rice-based farming improved their economic position more than rice monocropping farming. In order to enhance the production of rice by an alternative method, rice cum fish farming plays a crucial role, as rice production increases by 10–12% in this farming compared to rice monoculture (Subedi and Paudel, 2020).

The rice-based farming system sustained the economic returns, employment generation, improved soil fertility, and environmental protection of the state. Diversified farms are usually more economically and ecologically resilient. Rice-rapeseed is also one of the climate-resilient crops that can be grown without water in the residual soil moisture. By adopting zero tillage, the farmers could increase productivity, reduce the cost of cultivation, increase cropping intensity, and earn additional income with less effort. Growing a variety of crops, farmers spread economic risk and are less susceptible to the radical price fluctuations associated with changes in supply and demand (Rafique and Ali, 2023). It also helps to maintain economic stability and, hence, improves the life quality of farmers. Rice-based production is an integrated system of production practices that aims to be sustained for a longer duration while ensuring the basic human needs of the state.

1.5 Statement of the problem

Manipur is a part of the Eastern Himalayan agro-climatic zone, which is broadly divided into plain and hilly regions. The state is located in the nation's monsoon region, with semi-temperate to subtropical temperatures in the valley and temperate to subtropical climates in the hill sections. Manipur's rich natural resources and excellent ecology provide the state with the power and opportunity to boost agricultural output using the resources at hand. The majority of Manipur's land is mountainous, while the remaining 10% is valley. About 10.46% of the entire geographical region is cultivated, and 90% of farmers have marginal or tiny land holdings (Meitei, 2019). The hill tribes practice jhum farming, which has led to the classification of 2190 thousand hectares as an eroded region. According to reports, a total of 2232 thousand hectares fall under the category of degraded and waste land, while 1597 thousand hectares are impacted by soil acidity. About 1189 thousand hectares fall under various soil loss classifications due to water erosion (>10 t/ha/year). The barren rocky slopes are the result of sheet and gully erosion on the high mountainous slopes (Roy *et al.*, 2018).

Contrarily, traditional agricultural methods pose a challenge because of their unbalanced use of resources, which raises cultivation costs and decreases land yield, making them unsustainable from an economic and environmental standpoint. Unquestionably, new technology has significantly increased agricultural production around the world, but some of those technologies have also had unfavourable effects that need to be contained or reversed. This includes biodiversity loss, insect pesticide resistance, soil deterioration from wind or water erosion, and nutrient depletion. The practice of cultivating vast quantities of a single crop in Manipur is the main contributor to deforestation, the widespread use of heavy equipment that degrades soil quality, and the extensive use of agricultural chemicals. The commercial agricultural sector has grown only a small number of crop varieties; due to this, the loss of a few native breeds and genetic diversity has decreased.

Major agricultural chemicals used by conventional farmers are also dangerous or toxic to humans, soil microbes, pollinators, and wildlife and flow off

into water bodies, damaging rivers, wetlands, and other areas. These have the unfortunate effect of killing beneficial bacteria and soil microorganisms that are essential to healthy soils. The majority of fertilizers used by farmers only provide three fundamental nutrients: nitrogen, phosphorous, and potassium, which are manufactured from petrochemicals, which means that the crops may not receive other crucial nutrients or may have traces of minerals. A farming practice can be improved by properly managing the land and farm resources, which also helps to solve agricultural and natural resource problems. One of the methods that elder generations utilized to prevent unsustainable resource management in cultivation is the rice-based agricultural technique. One of the successful traditional methods that offers an acceptable degree of economic return and improves the standard of living in rural communities is rice-based farming. Consequently, the present study is important to identify, evaluate, and analyse the sustainability of current rice-based farm practices and farmers concerns about soil management, crop rotation, water management, tillage systems, education and policy initiatives, an adaptation strategies followed by farmers in Manipur. This study aims to provide a new viewpoint on ways to increase the state's agricultural sustainability. In order to build an appropriate model of a sustainable rice-based farming system, this study included a comparative analysis of the current agricultural practices in Manipur's hilly and plain regions. The goal of this study was to better understand the phenomenon of sustainable rice-based farming in Manipur. Therefore, the following objectives were set for the current study entitled "Sustainability of rice-based farming systems in Manipur: A critical analysis," with the following research questions:

1. What major cropping pattern exists in the rice-based farming system?
2. Are farm resource management practices sustainable, and how do farmers manage their farm resources?
3. How do farmers feel about the environmentally friendly farming?
4. To what extent are farmers aware of the current technology used in rice-based farming systems?

5. What are the main determinants of the viability of the rice-based farming system?
6. To what extent is the rice-based farming system generating income for households and employment?

1.6 Objectives

- 1.6.1. To study the socio-economic and psychological characteristics of the rice-based cultivation farmers.
- 1.6.2. To examine the cropping pattern and farm resource management under rice-based farming system followed by the respondents.
- 1.6.3. To measure the attitude and extent of adoption of sustainable practices by respondents under rice-based farming system.
- 1.6.4. To examine the factors determining the sustainability of rice-based farming system.
- 1.6.5. To analyse income and employment generation from livelihood enterprises under rice-based farming system.
- 1.6.6. To identify the constraints faced by the farmers in sustainable rice-based farming system and suggest measures to overcome them.

1.7 Scope and importance of the study

The present study concentrated on the variety of crops grown and examined the relationship between farm resource management, agricultural output, prospective productivity, and production factors like the need for capital, labour, and land management. Additionally, this research aims to discover the best and most efficient farming methods within the rice-based farming system to combat poverty and unsustainable agriculture, in addition to contributing to the discussion on rice-based farming in Manipur. In addition, the study determined, assessed, and examined the three sustainable pillars of the current rice-based farming system. The analysis of

social, economic, and environmental sustainability helped to show how people are concerned about conserving natural resources and managing their farms for profitable farming.

There have been numerous studies on rice crops and their methods of cultivation, but there has only been a limited amount of research on the sustainability of rice-based farming systems. Since rice base farming production in the hill region is extremely unusual compared to the valley portion of the state, this study may lead to an entirely new comprehension of how the hill districts practice their rice base farming method. And there could be a lot of opportunity to increase local rice production because the state's hill region's rice output is still only about 1.2 t/ha and has big yield gaps. By addressing a variety of locally unique biotic and abiotic stress and agronomic resource management practices in the region, current research is needed to close the yield gap. This investigation provides an extensive, dimensional analysis of the various farming methods used in the state. This study provided a comprehensive overview of the current rice-based farming practices in the hilly and lowland regions of Manipur, as well as a comparative analysis. Based on the farming system, an appropriate model of a sustainable rice-based farming system has been established.

1.8 Limitations of the study

The COVID-19 pandemic had a significant influence on research; during surveys, it became more difficult to enter communities and interview farmers. Experienced health issues due to the severe COVID-19 infection, which extended the time needed for research and limited financial support from the institution. The findings and applicability of the documented practices of the farming system may differ in other states.

1.9 Organization of the thesis

Thesis has been organized in order of the following chapters:

Chapter 1 **“INTRODUCTION”**- It includes importance of study, statement of the problems, objective, scope and limitations of the study.

Chapter 2 **“REVIEW OF LITERATURE”**- It has dealt with the available literature's related to the present study.

Chapter 3 **“RESEARCH METHODOLOGY”** – This constitutes research methods and procedures followed in the study.

Chapter 4 **“RESULTS AND DISCUSSION”**- This chapter includes the findings of the study and the essential discussion

Chapter 5 **“SUMMARY AND CONCLUSIONS”**- It summarizes the study and gives implications, recommendations and suggestions for further research. References and Appendices have been included at the end of the thesis. For writing reference, the style of Indian Journal of Agricultural Sciences has been followed.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A literature review is a compilation, classification, and evaluation of what other researchers have written on a particular topic. It is a description of the literature relevant to a particular field or topic. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypotheses, what questions are being asked, and what methods and methodologies are appropriate and useful. A literature review is an evaluation of research works available on a specific academic theme or topic or subject under investigation by a researcher. It involves a process of investigating already written and published bodies of writing to achieve specific research objectives other than those already achieved by the works under investigation. (Chigbu *et al.*, 2023). Literature review is a process that involves several activities including searching, identifying, reading, summarizing, compiling, analysing, interpreting, writing (including citing based on a prior established research question) and referencing.

Review of literature has been presented under the following heads:

2.1 Concept of sustainability

2.2 Dimensions of sustainability and the indicators for sustainability measurement

2.3 Socio-economic and personal characteristics of rice-based cultivation farmers

2.4 Cropping pattern and farm resources management under rice-based farming system

2.5 Attitude of farmers towards adoption of sustainable agricultural practices

2.6 Extent of adoption and factors determining adoption of sustainable rice-based farming system

2.7 Employment generation (mandays) under sustainable agricultural practices

2.8 Constraints faced by farmers in adoption of sustainable farming system

2.1 Concept of sustainability

The Brundtland Commission's report (1987) defined sustainable development as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs". The definition contains two major concepts: firstly, the concept of 'needs', in particular the essential needs of the world's poor, to whom overriding priority should be given; and secondly the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. Sustainability is a holistic approach that considers ecological, social and economic dimensions, recognizing that all must be considered together to find lasting prosperity.

Ben-Eli (2015) defines sustainability as a dynamic equilibrium in the process of interaction between a population and the carrying capacity of its environment such that the population develops to express its full potential without producing irreversible, adverse effects on the carrying capacity of the environment upon which it depends.

According to FAO (2018) sustainable development approach is based on five principles that balance the social, economic and environmental dimensions of sustainability. The five principles are increase productivity, employment and value addition in food systems, protect and enhance natural resources, improve livelihoods and foster inclusive economic growth, enhance the resilience of people, communities and ecosystems and adapt governance to new challenges.

Das (2020) in their study on sustainable agriculture: a path towards better future reported that sustainable agriculture act of farming using principles of ecology, the study of relationships between organisms and their environment. It has been defined as an integrated system of plant and animal production practices having a site-specific application that will last over the long term.

Mucharam *et al.* (2020) in their study to analyse the index and sustainability status of rice farming carried out by farmers in Jambi Province, Indonesia revealed that rice farming was less sustainable, with the sustainability 41.96 index. Index of the dimensions of ecological was 48.25, economic was 40.83, socio-cultural 40.97 and technological sustainability was 16.46 respectively.

According to University of California Sustainable Agriculture Research and Education Program (2021) reported that the goal of a sustainable agriculture is to meet society's food and textile needs in the present without compromising the ability of future generations to meet their own needs. Sustainable agriculture seeks to integrate three main objectives into their work: a healthy environment, economic profitability, and social and economic equity. There are many practices in sustainable agriculture and sustainable food systems i.e., promote soil health, minimize water use, and lower pollution levels on the farm.

Triyono *et al.* (2021) in his study on constraints perceived by the Litopenaeus vannamei farmers with implementation of better management practices (BMP's) in Andhra Pradesh reported that sustainability value was below zero, implying that no farmer achieved optimal performance. Most sustainability value (60%) were close to zero (maximum value), indicating the potential of rice farming to increase its efficiency. Sustainability can be achieved by managing agricultural resources more efficiently and productively. Sustainable efficiency is indicated by a farm's RtC. Most RtC (sustainable efficiency) values were less than optimal, indicating that most farms demonstrated a relatively low RtC (sustainable efficiency) ratio. Thus, the sustainability performance was around 24–25%.

Diogo (2022) reported that sustainable agriculture has been proposed as a promising concept based on the application of a wide variety of technologies, focusing on increasing yields while simultaneously conserving land, other natural resources, and the environment, promoting a good quality of life, and preserving global food security.

Suresh *et al.* (2022) in their study on agricultural sustainability and its trends in India reported that sustainable agricultural implies an agricultural production that ensure the ecological stability, economic viability, and socio-cultural permanence.

Aalst *et al.* (2023) in the study of the economic sustainability of rice farming in Vietnam reported that a majority of the rice farmers (66%) perceived triple rice cultivation as economically sustainable in the short-term, farmers recognize the environmental unsustainable of intensive rice cultivation, with (68%) indicating it decreases soil quality and/or depletes fresh water sources (47%).

According to Mollenkamp (2023) sustainability refers to the ability to maintain or support a process continuously over time. Sustainability seeks to prevent the depletion of natural or physical resources, so that they will remain available for the long term.

2.2 Dimensions of sustainability and the indicators for sustainability measurement

Sharifzadeh and Abdollahzadeh (2017) studied the sustainability composite index SCI comprising 13 indicators sustainable farming practice method (crop/land rotation, organic, green and animal fertilizers and conservation of plough); farmer and village factors such as age, education, income, access and contact with service, research and extension agencies and farmers attitude towards sustainability; farm characteristics, land cultivated and social and institutional factor such as farming job, preference with regards to sustainability and social participation that measures sustainability level in a wheat cropping system.

Mensah (2019) there are three types of sustainability viz., environmental sustainability, social sustainability and economic sustainability. Environmental sustainability is about the natural environment and how it remains productive and resilient to support human life. Environmental sustainability relates to ecosystem integrity and carrying capacity of natural environment. It requires that natural capital be sustainability used as a source of economic inputs and as a sink for waste. Social sustainability encompasses notions of equity, empowerment, accessibility, participation, cultural identity and institutional stability. Economic sustainability: It implies a system of production that satisfies present consumption levels without compromising future.

Mucharam *et al.* (2020) in their study to assess the sustainability of rice farming at the provincial level in Indonesia indicated that on the economic dimension, sustainable rice farming ordination with a value of 6.69%, land suitability in the ecological dimension is the most crucial attribute in the ordination of sustainable rice farming with a value of 6.37%. Other indicators that become leverage for the ecological dimension are the Cropping Index and the use of chemical fertilizer with a value of 6.36% and 6.31%. Leverage analysis on the social dimension showed that the village accessibility is the most crucial attribute on the

ordination of sustainable rice cultivation at the provincial level with a value of 5.37%.

Arouna *et al.* (2021) on their study of an assessing rice production sustainability performance indicators and their gaps in twelve sub-Saharan African countries quantified five sustainability performance indicators (grain yield, net profit, labour productivity, and nitrogen (N) and phosphorus (P) use efficiency) to benchmark rice production systems in SSA.

Otalora *et al.* (2021) on their study used the economic sustainability indicators profitability (net farm income, land productivity, animal productivity, and feed efficiency), autonomy (economic self-sufficiency, feed self-sufficiency farm diversification food production), and economic diversification (non-food earnings, added value products durability succession and transferability).

Coppola *et al.* (2022) showed that an efficiency indicator (EI) and two income indicators [a factor profitability indicator (FPI) and a comparable income indicator (CII)] expressing the ability to remunerate the entrepreneur's production factors at their opportunity cost and the farm's income capacity have been used in a principal component analysis (PCA) to build an economic sustainability index (SI).

Macedo *et al.* (2022) reported that rice-soybean had medium productivity. Rice-cover crop had the highest economic incomes, rice-soybean and rice-pasture had a similar gross margin, the variability in rice-pasture was lower and with lower input costs. Rice-soybean and rice-pasture had a multi-criteria performance index 65% higher than rice-cover crop (0.35). Rice-pasture with annual crops could reduce the stability of sustainability without increasing economic performance, even for rice-soybean that showed the best the multi-criteria performance but with less stability across indicators.

Mungkung *et al.* (2022) revealed that the current rice farming practices, the SRP (sustainable rice platform) scores for all rice varieties cultivated in Thailand were from 53% to 81%, SRP score of rice variety, Khao DawkMali 105 had the highest score (81%), followed by RD6 (73%), Rice berry rice (70%), and Khao Tahaeng 63%). In the irrigation production system, it was found with average SRP score was 53%, however it has the highest score of labour rights (100%) and intermediate scores in pre-planting (66%), harvest and post-harvest (61%), nutrient

management (55%), IPM (54%), and water use (52%). The SRP score of organic farming was 81% with the highest score for labour rights (100%), for food safety the score of health & safety (100%), followed by health and safety (94%), water use (91%), harvest and post-harvest (76%), pre-planting (71%), nutrient management (71%), and farm management (51%), respectively. The SRP score for non-organic farming practices was 71%, with the highest score in labour rights (100%) followed by IPM (86%), health and safety (83%), water use (76%), harvest and post-harvest (75%), pre-planting (70%), nutrient management (60%), and farm management (20%), respectively.

According to McGill University (2023) sustainability is based on three dimensions: Environmental sustainability occurs when humanity's rate of consumption does not exceed nature's rate of replenishment. Social sustainability is the ability of a society to uphold universal human rights and meet people's basic needs, such as healthcare, education, and transportation. Economic sustainability is the ability of human communities around the world to maintain their independence and have access to the resources.

Dubey *et al.* (2023) in their 3-year study comprising extensive field surveys and experiments was undertaken to compare single transplantation (ST) and double transplantation (DT) in rice along with organic addition (farm-yard manure, FYM) on crop growth, yield, climate resilience, soil quality, and overall sustainability i.e., social (women involvements and labour productivity), environmental (water productivity and nutrient use efficiency), and economic (benefit: cost ratio) were taken as dimensions of sustainability.

2.3 Socio-economic and psychological characteristics of rice-based cultivation farmers

2.3.1 Age

Chittem and Kunda (2018) in their study on constraints perceived by the *Litopenaeus vannamei* farmers with implementation of better management practices (BMP's) in Andhra Pradesh reported that most of the Vanna Mei shrimp farmers in the Andhra Pradesh belonged to the age groups of 31-45 years (53.03%).

Ajibesin *et al.* (2019) in their study on examine the socio-economic factors influencing the adoption of post-harvest technologies among maize farmers in Kwara State, Nigeria found that majority of the farmers (47.8%) were aged between 51-60 years.

Hameed and Sawicka (2019) found that the age of respondents, who participated in the study ranged from 18 to 65 years. The mean age of respondents was 31.33 years with the standard deviation of 4.90. The respondents aged 42–53 and 54–65 was in the majority (81.59%), followed by the age group 30–41 (15.13%), next by the age group 18-29 years (3.28%).

Ghosh *et al.* (2020) in their study on knowledge of farmers to sustainable agriculture practices: A case study in south-western region of Bangladesh of knowledge of farmers to sustainable agriculture practices reported that the young aged constituted the highest proportion (48.8%) of the respondents, followed by middle (35%) and old aged (16.12%) category.

Maina *et al.* (2020) in their study on analysing the socio-economic determinants of adoption and the impact of adopting *Brachiaria* grass reported that average age of the household head was 54–58 years.

Prabha and Raviselvam (2020) in their study on socio-economic status of farmers in Thanjavur district reported that most of the respondents in this study were between the age group of 45 to 55 years.

Jha and Gupta (2021) in their study on farmer's perception and factors determining the adaptation decisions to cope with climate change reported that the average age of the farmer in the study area is 51 years. The youngest farmers were 24 years old, and the oldest was 70 years old.

Kehinde *et al.* (2021) in their study on land tenure and property rights, and household food security among rice farmers in Northern Nigeria found that majority (57.0%) of the rice farmers across the three geopolitical zones of Northern Nigeria were within the age bracket of 31-50 years. The mean age was 43 years.

Kumar *et al.* (2021) in their study on socio-economic profile of sugarcane growers in east Champaran district of Bihar revealed that majority of the respondents were found in middle age group (56%).

Suraj (2021) in their study on analyse the socio-economic variables of the dairy entrepreneurs of Kerala revealed that respondents were belonged to elderly group.

Liao *et al.* (2022) in their study on the use of the knowledge, attitude, and practice (KAP) model to examine sustainable agriculture in Thailand revealed that the average age of the farmers in the two sub-districts was 52 years old.

Martey *et al.* (2022) in their study to examine how perceptions of COVID-19 shocks influenced the adoption of SAPs among smallholder farmers in Ghana reported that farmers were relatively young (between 43 and 46 years).

Sarma *et al.* (2022) in their study on hybrid rice production reported that about 57% of the adopters were in the age between 36–45 years, 28.69% between 46–55 years of age of the adopter's farmers of hybrid rice production. On the other hand, about 45.90% farmer's age was between 36–45 years and 31.97% between 46–55 years in the non-adopter farmers group.

Sumo *et al.* (2022) in their study on comparison of the socio-economic characteristics of households by access to extension services revealed that the average age of farm household heads was 44.

Tran *et al.* (2022) in their study to assessed the livelihoods of rice households in Nghe province of Vietnam revealed that the mean age of farmers was 55 years old, implying a high proportion of older farmers in the study area.

Asmara *et al.* (2023) reported that the age category with a range of 48–55.6 years (45%) had the largest number of respondents. The smallest number of respondents was in the age category with an age range of 64–72 years (6%). The average age of respondent farmers in Banaran Wetan Village was 49 years.

Sravanthand and Sundaram (2023) in a study of analysis of socio-economic status of young migrant farmers in India using probit regression reported that the average age of young farmers was 26.7 years.

2.3.2 Sex

Hayran *et al.* (2018) conducted a study on farmer's sustainable agriculture perception in Turkey. It was revealed that the majority sample farmers were male.

Ajibesin *et al.* (2019) in the study to examine the socio-economic factors influencing the adoption of post-harvest technologies among maize farmers in

Kwara State, Nigeria found that majority of the farmers (92.8%) were males while 7.2% were females. Further 44.4% of the farmers had a household size that ranged from 7-9 members.

Hameed and Sawicka (2019) in their study on farmer's knowledge of sustainable potato cultivation techniques in Poland revealed that 93.42 per cent of farmers were males, while 6.58 per cent were females.

Henry *et al.* (2020) in their study on factors influencing implementation of by laws on sustainable crop intensification in Uganda found that female farmers were far less on average in by laws implementation compared to the male farmers.

Maina *et al.* (2020) on their study of an analysing the socio-economic determinants of adoption and the impact of adopting *Brachiaria* grass reported that majority 77 per cent of the households were male-headed.

Iheke *et al.* (2021) in the study examined the socio-economic characteristics of the food crop farmers reported that about 53.33% of the farmers were males.

Jha and Gupta (2021) in the study of farmer's perception and factors determining the adaptation decisions to cope with climate change reported that most of the sample in the study region was male farmers. The percentage of male farmers is 81 per cent, and female farmers are 19 per cent.

Kehinde *et al.* (2021) in a study of land tenure and property rights, and household food security among rice farmers in Northern Nigeria found that 94% of the rice farmer belonged to a male-headed household.

Somanje *et al.* (2021) reported that 74% were male and 26% were female respondents (heads household). In Zambia, the results indicate that male respondents accounted for 66% of farmers and female respondents accounted for 34%.

Liao *et al.* (2022) in their study of the use of the knowledge, attitude, and practice (KAP) model to examine sustainable agriculture in Thailand reported that more female farmers than male farmers participated in the study 60% of the respondents in Dan and 52% in Naengmut, respectively.

Martey *et al.* (2022) in their study examined how perceptions of COVID-19 shocks influenced the adoption of SAPs among smallholder farmers in Ghana

reported that more than 80% of the non-adopters, low- and high adopters are males' farmers.

Sarma *et al.* (2022) in a study of hybrid rice production reported that among the total sample farmers, 90.16% of adopters and 51.64% of non-adopters were male, and 9.84% of adopters and 25.41% of non-adopters were female.

Sumo *et al.* (2022) in a study of comparison of the socio-economic characteristics of households by access to extension services reported that about 82.4% of the rice farmers were male.

Tran *et al.* (2022) in their study to assess the livelihoods of rice households in Nghe province of Vietnam revealed that 79% were male.

Begum *et al.* (2023) in a study aimed to investigate the production risk and technical inefficiency of bean farms in Bangladesh reported that the number of female members was about 33%.

2.3.3 Family type and family size

Singh *et al.* (2014) in their study on knowledge level, attitude and adoption behaviour about improved production technology of high yield varieties of wheat found that majority of the respondents live in nuclear type of family.

Saikia and Deka (2017) revealed that more than half of the respondents were from nuclear family that is 63.33 per cent on their study entrepreneurship development through micro enterprise and its impact on women empowerment in Assam.

Nithya *et al.* (2018) found that 48.30 per cent were nuclear family and 51.70 percent were joint family on their study empowerment of women in rice farming system.

Honaryar (2019) in his study an economic analysis of production, marketing and value chain of potato in Bamyar province' indicated that the farmers had an average (6.37) small family size, (5.42) medium family size and (6.95) large family size respectively.

Shree *et al.* (2019) in their study of socio-economic assessment of farm women in rice cultivation revealed that family size was found to be positively correlated with knowledge and adoption of the rice cultivation practices.

Medhi *et al.* (2020) reported that majority of the trainee respondents were from medium family group (70.00%) with 4–6 members followed by large family group (21.67%) with 7 members and above and small family group (8.33%) with up to 3 members only.

Ghosh *et al.* (2020) in their study of knowledge of farmers to sustainable agriculture practices reported that the number of family members of the respondents ranged from 2 to 10 with 5.76 mean, the highest (48.8%) proportion fell under large family size which is more than 5 members.

Ugochukwu (2020) in their study of market orientation of smallholder South African farmers reported that the mean of household size was 4 persons, with minimum of 2 and maximum of 7 persons in the household.

Iheke *et al.* (2021) in their study examined the socioeconomic characteristics of the food crop farmers reported that there was average 6 persons per household.

Jha and Gupta (2021) in their study reported average household size of the surveyed household was 9 members. The minimum household size is 3 members, and maximum household size was 20 members.

Mugumaarhahama *et al.* (2021) in their study of the socio-economic characteristics of adopters and non-adopters of improved sweet potato varieties in South-Kivu reported that the average family size were seven members.

Sarma *et al.* (2022) in their study of hybrid rice production reported that 35.25% of the adopters had a family size of 6–10 persons, while 4.92% had 16 and above. On the other hand, approximately 39.34% of the non-adopters had 6–10 members per household, and 3.28% had fewer than 5 members per household.

Amitha *et al.* (2023) in their study of socio-economic categorisation of farm household reported that the farm household socio-economic status score having 21–24 points possessed 3–5 people in family, 17–20 score group of socio-economic status possessed 3–7 people, and 3 to 16 score group of socio-economic status possessed 2–3 people in the family.

Begum *et al.* (2023) in their study aims to investigate the production risk and technical inefficiency of bean farms in Bangladesh reported that the mean size of family was found 6 which is relatively higher than the national average.

2.3.4 Education

Chittem and Kunda (2018) reported that most of the Vannamei shrimp farmers in the Andra Pradesh majority (27.70%) of the farmers had education upto secondary school level (6th-10th class).

Ajibesin *et al.* (2019) in their study to examine the socio-economic factors influencing the adoption of post-harvest technologies among maize farmers in Kwara State, Nigeria found that the level of education among the farmers was fairly low as nearly 50% of the respondent had less than secondary education while only 6.7% completed tertiary education.

Hameed and Sawicka (2019) conducted a study on farmers knowledge of sustainable potato cultivation techniques in Poland and found that 3.28 per cent farmers were with primary education, 15.13 per cent and 11.84 per cent of respondents had vocational education in agriculture, and other vocational education, respectively. Meanwhile, 34.21 per cent of the farmers attained secondary education in agriculture, 13.15 per cent received other secondary education, 17.13 per cent of the farmers had higher education in agriculture and 5.26 per cent of the farmers had other higher education.

Gebska *et al.* (2020) in their study on farmer awareness and implementation of sustainable agriculture practices in different types of farms in Poland found that most respondents (46.30%) did education up to secondary school.

Gnanasubramaniam and Hemachandra (2020) on the study of perception of climate change and farmers' adaptation found that majority of the farmers' education level was between grade 6 and grade 11.

Maina *et al.* (2020) in their study on analysing the socio-economic determinants of adoption and the impact of adopting *Brachiaria* grass reported that the average number of years of formal education completed by the household head was 10 years.

Medhi *et al.* (2020) reported that majority respondents (43.33%) had medium level of formal education attaining either, high school or secondary standard followed by high level (31.67%) with graduate diploma or above and low level (23.33%) in standards of primary or middle school. Only 1.67 per cent

respondents were found to have no education from any of the formal educational institution.

Islam *et al.* (2021) in their study on knowledge level about important production practices of high-density apple growers of Kashmir Valley found that education had significant relationship with the knowledge level of the respondents.

Jha and Gupta (2021) reported that the average years of schooling of the surveyed household are 8 years. The maximum years of education are 17 years.

Pawar and Channaveer (2021) reported that two education status groups of farmers, such as up to high school studied and up to a degree level studied farmers. Among these two groups, the high-school level studied farmers group had 21.77 mean rank. In contrast, the degree-level studied farmer group had 28.43 mean rank, which means up to high school level.

Suraj (2021) in their study on analyzing the socio-economic variables of the dairy entrepreneurs of Kerala (India) and their relationship with economic movement revealed that they were educated mostly up to secondary level.

Wada *et al.* (2021) reported that majority of farmers (48.5%) completed primary education along with agriculture work, while 36.1% did not complete formal education, and only 1.4% had a certificate or above award for formal education.

Martey *et al.* (2022) in their study examined how perceptions of COVID-19 shocks influence the adoption of SAPs among smallholder farmers in Ghana reported that high adopters of SAPs have higher years of formal education (5 years) than non-adopters (3 years) and low adopters (4 years).

Reddy *et al.* (2022) revealed that most of the farmers studied at the high school level (61%), about only 4% had attained graduation, 15% studied until the primary, and 12% studied up to higher secondary and 8% were uneducated among the respondents.

Tran *et al.* (2022) in their study to assess the livelihoods of rice households in Nghe province of Vietnam revealed that a vast majority (98.7%) of the sampled respondents had participated in formal education, thereby enhancing their ability to maintain their livelihoods.

Amitha *et al.* (2023) in their study of socio-economic categorization of farm household reported that the farm household socio-economic status score having (21-24) score, (17-20) score and (5-10) score possessed educational level varied between primary to post graduate level. And scores less than 13 points on the socio-economic status score possessed illiterate educational status.

Asmara *et al.* (2023) reported that the highest number of respondents who completed the last education is senior high school level with a percentage of 51% and 6% the least number of respondents were not complete elementary school.

2.3.5 Experience in rice cultivation

Digambar *et al.* (2020) reported that 65.97 per cent respondents had high farming experience (above 20 years), 29.17 per cent of them had medium farming experience (11 to 20 years), and 4.86 per cent respondents had low farming experience on rice production technology in Rajnandgaon district of Chhattisgarh.

Gebska *et al.* (2020) found that most respondents (47%) came from the Mazowieckie voivodship had similar professional experience (average 20.3-21.1 years).

Ghosh *et al.* (2020) in their study of knowledge of farmers to sustainable agriculture practices reported that the farming experience scores of the respondent could range from 5 to 45, with an average being 20.60. The highest proportion (45.1%) of the respondent fell in medium experience category, followed by high experience and low experience.

Maina *et al.* (2020) in their study on analysing the socio-economic determinants of adoption and the impact of adopting *Brachiaria* grass reported that farming experience in dairy was 12 years for adopters and 11 years for non-adopters.

Medhi *et al.* (2020) reported that the improved rice cultivation farmers in West Garo hills district had 52.00 per cent of trained farmers belonged to medium experience category, followed by (40.00%) high experience and (8.00%) low experience category.

Iheke *et al.* (2021) in their study examined the socioeconomic characteristics of the food crop farmers reported that the mean years of farming experience were 14.7 years.

Mugumaarhahama *et al.* (2021) in their study of the socio-economic characteristics of adopters and non-adopters of improved sweet potato varieties in South-Kivu reported that farmers have more than 25 years of experience in growing sweet potatoes.

Suraj (2021) in their study of analyzing the socio-economic variables of the dairy entrepreneurs of Kerala (India) revealed that farmers had 13 years of experience in dairy entrepreneurs.

Wada *et al.* (2021) reported that the greatest number of farmers (59.7%) reported having been growing barley for the last 31 years or more.

Akinwale *et al.* (2022) in their study of assessment of factors that affect market orientation of cassava farmers in Osun State, Nigeria reported that about 53% of the cassava farmers had farming experience of more than nine years and the mean 12.50 years of farming experience in farming.

Goli *et al.* (2022) in their study on training need study of female rice cultivation reported that the work record of female rice farmers was minimum 3 years and 40 years maximum.

Martey *et al.* (2022) in their study to examine how perceptions of COVID-19 shocks influence the adoption of sustainable agricultural practices among smallholder farmers in Ghana reported that farmers had about 21 years of farming experience.

Sumo *et al.* (2022) in their study of comparison of the socio-economic characteristics of households by access to extension services found that the experience of the farmers in rice farming were 15 years.

Asmara *et al.* (2023) reported that the highest number of respondents are in the category of 24-32 years of farming experience with 37% respondents. Only three respondents have 5-14 years of experience, which this is the least years of experience category.

Begum *et al.* (2023) in their study aimed to investigate the production risk and technical inefficiency of bean farms in Bangladesh reported that the mean experience of the farmers was 25 years.

2.3.6 Total land holding size

Ghosh *et al.* (2020) in their study on knowledge of farmers on sustainable agriculture practices reported that the small farm size was 0.2 acres and the largest farm size was 5.26 acres with an average of 3.68 acres, highest proportion (46.2%) of the respondents had small farm size followed by medium and large farm size respectively.

Medhi *et al.* (2020) reported that majority (70.83%) of the respondents were marginal farmers possessing land holding size of up to 1.0 hectare followed by small farmers (27.50%) with land holding between 1.01 to 4.0 hectares. Only 1.67% respondents belonged to the high category of land holding size (above 4.0 ha).

Nwafor (2020) reported that the mean farm size was 0.94 hectares, 23% of respondents had a farm size smaller than half a hectare, 44% of respondents cultivated a farm size between half and one hectare, and approximately 34% of respondents cultivated a farm between one and two hectares. None of the respondents in the survey had a farm size greater than two hectares.

Ugochukwu (2020) in a study of market orientation of smallholder south African farmers reported that 23% of respondents had a farm size less than half a hectare, 44% of respondents cultivated with a farm size between half and one hectare, while approximately 34% of respondents cultivated a farm between one and two hectares. None of the respondents in the survey had a farm size greater than two hectares

Jha and Gupta (2021) reported that the average land size held by the farm household were 1.78 ha which was ranging from 0.125 ha to 12.5 ha. It was also observed that a higher number of farm households belong to the marginal group, i.e., 35 per cent and small land size group, i.e., 27 per cent. The medium-size farmers are 24 per cent, and large size farmers are 14 per cent.

Martey *et al.* (2022) in their study to examine how perceptions of COVID-19 shocks influence the adoption of SAPs among smallholder farmers in Ghana reported that the average farm size was 2.1 ha for all categories, and 61% farmers from both non-adopters and high adopters' own farmland.

Reddy *et al.* (2022) in the study on farmers' perception and efficacy of adaptation decisions to climate change revealed that majority of farmers were marginal and small, with less than one hectare of land.

Sumo *et al.* (2022) on a study of comparison of the socio-economic characteristics of households by access to extension services reported that the average, farmers operated a farm size were 1.4 ha.

Amitha *et al.* (2023) in their study of socio-economic categorization of farm household reported that the farm household socio-economic status score having 21-24 points possessed 10-20 acres of land, 17-20 score group of socio-economic status possessed 5-10 acre, and 3 to 16 score group of socio-economic status possessed 1-5 acres of land. And scores less than 13 points on the socio-economic status score possessed up to only one acre.

Sravanthand and Sundaram (2023) reported that marginal young farmers accounted for 8.2% of cultivated land, small young farmers had 40.2% of cultivated land, semi-medium young farmers had 40.4% of cultivated, medium young farmers had 10.6% of cultivated and large young farmers had 0.6% of cultivated land.

2.2.7 Size of land under rice-based farming system

Digambar *et al.* (2020) reported that about 34 per cent were having the medium size of land (2.1 to 4 ha), followed by 27.78 per cent were having a small size of landholding (1.1 to 2 ha), a higher percentage (30%) of the respondents had a medium size of landholder under rice production.

Maina *et al.* (2020) in their study of analysing the socio-economic determinants of adoption and the impact of adopting *Brachiaria* grass reported that the average farm size for adopters (4.37 acres) was significantly higher than for non-adopters (2.96 acres).

Kumar *et al.* (2021) in their study on socio-economic profile of sugarcane growers in East Champaran district of Bihar revealed that majority (45%) of the respondents had semi-medium size of land holding.

Wada *et al.* (2021) in the study of farmers' knowledge on cultivation, utilization and conservation practices of barley (*Hordeum vulgare* L.) in three

selected districts in Ethiopia reported that majority of the farmers (57.1%) grow barley on 0.5-0.75 hectares, followed by farmers grow on >0.75–1 hectare.

Goli *et al.* (2022) in a study on training need study of female rice cultivation reported that the lowest area under rice cultivation in this study was about 0.5 hectares, and the highest area under rice cultivation was 5 hectares.

Tran *et al.* (2022) in their study to assess the livelihoods of rice households in Vietnam revealed that land holding range under rice cultivation ranged from 0.02 ha to 2.35 ha.

Santoso *et al.* (2023) reported that most respondents (57.93%) have a land area of fewer than 0.5 hectares, 0.51–1 ha as much as 23.47%, and an area of 1.1–5 ha as many as 17.76%. Some respondents have land above 5 ha, which is 0.84% under rice plantation.

2.3.8 Annual income

Chittem and Kunda (2018) in their study on constraints perceived by the Litopenaeus Vannamei farmers with implementation of better management practices (BMP's) in Andhra Pradesh, India reported that majority 34.44 per cent of respondents had annual income of Rs. 1-2 lakh.

Hameed and Sawicka (2019) revealed that most of respondents (74.34%) in the study region worked in agriculture treated farm as a major source of income while 23.04% of respondents working on a farm also had additional source of income besides the farm.

Musa *et al.* (2020) in their study of smallholder farmers sesame market orientation in Kondala district, Etopia revealed that the average value of non-farm income the respondents was 1388.34 ranging from zero to 16342.

Ghosh *et al.* (2020) in their study of knowledge of farmers to sustainable agriculture practices reported that the income of the respondents ranged from Tk. 30000 to Tk. 110000, the average being Tk. 54572.66.

Gnanasubramaniam and Hemachandra (2020) in their study of perception of climate change and farmers' adaptation found that most of the farmers' monthly income ranged between Rs. 15,858 and Rs. 50,000.

Prabha and Raviselvam (2020) in their study of socio-economic status of farmers in Thanjavur district reported that 30% of the respondent's income per

month is between Rs.10,000 to Rs. 20,000, 24% of the respondents each earn less than Rs.10,000 and more than Rs.30,000 respectively and 20% of the respondents earn an income of between Rs.20,000 to Rs.30,000.

Kumar *et al.* (2021) in their study on socio-economic profile of sugarcane growers in east Champaran district of Bihar revealed that a higher 26 percentage (71.67%) earned medium annual income between Rs. 64,000- 3,40,000.

Suraj (2021) in the study of analysing the socio-economic variables of the dairy entrepreneurs of Kerala (India) revealed that gross annual income of below ₹25 lakh from sale of milk and milk products.

Begum *et al.* (2023) in a study aimed to investigate the production risk and technical inefficiency of bean farms in Bangladesh reported that the average annual income of bean farmers was Tk. 304400 which is ranging from Tk. 120000 to Tk. 960000.

Amitha *et al.* (2023) in their study of socio-economic categorization of farm household reported that the farm household revealed that the monthly income 21-24 group was above Rs 15,000-20,000 with (18%) farmers, 17-20 score group of socio-economic status with monthly income above Rs 10,000-15,000 with (30%) farmers, and 3 to 16 score group of socio-economic status with monthly income of above Rs 5,000-10,000 with (22%) of the respondents. And scores less than 13 points on the socio-economic status score had the income below Rs 5000 with (15%) farmers.

2.3.9 Income from rice-based farming system

Deep *et al.* (2018) in their study of rice based cropping system showed that rice-maize rotation produced the highest rice equivalent yield (10.2 tonne/ha) and gross monetary returns (59,110/ha).

Haobijam *et al.* (2018) found that integration of rice cultivation with fish farming enabled optimum utilization of available local resources it generates more net income in Manipur.

Khan and Parashari (2018) reported that all the crops (combined) generated total income Rs. 3974000, livestock added Rs.3260000 to the farmers' income. Integrated farming systems gave increasing by 51.4 per cent income. Per day profit of marginal and small households can be increased by 69.2 per cent it boosts the

income generation and creates employment opportunity while it also reduces the risk of crop failure.

Digambar *et al.* (2020) reported that the rice producing farmers of Rajnandgaon district of Chhattisgarh family of majority (52.08%) were received less than Rs 100000 per year. About 25 per cent respondents got Rs 1,00001-2,00000 and 16.67 per cent respondents get 2,00001- 4,00000.

Medhi *et al.* (2020) reported that the improved rice cultivation farmers in west Garo hills district had 87.50 per cent respondents belonged to medium category of annual income from all sources which ranged from ₹ 33,281 to ₹ 1,65,066 followed by high category (10.00%) with income above ₹ 1,65,066 and low (2.50%) with income less than ₹33,281 per year.

Musa *et al.* (2020) on their study of smallholder farmers sesame market orientation in Kondala district, Etopia revealed that the farm income, the respondents had on average 12745.5 birr ranging from 1300 to 65420

Nwafor (2020) reported that the maximum total value of crops produced by the respondents was R27,890 while a minimum was R2,675, with a mean of R12,271

Iheke *et al.* (2021) reported that fruit crop production was profitable as the farmers made a net return ₦246,200. Cassava and yam also contributed 40.25% and 32.73% of total farm income.

Kharumnuid *et al.* (2021) in their study on potato production for nutritional security and doubling farmers' income found that potato is a potential crop for doubling farmers' income.

Krishnankutty *et al.* (2021) reported that the farmers in Wayanad had the highest average gross income (Rs. 85,281/ha), while those in Palakkad had the lowest (Rs. 71,578/ha). Similarly, Wayanad had the highest farm business income (Rs. 34,218/ha) and Palakkad had the lowest (Rs. 20,772/ha).

Akinwale *et al.* (2022) revealed that about 65% of respondents earned less than ₦400,000 income from cassava per annum while 16.7% of the respondents made between ₦600,000 and ₦799,999 per annum. The mean annual income was ₦343,183.33. This annual income was lower than the national annual minimum wage of ₦360,000.00.

Sarma *et al.* (2022) in their study of hybrid rice production reported that a high proportion (65.57%) of the adopter earned about BDT 20001–50000, while only (4.10%) of the adopters earned about less than BDT 30000, whereas 27.05% of non-adopters earned less than BTT 30000 this is followed by 18.03% who had BDT 50001–70000 monthly income, 4.92% had BDT 70001–100000 monthly income, and 7.38% had 100001 and above, while 10.66%, 2.46% and 1.64% of non-adoption farmers, respectively.

Upadhaya *et al.* (2022) found that the highest gross return of the farmers was (Rs 4,64 and 274 ha⁻¹); net returns (Rs 3,64 and 024 ha⁻¹) and benefit–cost ratio (3.63) was recorded economic efficiency (299.52%) was significantly higher in the maize- cabbage-sesame cropping system compared to the rest of the cropping systems

2.3.10 Training exposure

Pham and Waibel (2018) reported that about 1% of household had attended a training course in the past in their study on risk attitudes, farmers' knowledge, management ability and agricultural productivity.

Adusei (2020) in the study to investigate the factors that affect the adoption of organic agriculture found that 28 effective extensions monitoring and training were needed to enhance the adoption and sustainability of organic agriculture.

Gebska *et al.* (2020) in their study of farmer awareness and implementation of sustainable agriculture practices in different types of farms in Poland reported that over 61% of respondents enriched their knowledge by participating in courses and training.

Jamanal *et al.* (2020) in their study of socio-economic characteristics of crop insured farmers of northern Karnataka revealed that majority (94.16%) of the insured farmers were not received the training, 5.00% were received one training and only 0.83% were received more than one training.

Medhi *et al.* (2020) reported that the improved rice cultivation farmers in west Garo hills district had medium level of training (64.17%) followed by low (35.83%) and no respondents were found in the high-level category

Issahaku (2021) reported that all 91.1% farmers stating that training was very useful while 8.9% said it was useful. Cent per cent farmers indicated that the

training was useful and helped them acquired capabilities such as identification of proper ploughing, quality seed selection, recommended seeding, timely weed, pest and disease control which eventually led to increase in rice yield.

Mgendi *et al.* (2021) in their study on is a training program sufficient to improve the smallholder farmers' productivity in Africa reported that indicates that 70% of the sample had at least attended agricultural training, while 30% did not attend any agricultural training program. Also indicates that about 27.3% of farmers in the sample population attended the ATDC training program in treated villages while 72.7% did not attend the ATDC program in treated villages.

Somanje *et al.* (2021) reported that in Ghana, 62% of farmers perceive PEA training as a highly effective agricultural extension approach, compared with 72% in Zambia. Only 4% of farmers in Ghana perceive PEA training as not effective, compared with 1% in Zambia. A detailed analysis of other specific training approaches revealed that 62% of farmers in Ghana perceive on-farm trials and research as not effective, compared with 12% in Zambia.

Goli *et al.* (2022) in their study of training need study of female rice cultivation reported that the number of training courses were (-0.284). And according to the findings, training programs should take into account the educational needs of female rice farmers in order to gain the necessary expertise and skills in new methods and transfer them to other farmers.

Podikunju and Arathy (2022) revealed that 45.8% of the respondents had attended 1 to 3 training followed by 42.5 per cent of the respondents having attended 4-6 training and only 11.7 per cent of the respondents had attended 7 to 10 training.

Tran *et al.* (2022) in their study aimed at assessing the livelihoods of rice households in Nghe an province of Vietnam reported that more than 50% of the surveyed households had not received any training courses.

Begum *et al.* (2023) in their study aimed to investigate the production risk and technical inefficiency of bean farms in Bangladesh reported that the mean training of the farmers was 1.8.

2.3.11 Information sources utilization pattern

Khan *et al.* (2019) on the study of farmers' use of mobile phone for accessing agricultural information in Pakistan: A case of Punjab province reported that 91.2% of the farmers were mobile phone ownership. Further revealed that 87.20% of the farmers used private sectors advisory staff to obtain agriculture information.

Digambar *et al.* (2020) reported that the (97.91%) farmers of rice producing in Rajnandgaon district of Chattisgarh received information regarding the cultivation practices of major crops from friends, relatives, and neighbour, 91.66 per cent farmers obtained information from television and 86.11 per cent from RAEs, 63 per cent farmers obtained the information from progressive farmers and 43 per cent of them obtained information from Kisan Mitra.

Jamanal *et al.* (2020) in their study of socio-economic characteristics of crop insured farmers of northern Karnataka revealed that 44.16% of the insured farmers belonged to medium category of mass media exposure, while 35.84% and 20.00% of them belonged to low and high category of mass media exposure respectively. The possible reasons might be that, majority of the farmers nowadays possess TV, mobile phones, newspaper, radio and agricultural magazines.

Medhi *et al.* (2020) reported that 100.00 per cent of rice growers took information from only one credible source namely Krishi Vigyan Kendra for rice cultivation, while 83.33 per cent, 56.66 per cent, 10.00 per cent and 5.00 per cent of the rice growers took information from various formal and informal sources like representative of input agencies or dealers, radio, friends and farmers of the other villages.

Musa *et al.* (2020) in their study of smallholder farmers sesame market orientation in Kondala district, Etopia revealed that 26.98% of them had no access to market information while the rest 73.02% had access to market information from neighbors, friends and traders on prices, quality and market demand

Nikam *et al.* (2020) reported that that high number of respondents (60%) had checked Whatsapp few times daily and (9%) farmers had checked their Whatsapp many times a day. Only (3%) farmers had not used messaging facility of the mobile while about (37.8%) farmers were using SMS service as per need. Social networks

like Facebook and Whatsapp were more popular among the farmers. Only 9.7 per cent farmers were not using the Facebook.

Kharumnuid *et al.* (2021) in their study on potato production for nutritional security and doubling farmers' income concluded that people should be made aware of the nutritional value of potatoes through mass media and other awareness programmes.

Moruppa and Ijabula (2021) revealed that 43.8% of the respondent uses Facebook in accessing agricultural information, while 33.6% uses WhatsApp, 16.4% uses YouTube but only 6.2% uses Twitter. And in terms of frequency of accessed of social media for agricultural information was revealed that 23.1% of the sample always used the social media, 43.6% used social media often, 26.9% used it occasionally, while 6.4% rarely used the social media for accessing information needed to improve their farming activities.

Somanje *et al.* (2021) reported that 60% of farmers in Ghana and 22% in Zambia perceive office visits as not effective. The use of radio platforms is perceived as highly effective for 54% of farmers in Ghana, compared with 47% in Zambia. Further found that the internet is perceived as not effective by 97% of farmers in Ghana, compared with 50% in Zambia.

Audu (2022) reported that mobile phone (98.2%) and radio (94.3%) were major sources of information used by the respondents. Television (56.3%), local market days (47.6%), Non-Governmental Organizations (NGOs) (44.9%) and government extension agents (38.1%) were also used by the farmers during the pandemic to source the needed information. The majority (78.3% and 80.1%) of the respondents utilized radio and mobile phone respectively on a daily basis.

Akinwale *et al.* (2022) revealed that cassava farmers used less of marketing websites (17.5%), extension services (27.5%), email (29.2) and social media (35.8%) as sources of market information, and sought less of agricultural extension service information (34.2%). And 92.5%, 85.0% and 83.3% used fellow farmers, radio and telephone calls respectively as sources of market information.

Singh *et al.* (2022) reported that majority of farmers (56.25%) were often used television for obtaining information regarding management of organic waste, majority of farmers (67.5%) were using phone call often, a majority of farmers

(57.5%) were found to be often used WhatsApp and YouTube, majority (46.3%) of respondents had medium mass media usage followed and majority (47.5%) of respondents have high ICT utilization.

Sumo *et al.* (2022) in a study of comparison of the socio-economic characteristics of households by access to extension services reported that more than half of the rice farmers owned a mobile phone.

Tran *et al.* (2022) in a study aimed at assessing the livelihoods of rice households in Nghe Vietnam reported that more than half of the respondents participated in farmers' associations (53%) and an agricultural cooperative (71%) to gain access to formal credit, climate information, and market information.

Yalakonda *et al.* (2022) in their study regarding the utilization pattern of the impersonal cosmopolite channels are depicted that television (88.33%), YouTube (76.45%) and ICTs (72.50%) were the most important impersonal channels to seek information about paddy cultivation by the respondents whereas the agricultural exhibition (51.66), agricultural campaign (44.58) and workshop (43.33) were less used personal cosmopolite channels by the respondents for obtaining information on paddy cultivation.

Yaseen *et al.* (2023) revealed that there are significant variations among farmers in the utilization of mobile phones, internet, television, radio, newspapers, extension services, market commission agents, and fellow farmers. The findings highlighted the usage of several combinations of ICT, traditional media, extension services, and farmers' social relations by the respondents.

2.3.12 Extension contacts

Pham *et al.* (2018) in their study to know the relations among risk attitudes, farmers' knowledge, management ability and agricultural shown that most of the farmers have contact extension one to two per year less than 5% have weekly or monthly contact.

Digambar *et al.* (2020) reported that 86.11 per cent respondents were having contacts with Rural Agriculture Extension Officers (RAEOs), 43 per cent respondents were having contacts with Krashak Mitra, 0.69 per cent of respondents were having contacts with scientists/SMS, only 2.77 per cent respondents were having contact with Senior Agriculture Development Officers (SADOs).

Ghosh *et al.* (2020) in their study of knowledge of farmers on sustainable agriculture practices reported that the extension contact ranged from 1 to 24 and the average score was 8.63. Most of the respondents (81.3%) had low extension contact followed by medium and high extension contact respectively.

Jamanal *et al.* (2020) in a study on socio-economic characteristics of crop insured farmers of northern Karnataka revealed that 43.75% of the insured farmers belonged to medium level of extension contact while 33.75 belonged to low level of extension contact and 22.50% of them belonged to high level of extension contact respectively.

Maina *et al.* (2020) in their study on analysing the socio-economic determinants of adoption and the impact of adopting *Brachiaria* grass reported that (84%) larger proportions of adopters significantly had more access to extension compared to (60%) non-adopters.

Mgendi *et al.* (2021) in their study on a training program sufficient to improve the smallholder farmers' productivity in Africa reported that access to any extension advice would increase farmers' participation in ATDC training program by 70.7% and 85.2% in the ATDC and other program, while other only programs would rise to 59.3%, which would make the average 60.5% participation in all training programs increased.

Iheke *et al.* (2021) in their study examined the socio-economic characteristics of the food crop farmers reported that 75% of the farmers do not have contact with extension agents and 48.33% were members of farmers' cooperative societies.

Satyam *et al.* (2021) in their study on socio-economic profile of sugarcane growers in east Champaran district of Bihar revealed that majority (60%) of the respondents had medium level of contact with the extension personnel's.

Wani *et al.* (2021) in their study on knowledge level about important production practices of high-density apple growers of Kashmir Valley found that extension contact had significant relationship with the knowledge level of the respondents.

Daniso (2022) in their study factors affecting farmers' decision to participate in various agricultural related information sources in Ethiopia reported that there

were 32.73% of farmers in the study area had contact with extension agent every week and 0.61% had a contact with extension agent once in a year.

Martey *et al.* (2022) in their study examined how perceptions of COVID-19 shocks influence the adoption of SAPs among smallholder farmers in Ghana reported that over 40% of the farmers have access to extension services and high adopters had two extension contacts per farming season.

Sumo *et al.* (2022) in their study of comparison of the socio-economic characteristics of households by access to extension services reported that approximately 69% of the farmers were aware of the existence of NGO extension programs.

Begum *et al.* (2023) in their study aimed to investigate the production risk and technical inefficiency of bean farms in Bangladesh reported that extension service was about 1 day.

2.3.13 Scientific orientation

Gurjur *et al.* (2017) in their study on entrepreneurial behaviour of potato growers and constraints faced by farmers in production and marketing of potato and their suggestion reported that majority (58.33%) had medium level of scientific orientation followed by 23.33 per cent had low level and 18.33 per cent had high level of scientific orientation.

Verma *et al.* (2017) in their study to examine the member of Gram Panchayat about farm television reported that majority 68.75% of the respondents had medium scientific orientation followed by high 16.67% and low 14.58%.

Tikariha and Soni (2018) in their study on entrepreneurial behaviour of potato growers reported that the entrepreneurial behaviour of the farmers had medium to high level of scientific orientation.

Jamanal *et al.* (2020) in their study of socio-economic characteristics of crop insured farmers of northern Karnataka revealed that 42.08% of the insured farmers belonged to medium scientific orientation followed by (33.75%) low level and (24.17%) high level of scientific orientation.

Madhu *et al.* (2020) in the study on knowledge and attitude of farmers and constraints faced by them on soil health cards in Mandya district of Karnatak

reported that scientific orientation had significant association with the knowledge level of respondents towards soil health card at one per cent level of significance.

Yedida *et al.*(2020) in a study on scientific, economic and management orientation of coconut growers of East Godavari district of Andhra Pradesh, India reported that 69% of the total selected respondents were with medium level of scientific orientation followed by 16% were found to have high levels of scientific orientation and only 15% of the respondents were found to have low level of scientific orientation.

Islam *et al.* (2021) in their study on knowledge level about important production practices of high-density apple growers of Kashmir Valley found 31 that scientific orientation had significant relationship with the knowledge level of the respondents.

Raghuwanshi *et al.* (2022) in the study on profile characteristics of farmers on knowledge, attitude and accessibility towards privatization of agricultural extension services reported that 56.90 per cent farmers were having medium level of scientific orientation, followed by 24.14 per cent high level of scientific orientation and while only 18.96 per cent had farmers comes under low level of scientific orientation.

Angela and Sharma (2023) reported that there is positive linear relationship between communication media usage versus scientific orientation ($p=0.562$, $P<0:05$). It is clearly indicating that as the communication media usage increases, the socio-psychological variables such as scientific orientation improved.

2.3.14 Innovativeness

Verma *et al.* (2017) in their study to examine the member of Gram Panchayat about farm television reported that majority 39.59% of the respondents had high innovativeness followed by high 15.63 and low 13.54%.

Singh *et al.* (2019) reported that 52.00 percent of dairy farmers had medium level of innovativeness, whereas 33.00 percent of dairy farmers belonged to high innovativeness. It was interesting to note that only 15.00 percent of dairy farmers belonged to low innovativeness category

Jaiswal *et al.* (2020) in their study on entrepreneurial behaviour of vegetable growers at Gangeo block of Rewa district (M.P.) reported that majority 67.50 per

cent of the respondents had medium level of innovativeness followed by 16.66 per cent of the respondents had low level of innovativeness and 15.83 per cent of the respondents had high level of innovativeness.

Medhi *et al.* (2020) reported that majority (50.00%) of the respondents belonged to medium innovation proneness category followed by high (28.34%) and low (21.66%) by the respondents of improved rice cultivation in west Garo hills district.

Evahelda *et al.* (2021) reported that the results of the assessment of farmers revealed that 35% of farmers agree and 18% strongly agree that farmers can innovate.

Reddy *et al.* (2021) in their study on entrepreneurial behavior of dairy farmers reported that majority (59.40%) of dairy farmers had medium level of innovativeness while 21.8 and 18.8 per cent of dairy farmers had high and low levels of innovativeness, respectively. This could be due to the fact that limited awareness on new technologies and skills, poor literacy, rigid beliefs and confined habits of the dairy farmers might have prevented them from being innovative in trying out new technologies.

Podikunju and Arathy (2022) in their study on pesticide handling behaviour of vegetable farmers conducted in Thiruvananthapuram district of Kerala reported that majority (43.3%) of the respondents belonged to medium level innovativeness.

Raghuwanshi *et al.* (2022) in the study on profile characteristics of farmers on knowledge, attitude and accessibility towards privatization of agricultural extension services reported that 51.72 per cent comes under innovative proneness followed by 31.61 per cent were high level of innovative proneness and 16.67 per cent farmers possessed in low level of innovative proneness.

Angela and Sharma (2023) reported that there is significant positive linear relationship between communication media usage and innovation proneness ($\rho=0.212$, $P<0.05$) in the study on analysis of socio-economics and occupational dimensions of shrimp farmers of Tamil Nadu. It is clearly indicating that as the communication media usage increases, the social-psychological variables such as innovativeness improved.

2.3.15 Risk orientation

Verma *et al.* (2017) in their study to examine the member of Gram Panchayat about farm television reported that majority 70.83% of the respondents had high risk orientation followed by medium 30.2% and low 30.21%.

Singh *et al.* (2019) reported that more than half of the dairy farmers 62.00 percent had medium risk orientation, however 25.00 percent of dairy farmers had high risk orientation, whereas 13.00 percent of dairy farmers had low risk orientation.

Burman *et al.* (2020) in their study on behavioral pattern of farmer entrepreneurs and success factors for establishment of agribusiness ventures under ACABC scheme found that majority of the respondents had high level (46.67%), whereas 33.33% of the entrepreneurs had medium category of risk taking behavior and rest of the farmers had low (20.00%) level of risk taking behavior.

Chand and Shukla (2020) in their study of perception of the farmers towards technical capability of public extension personnel in middle Gujarat revealed that about (72.50%) of the farmers has medium level of risk orientation.

Digambar *et al.* (2020) reported that the farmers of rice producing Rajnandgaon district of Chhattisgarh had majority (57.64%) had a medium level of risk orientation.

Jamanal *et al.* (2020) in their study of socio-economic characteristics of crop insured farmers of northern Karnataka revealed that majority of insured farmers (52.50%) belonged to medium risk orientation category followed by low (29.58%) and high (17.92%) risk orientation category.

Madhu *et al.* (2020) reported that farmers take moderate risk to precisely to achieve success, stabilized and maximization of yield and income by following soil health card information

Medhi *et al.* (2020) reported that most (45.00%) of the respondents were found to have high risk bearing ability followed by 36.67 per cent having medium risk bearing ability while 18.33 per cent were found to have low risk bearing ability by the respondents of improved rice cultivation in west Garo hills district.

Evahelda *et al.* (2021) reported that Muntok Pepper farmers were entrepreneur oriented in managing their farms that 98% of farmers agree that they

dare to take risks, respond to risks, and know risks in their work, finances, production, and investment. The assessment of farmers revealed that 55% of farmers agreed, 43% stated strongly agree on the assessment of risk variables.

Mandala *et al.* (2021) in their study on influence of agricultural farmers' entrepreneurial behaviour reported that at the greatest number (half) of dairy farmers had a medium level of risk orientation followed by 35% of them had a high class of danger direction. Just 15% had a low class of danger direction.

Rathore *et al.* (2021) revealed that almost half of the farmers (56.25%) possessed a medium level of risk orientation, and only 31.25 per cent and 12.50 per cent respondents were reported to have low and medium level of risk orientation.

Podikunju and Arathy (2022) in their study entitled pesticide handling behaviour of vegetable farmers conducted in Thiruvananthapuram district of Kerala reported majority (65%) of the respondents belonged to medium risk orientation.

Asmara *et al.* (2023) reported that the risk orientation of shallot farmers in Banaran Wetan village were moderate (51%) followed by (31%) low and (18%) high.

2.3.16 Production orientation

Biswas *et al.* (2020) revealed that the family income had the highest total effect as well as highest direct effect on production orientation. The variable age had the highest indirect effect on production orientation and the stepwise regression analysis suggests that only one variable retained in the last has contributed 62.70% of the variable explained.

Kharlukhi and Jha (2021) reported that production orientation had the highest with mean score 9.95 of an entrepreneurial behaviour of different horticultural growers.

Shreedutt and Mazhar, (2022) in their study on entrepreneurial behaviour of rose growers in Prayagraj district of Uttar Pradesh reported that more than half of respondents 65.00 per cent fell under medium category of production orientation, followed by 20.00 per cent and 15.00 per cent of respondents fell under low and high of production orientation. Thus, it is concluded that majority of rose growers had medium level of production orientation.

Upadhyay *et al.* (2022) on their study in production-oriented survey on different aspects of rice cultivation and farmers practices of Eastern U.P. reported that popular rice varieties cultivated in this area were Jalpriya, Jalmagna, Madhukar, Pusa Basmati 1 and Arize 6444. Different cropping systems followed by the farmers were rice-wheat, rice-mustard + lentil, rice-vegetables and rice-lentil + sugarcane. Average yield was 3500-4200 kg/ha.

2.3.17 Market orientation

Okoye *et al.* (2019) reported that females tend to increase their probability of being market-oriented, level of market-orientation and for all the farmers by 0.960 percent, 0.466 percent and 1.426 percent respectively compared to their male counterparts. The results of the study show that the mean market-orientation for male and female sweet potato producers were 0.17 (SD=0.08) and 0.59 (SD=0.19) respectively with a Z test value of $5.82 > 0.05$.

Medhi *et al.* (2020) reported that average score of respondents in market orientation was mean (24.02). Majority of the rice growers had high level of market orientation (45.00%) followed by medium (38.33%) and low (16.67%). This indicates that the sample farmers had high to medium level of market orientation.

Musa *et al.* (2020) revealed that sesame market orientation index was low (16.6%) indicating that small proportion of land was allocated for sesame production. The result shows that access to market information to sesame producers will increase sesame market orientation by 3.2% on average.

Nnadi *et al.* (2020) reported that the awareness of market orientation culture by an overwhelming majority of farmers' cooperatives (98%) with the standard deviation score of approximately 0.12 implies that the farmers were homogeneous in their responses while a grand mean of approximately 3.24 indicated slight market orientation.

Nwafor (2020) reported that the smallholder farmers in the survey had an average market orientation index of 0.55, with a maximum and minimum values based on which smallholder farmers who sell 50% of produce are considered to be market-oriented, the study respondents had an average market orientation index of 55% and sold approximately 62% of their crops in the market.

Ugochukwu (2020) in their study on market orientation of smallholder south African farmers reported that the smallholder farmers in the survey had an average market orientation index of 0.55, with a maximum and minimum values of 0.79 and 0.40 respectively.

Agyekum *et al.* (2021) in their study reported that participants of Farmer Business School (FBS) cocoa farmers were more market oriented ($M=2.63$, $SD=0.35$) than the non-participants ($M=2.56$, $SD=0.50$). There is a mean difference of 0.07.

Evahelda *et al.* (2021) reported that more than 50% of farmers agree that they have been trying to be competitor oriented and continue to explore market information, only 47% of farmers agreed to strongly agree that they are customer-oriented in managing their farms, 27% of farmers stated that they do not know the target market and product quality needed by customers and 26% of farmers have tried to find out the target market and product quality needed by customers but cannot produce according to customer needs.

Akinwale *et al.* (2022) in their study on assessment of factors that affect market orientation of cassava farmers in Osun State, Nigeria reported that none of the respondents had low market orientation, 10.8 % had average market orientation and 89.2% had high market orientation.

Lal *et al.* (2022) in their study on marketing Orientation of Farmers Towards Organic Produce: Study of Indian Himalayan States showed that education level of the farmers significantly affects the distribution strategies of the farmers towards organic products. The study finds that producers are selling their organic product in the local market and are ready to be part of clusters/ groups to expand their market.

Mkuna and Wale (2022) indicated in their study that most of the farmers' market orientations were in the range of 0-0.2, followed by 0.2-0.4, 0.4-0.6 and 0.61-0.8 which were 42.8%, 16.3%, 15.3%, and 9.3%, respectively.

Shreedutt and Mazhar (2022) in their study on entrepreneurial behaviour of rose growers in Prayagraj district of Uttar Pradesh reported that more than half of respondents 70.00 per cent fell under medium category of marketing orientation, followed by 15.00 per cent of respondents fell under low and high of production orientation.

2.3.18 Knowledge level

Karangami *et al.* (2019) in their study on knowledge about recommended rice cultivation practices by farmers from Palghar district reported that the maximum number (75.00 per cent) of the respondents had 'medium' knowledge of the rice. While each 12.50 per cent of the respondents had 'low' and 'high' level of the knowledge respectively. Average knowledge score of the farmer was 55.02.

Gebaska *et al.* (2020) in their study aimed to determine polish farmers' awareness of sustainability with regards to animal and crop production results show that dairy farmers and pork farmers declared higher knowledge and better implement sustainable practices than other farmers.

Ghosh *et al.* (2020) in their study on knowledge of farmers to sustainable agriculture practices reported that the overall knowledge scores on sustainable agriculture of the respondents range from 8 to 41, with an average being 21.1. Knowledge score on sustainability of the respondents could range from 0 to 42. On an average the knowledge score was about 21 which mean the respondents gave about 50% correct answer of the questions on sustainable agriculture practices.

Kumar *et al.* (2020) reported that majority 67.5% of the respondents from trained category had medium extent of knowledge; while 20% had high extent of knowledge, and 12.5% had low extent of knowledge. In untrained category the majority 76.875% respondents had medium extent of knowledge, while 18.125% were having low extent of knowledge and only 5% having high extent of knowledge.

Madhu *et al.* (2020) reported that out of the 28 farmers who had low level of knowledge on soil health card (16.66 %), out of 59 farmers with medium knowledge, one-fifth of them (20.00 %) and out of 33 farmers with high knowledge level, almost all of them (25.00 %) towards soil health card.

Touch *et al.* (2020) in their study on assessments of lowland rice-based farming systems found that their knowledge gaps, limitations and the rice yield gap which exist in Northwest Cambodia in the interviewed of 524 farmers.

Kumar and Jahanara (2021) reported that most of the trained paddy growers had an equal percentage of medium (43.33%) and high (43.33%) level of knowledge. More than half of the untrained paddy growers (58.33%) had medium level of knowledge, followed by low (26.67%) and high (15%) level of knowledge.

Pawar and Channaveer (2021) in their study on farmers attitudes towards sustainable agricultural practice at Kalaburagi district reported that 31.67% of farmers lack knowledge regarding sustainable agriculture practice, while 28.75% of farmers lack knowledge on pest and disease control in sterility mosaic diseases.

Liao *et al.* (2022) reported that the statistics revealed that over half (52%) farmers have good levels of sustainable agriculture knowledge. Farmers in Naengmut tend to hold a higher level of knowledge regarding sustainable agricultural concepts. The majority of farmers in both sub-districts (over 80%) refer to sustainable agriculture as self-reliance of the rural community, while more than 90% farmers in Naengmut consider sustainable agriculture to be the sustainable integration of environmental, economic, and social resources, conservation of the environment, and protection of human health.

Podikunju and Arathy (2022) revealed that the 40 statements of knowledge test were divided into 8 different components. More than half of the respondents (54.2%) had medium level of knowledge about safe handling of pesticides followed by 24.2 per cent who had high level of knowledge and only 21.7 per cent had low level of knowledge about safe handling practices.

Sarma *et al.* (2022) in their study on hybrid rice production revealed that a high degree of knowledge regarding hybrid rice was held by 30.33% of adopters, followed by a medium level by 55.74% and a low level by 13.93%. Conversely, 8.20% of non-adopters had a high degree of understanding regarding hybrid rice, while the percentages with medium and low levels of knowledge were 25.41%, and 66.39%, respectively. The average knowledge index value of the two groups differed significantly at the 1% level,

Asmara *et al.* (2023) reported that the knowledge of farmers is moderate with a percentage of 49% followed by high 39% and low 12%. The respondent farmers admitted that their knowledge about shallot cultivation is quite good, considering their long experience of farming and success in achieving high amounts of shallot production.

2.3.19. Perception towards climate change

Amponsah *et al.* (2018) reported that more than half of the farmer (53.70%) has perception of perceived experienced up to about (9%) losses during the harvest

stage of rice crop while over (60%) experienced similar per cent losses during post-harvest activities of rice cultivation.

Jamanal *et al.* (2020) revealed that 51.25 % of the insured farmers belonged to high level of extent of perception on climate variation followed by medium (29.58%) and low (19.17) level. Majority of the insured farmers strongly agree to the statement of late onset of monsoon (65.00%) followed by occurrence of drought (59.17%), changes in time of sowing (56.67%), decrease in average rainfall (52.50%), uneven distribution of rainfall (46.67%), increased pest and diseases (48.75%) and decreased yield (35.83%). More than (70%) of the insured farmers disagree to the statement of reduced soil fertility (77.08%) and increased crop weed competition (70.83%).

Jha and Gupta (2021) reported that 87 per cent of the farmers noticed an increased number of hot days, while only 4 per cent observed a decrease in the number of hot days, and 9 per cent reported no change in it. About 44 per cent of farmers felt an increase in the number of cold days; 47 per cent observed a decrease and 9 per cent reported no change. Similarly, around 86 per cent of the sample farm household perceived changes in precipitation. However, 47 per cent farmers noticed a decline while 39 per cent observed the rise, and the remaining 14 per cent did not observe any change in rainfall level. And most of the surveyed farmers experienced floods (85per cent) and frost instances (76 per cent) in the past 5 years. Farmers also experienced medium instances of the cyclone (60 per cent) and hotness (45 per cent) in 5 years.

Nyangau *et al.* (2021) reported that there was a declining trend in the total annual rainfall for the last 35 years. The average annual decrease was 18.47 mm of rainfall with a co-variance of variation (CV) of 37.93% and 79.10% of the respondents changed planting time due to changes in temperature and precipitation. And the study revealed that 88.3% of the respondents perceived climate changes noted a decrease in rainfall, 79.1% reported poor rainfall distribution, 88.3% perceived a late onset of rainfall while 76.6% perceived an increase in temperature.

Belay *et al.* (2022) reported that many respondents (81.8%) perceived that climate condition has changed since the last three decades. Similarly, 71.95% farmers reported that the temperature has increased, and 53.15% of them reported

that the amount of rainfall has decreased, (81.8%) of the respondents have perceived increasing temperature and decreasing rainfall distribution in the last three decades, particularly in the recent 5-10 years. Survey participants reported the main changes in rainfall and temperature observed in their localities; 71% of respondents claimed that the rainfall and temperature trends become increasingly unpredictable.

Datta *et al.* (2022) revealed that there are changes in precipitation (57.81 percent), followed by temperature (33.33 percent), other MVs (wind pattern and cloudiness). The most common perception regarding the CCCs was reported as the increasing overall temperature pattern (17.19 percent). In terms of seasonal warming, farmers perceived a rise in summer temperature (5.73 percent) and an increase in the hot summer months (3.13 percent). However, there were mixed perceptions regarding the changes in winter temperature. Some studies reported increasing winter temperature (4.17 percent) and a decrease in the spanning of the winter season (3.13 percent).

Liao *et al.* (2022) reported that the indicators that reflect farmers' perceptions of environmental changes address drought, water pollution, air pollution, pest outbreaks, deforestation, and soil degradation. The perception of most (84%) farmers has changed. Natural hazards, namely pest outbreak (75%) and drought (69%), account for the largest proportion of perceived problems. In addition, most of the farmers observe deforestation (63%) and soil degradation (62%). Over half of them tend to agree with environmental pollution, including air pollution (65%) and water pollution (51%).

Reddy *et al.* (2022) revealed that about 62% of the sampled farmers perceived climate change in various meteorological indicators. Approximately 40% had perceived that there was a decrease in the quantity of rainfall. However, 42% had perceived a delay in monsoon onset by one day than earlier. Even 72% of farmers perceived an increase in annual temperature, and few of them (30%) stated that there is an increase in the length of the summer season, and the span of the winter season was decreased. Approximately 80% of farmers have perceived that groundwater level has depleted, while 72% have stated that water quality has degraded over the years.

2.4 Cropping pattern and farm resources management under rice-based farming system

Deep *et al.* (2018) in their study on rice base cropping system in India reported that wheat (R-W), and rice-maize (R-M) are the predominant cropping systems in tropical and sub-tropical environments of South Asia. In rice–wheat cropping systems, green manuring has proved a feasible and reliable practice to improve the productivity and soil fertility as well. The main bio-fertilizers which can be used as supplement to chemical fertilizers are blue-green algae and Azolla for rice. Blue-green algae are capable of fixing atmospheric nitrogen, particularly under puddled rice soils, contributing about 50–100 kg N/ha.

Haobijam *et al.* (2018) found that integration of rice cultivation with fish farming enables optimum utilization of available local resources, by turning the practices into low input self-supporting system. Paddy-cum-fish is beneficial for the farmers in Manipur as integrated farming reduces the risk of separate cultivation of paddy and fish monoculture and it generate more net income.

Jayanthi (2018) in their study on integrated rice based farming system for enhancing productivity and climate resilience revealed that farmers grown rice-soybean-sunflower and rice-gingerly-maize cropping systems each in 0.18 ha with pigeon (40 pairs), fish (400 polyculture fingerlings in 0.04 ha of ponded water) and mushroom (2 kg/day) was best in obtaining higher productivity in the system as a whole than the conventional cropping system being popular with rice green gram-maize (0.20 ha) and rice-sunhemp - maize (0.20 ha) cropping systems.

Khan and Parashari (2018) reported that wheat-rice-sugarcane-livestock is the most prevalent system adopted by 22.50 per cent farmers, 18.33 per cent farmers adopted wheat- rice- livestock, 15.83 per cent farmers adopted wheat-rice-sugarcane-pulse-oilseeds-maize-livestock, 13.33 per cent farmers adopted wheat-rice-sugarcane-vegetables-livestock, 11.67 per cent farmers adopted wheat-rice-millet-sugarcane-oilseeds-pulses-livestock, 10.83 per cent farmers adopted wheat-sugarcane-horticulture-livestock and 7.50 per cent farmers adopted wheat-rice-sugarcane-vegetable-pulses-livestock. All the integrated crop livestock systems are wheat and rice-based systems while 5 systems out of 7 are also sugarcane based.

Jamanal *et al.* (2020) revealed that in kharif season majority of the insured farmers of Karnataka were growing cotton (67.50%), followed by green gram (59.58%), onion (48.33%), vegetables (47.92%), chilli (40.41%), soybean (38.33%), maize (25.42%), pigeon pea (20.00%), groundnut (17.08%) and other crops (9.16%). In rabi season, majority of the insured farmers (88.75%) were growing jowar, followed by chickpea (74.17%), wheat (27.92%) and other crops (7.92%). In summer season, about 10.00% of the insured farmers were growing soybean, 7.08% of them were growing maize, 4.58% of them were growing vegetables and only 3.33% of them were growing groundnut.

Kumar *et al.* (2019) in their study on crop diversification for enhancing the productivity for food and nutritional security under the Eastern Himalayas reported that higher land use efficiency was recorded with rice-cabbage (78.2%) due to the longer duration of sequences, followed by rice-pea (78.1%) and rice-tomato (76.4%). This confirmed that crop diversification utilises land resources efficiently, which would not only increase profitability but also generates more employment during the lean period.

Mugisa *et al.* (2020) in their study on analysis of the three rice-based inter-crops showed that the best row inter-crops the rice-beans and rice-groundnuts mixtures was inter-crop 3 which had a planting ratio of 4:3 (rice:Inter-crop) and produced both better yields and higher LERs. However, for the case of rice-maize, inter-crop 1 with a planting ratio of 3:2 (rice:maize) performed best.

Nwafor (2020) reported that respondents were maize-based farmers and many also planted other crops including Irish potato (29%), cabbage (21%), sweet potato (4%) and spinach (19%) during the last planting season. Furthermore, about 96.7% of respondents purchased fertilizers during the past season while 3.3% of them did not.

Mpanga *et al.* (2021) reported that the most used sustainable and regenerative practice by respondents were soil health and quality (17%), water use efficiency (17%), reduced pesticides and herbicides use (15%), and recycling waste into resources (16%). Other sustainable and regenerative practices used among the respondents included increasing biodiversity (12%), conservation agriculture (8%), energy use efficiency (10%), and efficient mineral nutrient use (6%).

Mugumaarhahama *et al.* (2021) in their study on the socio-economic characteristics of adopters and non-adopters of improved sweet potato varieties in South-Kivu reported that majority of the potato farmers practice the inter-cropping system on plots of nearly 45 ares with medium to high soil fertility levels.

Nyang'au *et al.* (2021) in their study on smallholder farmers' perception of climate change and adoption of climate smart agriculture practices reported that 77.6% of the farmers practised either crop rotation or mixed cropping to increase productivity.

Podikunju and Arathy (2022) revealed that majority of the respondents were grown 47.50 per cent of yard long bean followed by 38.33 per cent were growing cucumber as the major crop and a very less percentage (2.50%) were growing tomato.

Upadhaya *et al.* (2022) in their study on diversification of rice-based cropping system for improving system productivity and soil health in Eastern Gangetic plains of India reported that ten different cropping sequences were exploited using randomised block design and replicated thrice, with the system productivity ranging from 8.70 to 24.95 t/ha under the different cropping sequences. The system productivity was increased by 187% and profitability by 299.52% in the maize-cole crops-sesame cropping system over the rice-wheat cropping system. It was also revealed that a maximum land use efficiency of 94.52% was recorded with red gram inter-cropped with turmeric, followed by the green gram cropping sequence due to the crop duration (345 days)

Jenkins *et al.* (2023) reported that land fallowing was the most common methods suitable for soil fertility management (48.6% males and 46.2% females), followed by the use of organic manure (34.4% males and 32.6% females), additionally of organic matter was mentioned by 36.1% of male farmers and 11.1% of female farmers in Bo District. And the planting of leguminous plants was practiced by only 5.6% of female farmers in Kailahun District compared to only 22.2% male farmers in Tonkolili District. In Kenema District, more females (55.6%) than males (27.8%) mentioned the addition of organic matter as an indigenous method of fertility management, whereas in Bombali and Bonthe Districts, equal proportions of both males and females used the method.

2.5 Attitude of farmers towards adoption of sustainable agricultural practices

Nataraju *et al.* (2019) in their study on attitude of farmers towards agriculture found that a (42.00%) farmers had favourable attitude towards agriculture, while 35.00 and 23.00 per cent of farmers were having more favourable and less favourable attitude towards agriculture.

Madhu *et al.* (2020) reported that (16.66%) had less favourable attitude towards soil health card, (20.00%) had favourable attitude towards soil health card, (25.00%) had more favourable attitude towards soil health card.

Mandal and Alam (2020) in their study on measuring the attitude of the farmers towards agriculture as a profession reported that majority of the respondent farmers (72.86 per cent) obtained a medium attitude score followed by low score (17.14 per cent) and high score (10.00 per cent) accordingly.

Pandey *et al.* (2020) found that 28.58 per cent field functionaries had unfavourable attitude towards the department services whereas, only 7.66 and 2.53 per cent of them had neutral and most unfavourable attitude on a study to ascertain the attitude of field functionaries towards agricultural extension system of State Department of Agriculture.

Pawar and Channaveer (2021) in their study on farmers attitudes towards sustainable agricultural practice reported that 12 (26%) farmers had low attitudes, and 38 (74%) farmers had medium levels of attitude in the village.

Kumar *et al.* (2022) in the study on analysis of knowledge and adoption of rice cultivators trained by KVKs in Central Plain Zone of Uttar Pradesh revealed that majority of the respondents (56.25%) had the favourable attitude towards different farming systems, followed by 25.41 per cent had highly favourable and 18.34 per cent of the respondents had less favourable attitude towards different farming system. In general, the majority of the respondents (81.66%) had the favourable attitude towards different farming systems.

Liao *et al.* (2022) reported that most of the surveyed farmers express positive attitudes towards sustainable agriculture, farmers' attitudes. With respect to economic viability, farmers in the two sub-districts do not exhibit significantly different attitudes on "sustaining economic profitability to maintain life" and "minimizing agriculture marketing risks".

Londhe and Kadam (2022) in their study on farmers attitude towards organic farming in Marathwada region reported that majority (60.00%) of the respondents had favourable attitude towards organic farming, while 23.34 per cent of them had less favourable and 16.66 per cent of them had most favourable attitude towards organic farming.

Mahajan *et al.* (2022) reported that more than half (74.00%) of the farmers had moderately favourable attitude towards use of ICT tools, followed by less favourable attitude *i.e.* 14.67 percent and very few respondents had highly favourable attitude towards usages of ICT (11.33 percent).

Podikunju and Arathy (2022) in their study on pesticide handling behaviour of vegetable farmers revealed that more than half of the respondents (57.5%) had medium level of attitude towards safe handling of pesticides followed by 22.5 per cent who had high level of attitude and only 20 per cent had low level of attitude towards safe handling practices.

Ramu and Asokhan (2022) reported that almost half (48.50%) of the farmers were found to possess moderately favourable attitude towards conservation agriculture followed by more than one-third (36.48%) of the farmers with less favourable attitude and less than one-fifth (15.02%) of the farmers had highly favourable attitude towards conservation agriculture. It is clear from the above findings that majority (84.98%) of the farmers had moderately to less favourable attitude towards conservation agriculture.

Sarma *et al.* (2022) in their study on hybrid rice production reported that 33.82% of the adopters' sample farmers had a positive attitude toward the production of hybrid rice. However, 57.35% and 8.82% of the farmers who adopted hybrid rice farming had average and poor views, respectively. In contrast, 18.46% of the farmers in the non-adopters' sample had a high attitude toward hybrid rice, compared to 49.23% and 32.316% of the farmers in the non-adopter's sample who had a medium attitude and a low attitude, respectively.

2.6 Extent of adoption and factors determining adoption of sustainable agricultural practices

Pilarova *et al.* (2018) revealed that the adoption of sustainable practices by small-scale farmers is influenced predominantly by farmer characteristics and by

their perception of risk. The findings of this research confirmed that households with lower access to financial resources are less likely to adopt these practices.

Khonje *et al.* (2018) showed that joint adoption of multiple SAPs had higher impacts on yields, household income and poverty than the adoption of components of the technology package in Zambia.

Manda *et al.* (2018) found that farmers' decisions to adopt improved maize varieties are mainly influenced by education, household size, livestock holdings, land per capita, market information, and locations in Zambia.

Amondo *et al.* (2019) found that adopting drought-tolerant maize varieties increased maize yield by 15% in Zambia.

Gnanasubramaniam and Hemachandra (2020) in their study on perception of climate change and farmers' adaptation found that probability of adopting dry seeding is 3.8 per cent in major irrigation schemes and 5.4 per cent in the minor irrigation scheme. Bethma is highly practiced in major irrigation schemes.

Kumar *et al.* (2020) reported that out of 160 trained respondents, 129 (80.625%) were under high adoption category, 22 (13.75%) medium adoption category and 18 (11.02%) low adoption category whereas out of 160 untrained respondents 102 (63.75) were under high adoption category, 55 (34.38%) medium adoption category and 25 (15.63%) low adoption category. Only 5 (3.15%) were under no adoption category in HYV.

Marennya *et al.* (2020) concluded that a higher number of SAPs adopted resulted in higher maize grain yield and maize income in Ethiopia.

Martey *et al.* (2020) in their study on economic impacts of smallholder farmers' adoption of drought-tolerant maize varieties reveals that farmers' adoption of drought-tolerant maize varieties is mainly determined by access to seed, gender, access to extension, labour availability and location of the farmer in Ghana.

Shanabhoga *et al.* (2020) reported that the vast majority (96.67%) of the farmers had used crops as livestock fodder as they fall back in case of failure, followed by the majority (72.22%) of the selected appropriate varieties. Cent per cent of the farmers adopted the construction of waterways along the slope for safe disposal of rainwater. An overwhelming portion of the farmers adopted leveling of the land in between the bunds (96.67%) and construction of bunds to conserve

moisture (95.56%). The majority (76.67%) of the farmers intensified agricultural activities on irrigated land. Nearly half of them (47.78%) paddy growers were practising zero tillage to save time and money.

Iheke *et al.* (2021) in their study examined the socioeconomic characteristics of the food crop farmers reported that the mean level of commercialization and adoption of innovation was 54.61% and 32.22% respectively. The significant determinants of adoption were age of the farmer ($P<0.01$), gender ($P<0.01$), educational attainment ($P<0.01$), extension visits ($P<0.05$), income ($P<0.01$), access to credit ($P<0.01$), cost of innovation adoption ($P<0.05$) and membership of farmers association/cooperative society ($P<0.05$).

Kimathi *et al.* (2021) investigated farmers' decisions to adopt climate-resilient potato varieties and found that the main factors affecting adoption were access to information, quality seeds, training, group membership and variations in agro-ecological zones.

Mhoja *et al.* (2021) revealed that 60.6% of adopters were high (active), 25.3% were low while 14.1% were moderate in the Kilombero district. These results show that the majority of adopters (66.6%) were active adopters of improved rice seeds. In investigated adoption levels of pests and diseases management technology of respondents, 59.6% were high (active), 30.3% were low while 10.1% were moderate.

Nyangau *et al.* (2021) in their study on smallholder farmers' perception of climate change and adoption of climate smart agriculture practices reported that 18.4% of the farmers adopted water harvesting technology, 56.1% of the respondents adopted other soil conservation practices such as mulching and terraces in their farm.

Martey *et al.* (2022) reported that farmers in Ghana are 19 percentage points less likely to adopt mixed cropping and 48 percentage points more likely to adopt organic fertilizer. Older farmers are 2.4 and 0.9 percentage points more likely to adopt no tillage and mixed cropping, respectively. In contrast, older farmers are 1.6 percentage points less likely to adopt inorganic fertilizer. The probability of adopting no tillage and mixed cropping is 11.9 and 19.2 percentage points lower for farm households with migrants. Similarly, farm household members seeking off-

farm jobs are 7.1 percentage points and 7.8 percentage points less likely to adopt no tillage and pesticides.

Podikunju and Arathy (2022) in their study on pesticide handling behaviour of vegetable farmer-a multidimensional analysis revealed that majority of the respondents (48.3%) had medium level of adoption of safe handling of pesticides followed by 26.7 per cent who had high level of adoption and only 25 per cent had low level of adoption of safe handling practices.

Setsoafia *et al.* (2022) in their study to investigate the factors affecting smallholder farmers' decisions to adopt SAPs found that education has positive impacts in all estimated specifications but is only statistically significant in the specification of adopting improved seed and fertilizer and farmers' decisions to adopt SAPs are influenced by the social demographics of the households (*e.g.* gender, education, marital status, and household size), plot-level characteristics (*e.g.* number of crops, soil types, and topography), extension services, and locations.

Checco *et al.* (2023) reported that the findings synthesized from 99 studies suggested that variables (farm size, education, information access and farm location) examined extensively was not necessarily the most important determinants of adoption when undertaking a weighted analysis. Terrain, source of seed and technology-related attributes (perceived yield, maturity, ease of use, marketability and technical efficiency) was more important determinants of adoption, with determinants changing according to adoption type (probability or intensity of adoption), variety type and region.

2.7 Employment generation (mandays) under sustainable agricultural practices

Khan and Parashari (2018) in their study on income and employment generation through integrated crop-livestock farming system in Bulandshahr district: a geographical analysis reported that the IFS system creates employment opportunities, especially for women who are generally not employed during the off-season.

Dev *et al.* (2019) in their study on impact of mid-himalayan watershed development project on employment, income generation and problems faced by

farmers in Himachal Pradesh reported that farms labour employed of beneficiary varied from 28 mandays to 190 mandays, with a total of 460 mandays for different activities in a year. In case of non-beneficiary maximum (146.5 mandays) on livestock activities and minimum (24 mandays) on horticulture, activities per year. In a year the total labour employed on small farms was 498.15 mandays of which maximum (196 mandays) in livestock followed by (187 mandays) agriculture, forestry (39 mandays), horticulture (38.5 mandays) and off farm activities (37.5 mandays). Likewise, the beneficiary semi medium farmers employed 210 mandays on agriculture, 28.5 mandays on horticulture, 35 mandays on forestry, 220 mandays on livestock and 27.50 mandays on off farm activities during the year. So the total labour employment generated by different activities was 521 mandays per year. Thus, as the farm size increased the employment of labour (mandays farm year) also increased.

Pandey *et al.* (2019) in their study on income and employment generation and resource productivities of different factors in integrated farming systems in vindhyan plateau of Madhya Pradesh reported that income and employment generation from farming system IInd (Crops + Vegetables), IIIrd (Crops + Dairy) and IVth (Crops + Poultry) over to crop husbandry in study area found to increase in positive way. And the overall income generation in these farming systems were increased by (188.87%) over crop husbandry alone Ist and overall relative change in employment generation were increased by (128.10%) over base farming system i.e. crop husbandry alone Ist. Integrated Farming System provided additional (188.87%) farm income and additional (128.10%) family labour to the farmers over crop husbandry alone.

Rathore *et al.* (2019) in their study on integrated farming system: key to sustainability in arid and semi-arid regions reported that IFS (Integrated Farming System) involving livestock created higher employment opportunities compared to the traditional methods.

Sahoo *et al.* (2019) in their study on income and employment generation through contract goat farming in Odisha reported that average employment generation by CGF (Contract Goat Farming) was about 229 man days. It is evident

from the study that CGF provides a relative gainful employment of 33 to 418 man days for the resource poor goat farmers. Majority (41.66%) of the CGF farmers had medium level of employment through CGF followed by low level (31.66%) and high level (26.66%) of employment. The average employment generation through CGF for contractors was about 15.44 man days per year. The study further revealed that majority of the contractors (83.33%) had a low level of employment (6.98-22.25 man days) through CGF followed by 10 per cent contractors had medium level (10%) high level (6.66%) of employment generation.

Elamathi *et al.* (2021) in their study on integrated farming system model for sustained farm income and employment generation under rainfed *vertisol* of southern zone of Tamil Nadu reported that IFS (Integrated Farming System) model is good enough to provide sustained average net income of 137,712/ha and employment of 389 man days/year as compared to conventional cropping systems (CCS) which gave average negative net income of 644/ha during 6 years of investigation due to deficit of rainfall.

Meena *et al.* (2022) in their study on integrated farming system models development for small and marginal households for sustainable production and livelihood improvement in India indicated that 200 to 400% increase in gainful employment after adopting of integrated farming system as compared to existing farming system and additional income to farm families to increase their standard of living. Enterprises like integrated farming system (IFS) provide a lot of opportunities of employment and keeps farmers and their family engaged whole the year and as such can help in solving unemployment problem in India. The man days required for the production of crops alone was 182 ha/annum wherein under IFS this number was 2.91 times more (795-man days) than crops alone. In this way farming system approach not only ensures the livelihood of small farm holders but also diversified nature of IFS approach requiring significantly a greater number of man days increases more opportunities of employment particularly in rural areas. More number of enterprises integrated in to existing farming system requires a greater number of labour engagements.

Bhat *et al.* (2023) in their study on enhancing farm profitability and sustainability through integrated farming systems reported that integrated farming system (IFS) farm generated significantly higher mandays (509 mandays per year) compared to arecanut farming (401 mandays per year). For female laborers, IFS farms generated 2.05 times higher mandays through weeding, kitchen gardening, milking and feeding of cows, etc. This shows the potential of the IFS system in promoting and empowering women's participation in rural areas. The overall employment generated from IFS (1237 mandays year¹) and control farms (755 mandays year¹) differed significantly (t stat 20.0, $p < 0.01$).

2.8 Constraints faced by farmers in adoption of sustainable farming system

Sajid *et al.* (2018) in their study on socio-economic constraints affecting sustainable rural livelihood reported that rural livelihood and finance was the core problem, poor health issues block sustainability of rural livelihood, prevalence of diseases in livestock, decline income from crop production, extremes poverty due to lack of finance, poor road, market problem is a major obstacle in rural economy production, land shortage affects rural economy, rural livelihood are affected adversely by any kind of shock, and conflict leads decline in rural livelihood.

Khan *et al.* (2019) in their study on income and employment generation through integrated crop-livestock farming system in Bulandshahr district reported that farmers found two major constraints to attain the successful utilization of mobile phone for agricultural purposed which indicated a lack of education and mobile operating skills of the farmers in the study area.

Madhu *et al.* (2020) in the study on knowledge and attitude of farmers and constraints faced by them on soil health cards in Mandya district of Karnataka reported that the constraints faced by the farmers in the usage of soil health card were delay in distribution of soil health cards (85%) and devoid of fertilizer calculations in soil health card (69.16%) were the major constraint expressed by the farmers in the usage of soil health card. Difficulty in following the soil test-based results (58.33%) and illiteracy of farmers (56.67%) were the next major constraints. Equal per cent of farmers (50.00%) each perceived lack of awareness regarding

method of soil sampling and 41.67 per cent farmers were facing inadequate follow-up by extension agency.

Medhi *et al.* (2020) in their study on socio-economic, psychological profile and constraints faced by the KVK adopted farmers for improved rice cultivation in west Garo hills district reported that among the various problems identified by the respondents, inadequate availability of quality seed at proper time (95.83%), lack of knowledge about scientific cropping pattern and cropping system and their method of application (92.50%), non-availability of improved implements and other critical inputs such as FYM/organic fertilizers etc. And (87.50%), low price of product in local market (76.67%), lack of storage and marketing facilities (75.00%), lack of guidelines about seed treatment (74.16%) were considered as the major problems as indicated by its corresponding frequency.

Krishnankutty *et al.* (2021) in their study on sustainability of traditional rice cultivation in Kerala, India reported that the constraints expressed by the traditional rice farmers were shortage of skilled labour (64.64%), delay in payment (54.72%), shortage of water/rain (53.48%), lack of institutional support (53.09%), low productivity of labour (48.89%), transportation facility (47.53%), neighbourhood practices (46.09%), lack of milling facility (43.93%) and animal attack (39.87%).

Moruppa and Ijabula (2021) revealed that the challenges encountered in accessing agricultural information from social media indicated that 16.4% of the respondent show that relative cost for access, (15.5%) lack of infrastructure, (9.9%) illiteracy, (22.2%) poor network access, (4.1%) lack of awareness of information sources available, (15.8%) untimely provision of information, (6.7%) difficulty in understanding and proper utilization of information and (9.4%) lack of adequate satisfying heterogeneous users. This analysis revealed that poor network access, relative cost for access, untimely provision of information and lack of infrastructure were the most serious challenges militating against the use of social media when driving agricultural information by farmers in the study area.

Mugumaarhahama *et al.* (2021) in their study on the socio-economic characteristics of adopters and non-adopters of improved sweet potato varieties in South-Kivu reported that majority of the potato farmers practiced the inter-cropping system facing many more constraints related to diseases and pests.

Pawar and Channaveer (2021) in their study on farmer's attitudes towards sustainable agricultural practice at Kalaburagi district reported that 42.50% of farmers faced non-availability of credit in time.

Tambo and Kiru (2021) in their study on yield effects of conservation farming practices under fall armyworm stress reported that severe fall armyworm infestation reduced per capita household income by 44% and increased households' likelihood of experiencing hunger by 17%.

Tran *et al.* (2022) on a study aimed at assessing the livelihoods of rice households in Nghe province of Vietnam reported that more than 75% of respondents in the study area suffered from abnormal temperature fluctuations (either heat waves or cold spells) and more than 50% of the surveyed households who did not receive any training courses might impede their capacity to cope with the impacts of climatic stresses and improve the total productivity.

Baishakhy *et al.* (2023) in their study on overcoming barriers to adapt rice farming to recurring flash floods in Haor wetlands of Bangladesh showed that the most prominent barrier to adaptation was the lack of availability of submergence-tolerant rice variety with a PCI score of 331, farmers' lack of market access (PCI=325), lack of access to inputs (PCI=296) and knowledge of adaptation options (PCI=261), farmers' lack of access to credit facilities (PCI=245), lack of access to extension services (PCI=238), limited access to information sources on potential climate changes (PCI=237), lack of training facilities (PCI=234), lack of provision of alternative income sources (PCI=229), farmers disinterest towards adopting new practices (PCI=227), and existing transportation problem in Haor wetlands (PCI=196) and lack proper storage facility (PCI=191) along with inadequate threshing and drying places also made it challenging for the farmers to secure their harvest during flooding seasons.

CHAPTER III

RESEARCH METHODOLOGY

RESEARCH METHODOLOGY

This chapter, provides all the information about the techniques/methods that are adopted for conducting research. The methodology may include publication research, interviews, surveys and other research techniques, and could include both present and historical information. Research methods and procedures used for conducting the study are described into the following heads:

3.1 Research design

3.2 Locale of the research

3.3 Sampling procedure

3.4 Selection of variables and their empirical measurements

3.5 Hypothesis formulation

3.6 Tools and technique of data collection

3.7 Analysis of data

3.1 Research design

According to Kerlinger (1978), research design is the plan, structure and strategy of investigation so as to obtain answers to research question to control variance.

Ex-post facto research design was used in the present research. It is the description of the present situation as an effect of some previous acting casual factors and attempt to the back, over an interval of time to some assumed casual complex of which began.

3.2 Locale of research

The present study was conducted in Manipur, a hilly state in northeastern India, lies between latitude 23°50' N to 25°42' N and longitude 92°59' E to 94°46' E. The state covers an area of 22,327 sq. km, which constitutes 0.68% of the geographical area of the country. Manipur state shares an international border with Myanmar (Sagaing Region and Chin State) in the eastern side, and bordered by Nagaland to the north, Mizoram to the south, and Assam to the west. The state has a tropical climate with average annual rainfall ranging from 1,200 mm to 2,700 mm

and the average annual temperature ranging from 14.5°C to 38°C. According to the 2011 census, there were 28.56 lakh people living in Manipur, with 14.39 lakh men and 14.17 lakh women. The state has two major physio-graphic regions hill and the valley. The hills range in elevation from 1500 to 1800 meters above sea level, Senapati, Tamenglong, Churachandpur, Chandel, and Ukhrul are the five districts that make up the hill area occupied around 90% (20089 sq km) of the state while the valley is on average 790 meters above sea level it occupies only about 10% (2238 sq km) of the state's total territory and there are four districts in valley area viz., Imphal East, Imphal West, Thoubal and Bishnupur district.

The state's economy depends heavily on the agriculture industry. Agriculture makes a significant contribution to the state's GDP. Manipur employs 52.81% of its workforce force as agricultural labourers and cultivators. However, the performance of the state's agriculture is mostly dependent on the timing of rainfall and the weather. The primary economic sectors are forestry and agriculture. The main crop in the state is rice, although the fertile soil also supports orchard fruits, corn (maize), sugarcane, mustard, tobacco, and pulses (legumes). Permanent farming is often done in valley regions, whereas terracing is widespread in the highlands where farmers are located at hill region, jhuming or shifting farming is also extensively conducted in the areas of highlands. Manipur has been endowed with a great variety of rice landraces, including coloured, fragrant, glutinous, stress-resistant, and medicinal cultivator.

Rice can be grown in three ecosystems: uplands, lowlands, and deep-water environments. Even the floating vegetation (Phumdi) of Loktak Lake is used to cultivate it. There are over 350 different types of rice in Manipur. Rice is the main food crop in the state which is cultivated in both plain and hilly area with the total production of 602.21 thousand mt in 2020-2021. Since the need and important of rice crops cannot be replaced with other crops, many farmers in Manipur have adopted a rice-based farming technique in an effort to increase revenue and farm sustainability. In a farming system based on rice, farmers benefit from both rice and other associated crops. To study and analyse the farming practices of different rice base farming method, Manipur was selected for the present study.

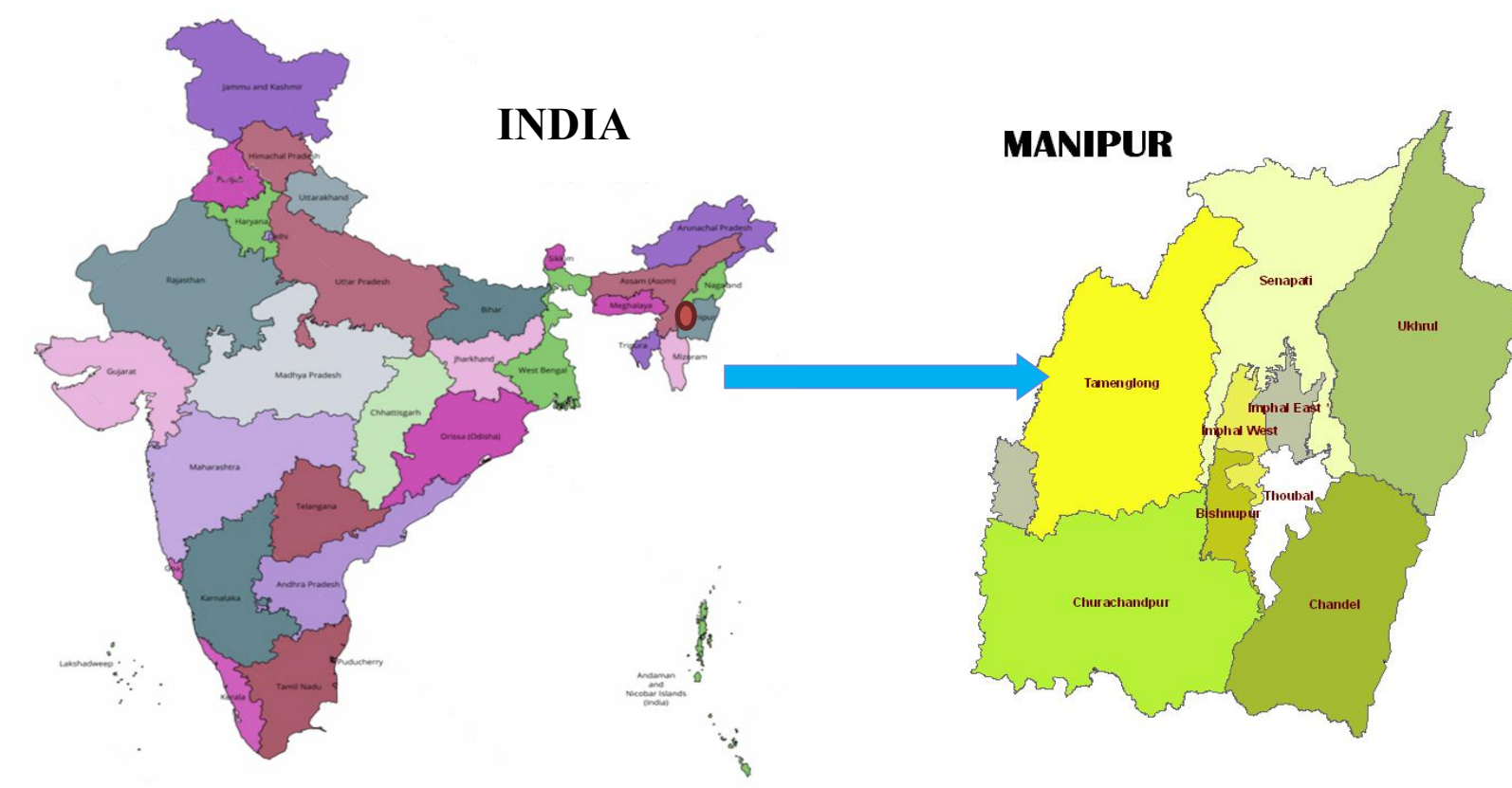


Fig 3.2.1 Selection of state

3.3 Sampling procedure

Sampling procedure for selection of respondents has been displayed in Fig 3.3.1.3

3.3.1 Selection of district

There are nine districts in Manipur wherein four districts are classified as plain area and five districts are classified as hill districts. Out of this based on productivity and cultivated area of rice, four districts were purposively selected for the current study. Two districts in each category viz., Imphal East and Thoubal district representing valley area and Churachandpur and Senapati district representing the hill area of Manipur. Churachandpur and Senapati districts fall under the category of low productivity (1.3 t/ha) of rice, whereas Imphal East and Thoubal districts are under the category of higher yield (3.75 t/ha) of rice against the average productivity (2.5 t/ha) of rice in the state. Conducting research in various topographies can provide a general overview of the main reasons why rice production is poor in hilly region, as well as contribution on how the farmers manage farm resources, access to technology, and the possibility for bridging the yield gap using rice-based farming systems. As a result, the study was carried out in four districts, two of which were in the state's valleys and two of which were in the hills of the state. In Manipur, Thoubal district has the highest productivity (3.94 t/ha) of rice with the total area of 30150 hectares under rice cultivation. In Imphal East district rice is grown on a total of 37610 hectares which is the largest area under rice cultivation and highest production of 136 thousand tonnes of rice all over the state. In Churachandpur district the total area under rice cultivation is 2900 hectares which is lower than the Thoubal and Imphal East district (valley region) however in hilly region Churachandpur district represent the highest rice production of 38000 tons in all over the hill districts of the state while the area under rice cultivation in Senapati district is 12100 hectares with an estimated yield of 1.34 t/ha having the highest productivity among the hill districts of Manipur. Based on the productivity, area under cultivation, and production of rice four most potential district were selected to include in the study. Therefore, Thoubal, Imphal East from valley region and Churachandpur and Senapati district hill region were selected for the present study.

Thoubal District

The Thoubal district is located in the southeast portion of the Manipur (Imphal) Valley, roughly between latitudes 24° 14' 29 45"N and 93° 51' E to 94° 9' 18"E. The district is shaped like a spawn, with the northern part acting as the head. The district is the eighth largest in terms of surface area among Manipur's nine districts, with a total area of 514 km². It is bordered on the north by the districts of Imphal West, Imphal East, and Senapati, on the south by the districts of Churachandpur and Chandel, and on the west by the districts of Imphal West and Bishnupur. The climatic condition in the district is almost similar to the condition prevailing in the adjoining valley districts, as it is under the influence of monsoon, both in summer and winter seasons. The highest temperature in the summer varies from 31°C to 38°C, which ensures that it is never oppressively hot. The Loktak Lake affects to keep warm and the district's temperature swings from 2°C to 5°C in the winter. The Thoubal area experiences yearly rainfall ranging between 90.79 cm and 118.95 cm. In the district, there are 87 villages, 61 of which are in Thoubal CD block and the rest 26 in the Kakching CD block. Out of the 87 villages, 83 (95.4 percent) have educational facilities, 68 (78.16 percent) have medical facilities, 31 (35.63 percent) have post offices, 43 (49.43 percent) have transportation and communication facilities, 2 (2.30 percent) have banks, and 10 (11.49 percent) have agricultural credit societies. All 87 villages of the districts can be reached through the pucca road, and there are amenities like telephones and electricity supplies accessible to 85 (97.70 percent) and 86 (98.85 percent) out of the 87 villages in the district (Directorate of Census Operations Manipur, 2011).

In Thoubal district, agriculture is the most important source of livelihood. The valley is fertile and the topography of the district provides good potential for irrigation, natural as well as artificial. Rice is the most important crop of the district. According to the Geological Survey of India, the district has a total area of 40,500 hectares, of which 37,285 hectares are used for crops and 30150 hectares are used for rice farming. According to reports, the district produced 118.75 thousand tonnes of rice in the years 2020–2021. The Imphal River, the Thoubal Multipurpose Project, the Sekmai Barrage, and various smaller irrigation projects all provide irrigation facilities for the area. In the district, double cropping is widely practiced. In some

areas, even tripple cropping is prevalent, as the first rice cropping starting in the late February or early March, second cropping in July and early August and the third cropping of mustard seeds, pulses, vegetables, etc. in November. In Manipur, Thoubal district has the highest rice productivity (3.94 t/ha) with the total area of 30150 ha under rice cultivation. And a majority of farmers in the district engage in rice-based cultivation. Therefore, Thoubal district was purposively selected for the present study.

Imphal East District

The Imphal East district is located in the northeastern portion of the Manipur (Imphal) Valley, however one of its sub-divisions, Jiribam, is actually 222 kilometers away from the district headquarters, Porompat, on the western state boundary. The district is approximately situated between latitudes 24° 39' 49.09" and 25° 4' 5.45" N and longitudes 93° 55' 30" and 94° 8' 42" E. Bound by Imphal West district on the west, Thoubal district on the south, and Senapati district on the north and east, respectively. The district is the sixth largest in terms of area in Manipur with a total area of 709 km² (Jiribam is 212 km²) and about 3.18 percent of the state's total land area. The district is the third-most populous district in the state in terms of population, making about 16 percent of the state's overall population. The district has an 81.90 percent literacy rate, which places it third out of Manipur's nine districts (Directorate of Census Operations Manipur, 2011). According to the 2011 census, the district comprises of three CD blocks, Imphal East-I, Imphal East-II, and Jiribam CD blocks. Out of total 191 villages of the district, 88 are located in Imphal East-I, 53 in Imphal East-II and 50 villages in Jiribam CD blocks.

In Imphal East district the primary source of income is farming. The valley is fertile, and the district's geography offers significant potential for both natural and artificial irrigation. Rice is the largest crop cultivated crop in the district. According to the Geological Survey of India, the district has a total area of 40,500 hectares, of which 37,285 hectares are cultivated and 21,077 hectares are under rice farming. The district produced 136 thousand tonnes of rice in 2020-2021, with a yield of 3.62 t/ha. The irrigation facilities in the district are provided by the Imphal river, the Thoubal Multipurpose Project, the Sekmai Brrage, and other smaller irrigation

projects are advantageous to the district. Double cropping is a common practise in the district. Even triple cropping is prevalent in some regions, with the first crop rice starting in late February or early March, the second crop starting in July or early August, and the third crop starting in November with mustard seeds, pulses, vegetables, etc. Sugarcane, oilseeds, maize, potatoes, pulses, chillies, vegetables including cauliflower, broccoli, brinjal, and tomatoes, among other crops, are farmed in the district. The district's primary crop, rice, is grown on a total of 37.61 thousand hectares, giving it the largest area and maximum production of 136 thousand tonnes of rice as compared to the other districts in Manipur. Therefore, the Imphal East district was selected purposively for the present study.

Senapati District

Senapati district is a hilly district located in the northern part of Manipur. District is situated between 24° 37'21" N and 25° 35'27" N latitudes and 93° 40'48" E to 94° 27'18" E longitudes. The district covers 3,271 square km. surrounded by the Nagaland state on the north, the Ukhrul district on the east, the Imphal East and Imphal West districts on the south, the Tamenglong district on the west, the Churachandpur and Bishnupur districts on the south west, and the Thoubal and Chandel districts. Senapati district lies at an altitude between 1061 meter to 1788 meters above sea level with an area of 3,271 sq.km. The headquarters of the district is at Senapati which is 62 km from Imphal. In terms of area the district occupies the 5th position among the 9 districts and covers 14.65 percent of the total geographical area of the state. The district enjoys on the whole a very pleasant climate throughout the year. The temperature is neither very hot nor very cold. The average annual rainfall of the district at Kangpokpi is 230.15 cm. Senapati district comprises of six sub-division namely Mao-Maram, Pao-Mata, Purul, Sadar Hill East, Saitu-Gamphazol and Sadar Hill West. Senapati is the second-most populated district in the state by population, behind Imphal West. According to the 2011 census, Senapati had a total population of 4,79,148 people, 2,47,323 of whom were men and 2,62,938 of them were women. The district has a 63.6 percent literacy rate, which places it last out of the state's nine districts. There are 669 inhabited villages in the

district (Ministry of Electronics & Information Technology Government of India, 2023).

In the Senapati district, forests cover 66.43% of the land area, with the remaining 20% being used for agriculture. The district's main agricultural products are grains, rice, maize, potatoes, and cabbage. Terrace cultivation is often practiced by the majority population, who work mostly in agriculture. Jhum and terraced agriculture are the two ways used to grow rice on hillside slopes. Among the major cultivated crop Cabbage, Cauliflower, Brinjals, Tree-Bean (Yongchak) Tomatoes may be mentioned. Since irrigation is extremely poor, rain is the only source of water in the district. Rice is the main crop grown in Senapati district. The area under rice cultivation is 12.10 thousand hectares, with an estimated yield of 1.34 t/ha having the highest productivity among the hill districts of Manipur. Therefore, the present study select Senapati district purposively base the productivity of rice.

Churachandpur District

Churachandpur district is the largest district in Manipur, it is located in the south-western region of the state. It is roughly located between longitudes 92°58'E and 93°52'8"E and latitudes 23°56'43"N and 24°42'N. On the north, it is bordered by the Tamenglong, Imphal East, Senapati, Bishnupur, and Thoubal districts; on the east, by the Chandel district; and on the west, by Assam State. The district comprises 4,570 square km in total area with 20.47 percent of the state's total land area. According to the 2011 census, the district has 274,143 inhabitants, of whom 138,820 are men and 135,323 are women, and it is the seventh most populous district in the state. The district has a total of 11 such sub-divisions namely Tipaimukh sub-division, Vangai sub-division, Thanlon sub-division, Mualnuam sub-division, Henglep sub-division, Kangvai sub-division, Churachandpur Sub-Division, Singngat Sub-Division, Sangaikot sub-division, Tuibong sub-division and Saikot sub-division (Ministry of Electronics & Information Technology Government of India, 2023).

Agricultural occupy the most important place in the economy of the district. Being the main source of livelihood of the people the entire economy of the district

depends on agriculture. Rice is a major crop of the district. Rice is cultivated on the slopes of hills by means of two methods namely, Jhum and terraced cultivation. There are also some areas around Churachandpur-Khuga Valley where wet rice cultivation is practiced. The total area cultivated with rice in 2020–2021 is 29 thousand hectares, and among the hill districts Churachandpur district produces the highest amount of rice with 38 thousand tons. Therefore, the present study select Churachandpur district purposively base the area under rice cultivation and total production of rice.

3.3.2 Selection of blocks

From each of the selected districts, two block based on the highest number of farmers concerned with rice cultivation and rice-based farming were selected purposively. Thus, 8 blocks viz., Thoubal block and Kakching block from Thoubal district, Imphal east-I block and Imphal Esat-II block from Imphal East district, churachandpur block and Saikot block from Churachandpur district, Purul block, Kangpokpi block from Senapati district were selected for the present study.

3.3.3 Selection of villages

A list of all villages growing rice-based cultivation farmer were prepared from the selected blocks. Out of these two villages were selected randomly from each of the selected blocks. Eight villages from plain area (Wangjing, Athokpam, Wabagai and Keirak) from Thoubal district and (Pangei, Haraorou, Andro and Thiyam Kongil) from Imphal East district and eight villages from hill area (Saikul, Aimol, Toyangkuki and Thingchom) from churachandpur district and Purul akutpa, Purul atongba, T Khullen and Taphou Kuki) from Senapati district comprising a total sixteen villages were included for the present study.

3.3.4 Selection of respondents

A list of farmers cultivating rice-based crop along with other important crops and engaged in agri-allied activities were prepared. From this list, farmers were selected randomly from each of the selected villages based on population size of the village. Therefore total 160 respondents from the selected hill districts and 160 respondents from the selected plain districts were included for the present study making a sample size of 320 respondents.

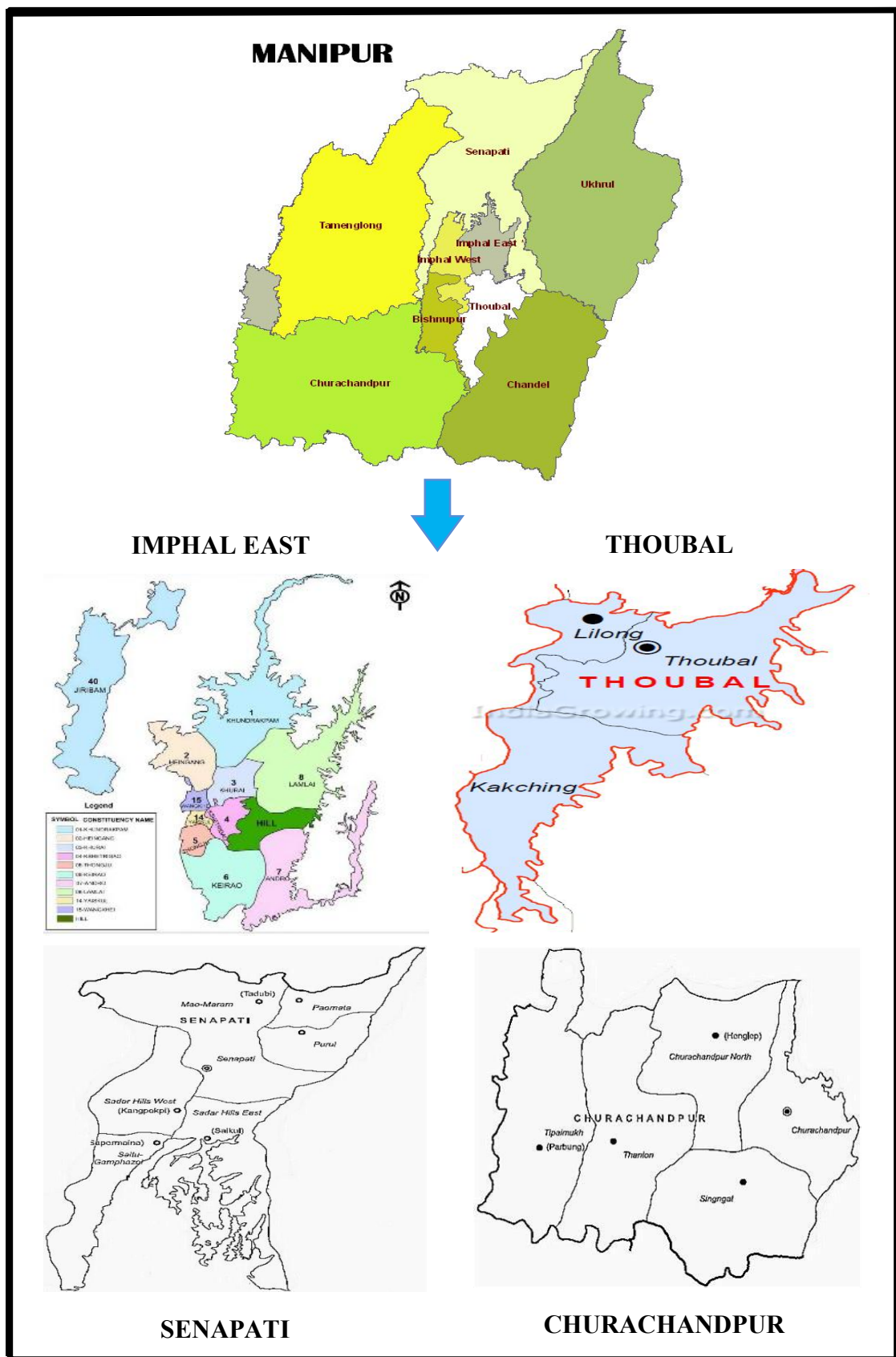


Fig 3.3.1.2: Selection of districts

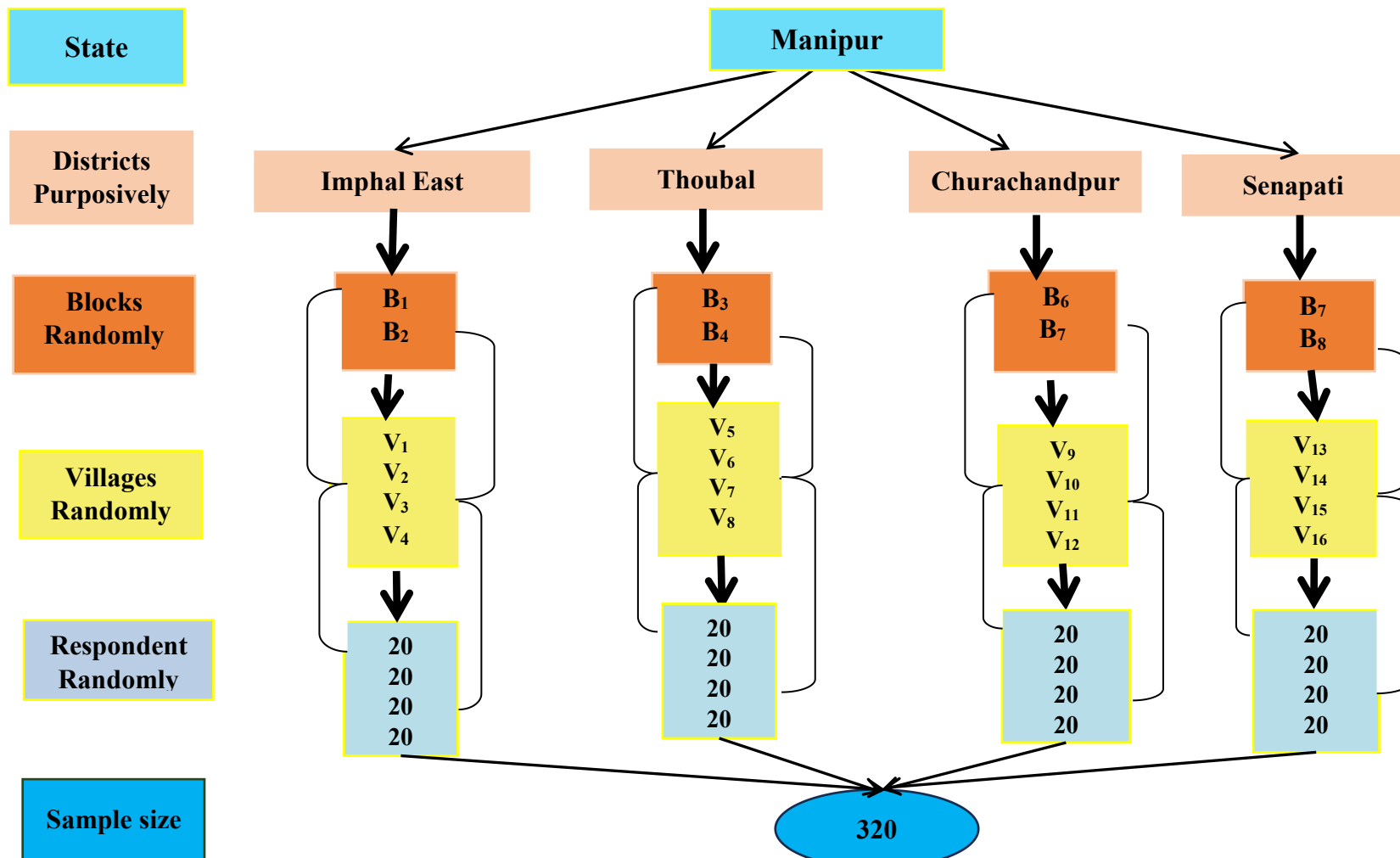
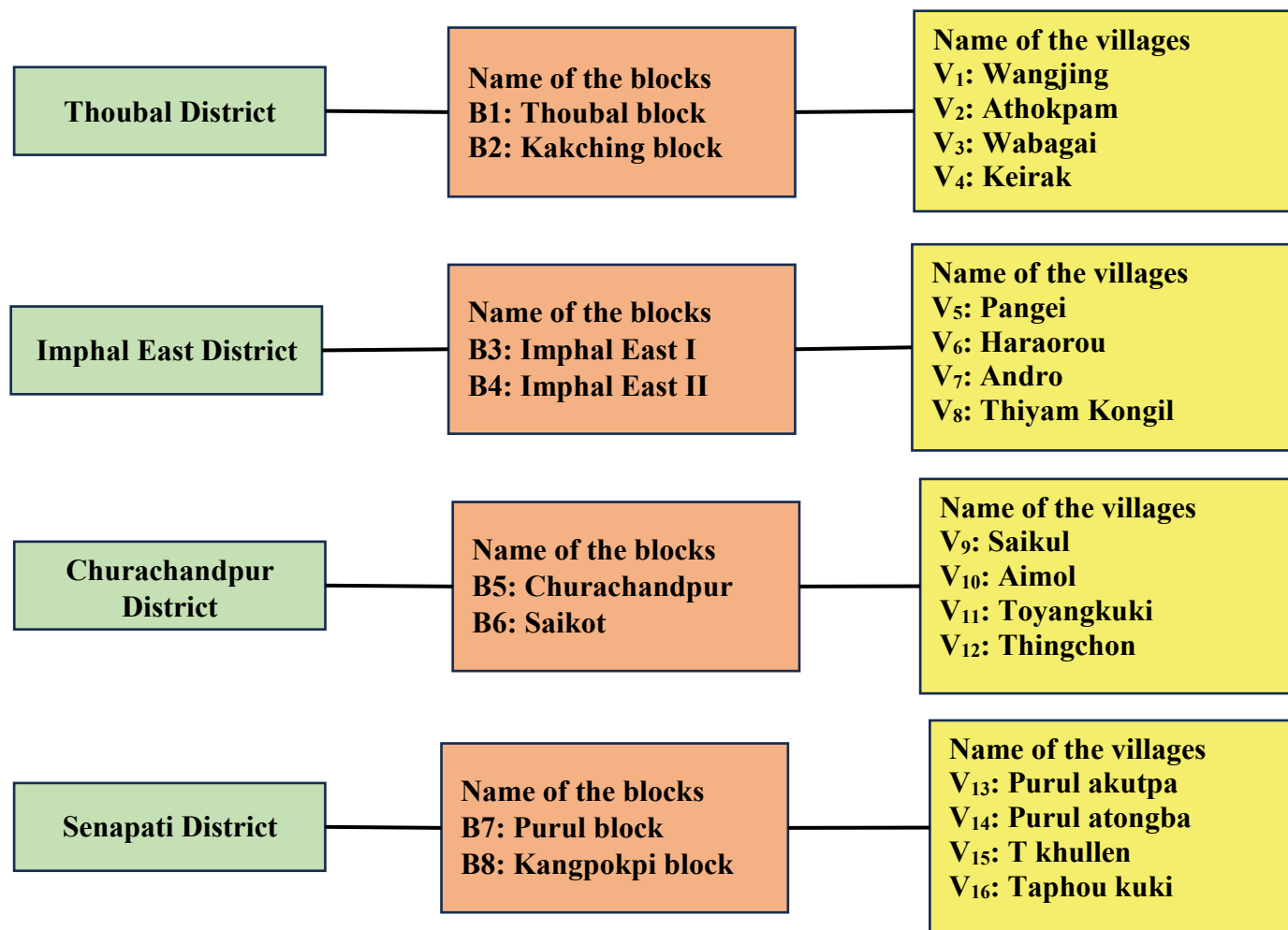


Fig 3.3.1.3: Sampling design

Fig 3.3.1:3 Selected blocks and villages



3.4 Selection of variables and their empirical measurements

3.4.1 Age

It refers to the chronological age of the respondent completed in years at the time of interview. The chronological age of the rice-base cultivation farmers at the time of interview was taken into consideration. All the respondents were classified into three age groups as below:

S/N	Category of Age	Range of age (Years)
1.	Young	Below 35 years
2.	Middle	Between 35-55 years
3.	Old	Above 55 years

‘Z’ value was also calculated to know the significant difference of age among the selected four districts.

3.4.2 Sex

It was expressed in terms of male and female. The empirical measure of the variable related to sex was done by frequency and percentage. The scoring was done from 1 to 2 for the analysis.

S/N	Category of Sex	Score
1.	Female	1
2.	Male	2

3.4.3 Family type and family size

Family is the basic unit of life. Each and every family belonged few member. They may stay together or separately. Based upon those different family types namely joint family and nuclear family were included for the present study.

S/N	Type of family	Score
1	Nuclear	1
2	Joint	2

The size of family refers to the actual number of members in the family. Family size was operationalised as the number of members of a family a respondent had possessed. Categorization was based on mean and standard deviation. If the family has more than seven members, it is categorized as the large family. Less than four members mean a small family. The respondents have family members between four to seven are categorize as medium family.

S/N	Family size	Score range
1.	Small family	Less than 4 members
2.	Medium family	4 to 7 members
3.	Large family	More than 7 members

‘Z’ value was also calculated to know the significant difference of size of family among the selected four districts.

3.4.4 Education

Education was operationalised as the ability of the respondents to read and write or the extent of formal education possessed by them. Education was qualified

using modified scale of Venkataramaiah (1983) revised in 1991 with slight modification. The respondents were further classified into following categories:

S/N	Level of education	Score
1.	Illiterate	0
2.	Primary (up to 5 th)	1
3.	Middle (up to 8 th)	2
4.	Secondary (up to 10 th)	3
5.	Higher secondary (up to 12 th)	4
6.	Graduate	5
7.	Above graduate	6

‘Z’ value was also calculated to know the significant difference of educational level among the selected four districts.

3.4.5 Experience in rice-based farming system

Experience in farming refers to the span of time a farmer has been actively involved in farming involving accumulation of knowledge and different farming methods with adaptive measures. This variable was measure with the number of years of experience by a respondent has in cultivation of rice-based farming system. Assigning score as 1 for each completed year to the experience of individual farmer. The following categorization of experience of farmers was categorized based on the study of Digambar *et al.*, (2020). So, the experience of farmers was categorized as below:

S/N	Category of experience	Years
1.	Low experience	Below 10 years
2.	Medium experience	Between 10-20 years
3.	High experience	Above 20 years

‘Z’ value was also calculated to know the significant difference of experience on rice base farming among the selected four districts.

3.4.6 Total land holding size

The size of land holding refers to the total number of hectares of land owned by the respondent. For frequency and percentage analysis, total land holding size was categorized as follows:

S/N	Categories of farmers based on land area	Score
1	Marginal	Less than 1 hectare
2	Small	1-2 hectare
3	Medium	2-3 hectare

3.4.7 Size of land under rice-based farming system

Size of land under rice base farming system put by an individual respondent. For frequency and percentage analysis, total land holding size was categorized as follows:

S/N	Categories of land area	Score
1.	(<1 acre)	1
2.	(1-2 acre)	2
3.	(2-3 acre)	3

3.4.8 Total annual income

Annual income was calculated as the total amount of earnings from all available sources (i.e., Primary and secondary sources) by the respondents and his/her family members. It was expressed in rupees. 'Z' value was also calculated to know the significant difference of annual income among the selected four districts.

Farmers under different category of land holding were categorized based on the mean annual income as follows

S/N	Category	Mean annual income (Rs)
1.	(Less than 1 acre)	
2.	(1-2 acre)	
3.	(2-3 acre)	
4.	Above 3 acres	

‘Z’ value was also calculated to know the significant difference annual income among the selected four districts.

3.4.9 Income from rice-based farming system

Income from rice base farming was calculated as the total amount of earnings from rice base farming in a season by the respondents and his/her family members. It was expressed in rupees. ‘Z’ value was also calculated to know the significant difference of income from rice-base farming among the selected four states four districts. Farmers under different category of land holding were categorized based on their mean income from rice base farming as follows:

S/N	Category	Mean annual income (Rs)
1.	(Less than 1 acre)	
2.	(1-2 acre)	
3.	(2-3 acre)	

‘Z’ value was also calculated to know the significant difference income from rice-based farming among the selected four districts.

3.4.10 Training exposure

Training is one of the means by which farmers acquire new knowledge and skills. It was measures as the number of training's the farmer has received technology training in the last few years. The scoring was done as one (1) for one-

three days training attended by the farmers, (2) for three-five days training attended by the farmers, three (3) for more than five-days training attended by the farmers and zero (0) score was given to the respondents who did not receive any training.

S/N	Number of days training attended	Score
1.	Farmers never attended training	0
2.	Farmers attended training (1-3days)	1
3.	Farmers attended training (3-5days)	2
4.	Farmers attended training (Above 5days)	3

3.4.11 Training needs

Training is the process of acquiring new skills, attitude and knowledge in the context of sustainable agriculture for improving one's productivity. The information or skills that farmers require to operate effectively in agriculture is training needs. The process of determining the priority of the respondents' requirements is done through training needs analysis. The collected statements were asked to the respondents and the score was given as 1 score for training requirement and 0 score for training not require. Base on the responses of the respondent's frequency and percentage was calculated.

S/N	Categories of training needs	Score
1.	Farmers require training about INM	1
2.	Farmers require training about IPM	2
3.	Farmers require training about water management	3
4.	Farmers require training about improved technology	4
5.	Farmers require training about Rice base farming	5
6.	Farmers require training about nursery production of horticultural crop	6

3.4.12 Sources of information

Information sources utilization referred to the various sources of information utilized by the respondents for the selected paddy crop cultivation practices. Information sources utilized was classified based on the use of mass-media sources, formal information sources and informal information sources. It was qualified by using Ramchandran scale (1974).

3.4.12.1 Mass media information sources utilization

Under mass-media sources, five sources of information (radio, television, newspaper, exhibition, printed media, mobile phone and conferences) were included and frequency of use was scored as Most often (2), Sometimes (1) and Never (0). Based on the total score, the farmers were classified into three categories: low, medium and high-level using mean ($\bar{x}$) and standard deviation (σ) are as follows:

S/N	Level of information sources utilized	Score range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

‘Z’ value was also calculated to know the significant difference of mass media sources of information among the selected four districts.

3.4.12.2 Formal information sources utilization

Formal information sources included the information received through the contact of six sources of information and their frequency was score, as most often (2), sometimes (1) and never (0). Based on the total score, the farmers were

classified into three categories: as low, medium and high level using mean value ($\bar{x}$) and standard deviation (σ) are as follows:

S/N	Level of information sources utilized	Score range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

‘Z’ value was also calculated to know the significant difference of formal sources of information among the selected four districts.

3.4.12.3 Informal information sources utilization

Information source of information referred to the information obtained through contact with four sources of information viz., friends, relatives, neighbour and progressive farmers for agricultural purposes. The frequency was scored as Most often (2), Sometimes (1) and Never (0). Based on the total score, the farmers were classified into three categories; low, medium and high-level using mean ($\bar{x}$) and standard deviation (σ) are as follows:

S/N	Level of information utilized	Score range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

‘Z’ value was also calculated to know the significant difference of informal sources of information among the selected four districts.

3.4.13 Extension contacts

Extension contact is conceptualized as contact with the extension personnel’s rural development workers/ extension personnel of agri & allied

department/Representatives of private input agencies/Representatives of banks for getting the required information on sustainable rice base farming. The frequency of contact was classified as contacted and not contacted, and it was scored as 0 and 1. Based on the total score, the farmers were classified into three categories; low, medium and high-level using mean ($\bar{x}$) and standard deviation (σ) are as follows:

S/N	Level of extension contact	Score Range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

‘Z’ value was also calculated to know the significant difference of extension contact level among the selected four districts.

3.4.14 Scientific orientation

In a scientific orientation, the natural process of projection is carried out with a high degree of awareness. Scientific orientation was measure by using the scale developed by Supe (1969). The measurement was carried out by assigning score 5, 4, 3, 2, and 1 for Strongly Agree (SA), Agree (A), Undecided (UD), Disagree (D) and Strongly Disagree (SDA), respectively to positive statements. While opposite scoring was followed with respect to negative statements. Thus, the total scientific orientation score of all the respondents was worked out and then classified into three categories: low, medium and high level using mean value ($\bar{x}$) standard deviation (σ) are as follows:

S/N	Level of scientific orientation	Score Range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

3.4.15 Risk orientation

Risk orientation was operationalised as the degree to which the farmers are oriented towards risk uncertainty in facing problems in farming. It was measured by using the scale developed by Supe (1969) with slight modifications. The scale consisted of six statements. The measurement of risk orientation was carried out by assigning score 5, 4, 3, 2, and 1 for Strongly Agree (SA), Agree (A), Undecided (UD), Disagree (D) and Strongly Disagree (SDA), respectively to positive statements. While opposite scoring was followed with respect to negative statements. Thus, the total risk orientation score of all the respondents was worked out and then they were grouped into the following categories.

S/N	Level of risk orientation	Score Range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

3.4.16 Production orientation

The scale of production orientation consisted of six statements and it was measure by using the scale developed by Samantha (1977). All the positive statements were assigned the score of 3, 2, 1 and 0 for Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SDA) and vice verse for negative statements. After obtaining the total scores, the respondents were classified into three categories based on mean ($\bar{x}$) and standard deviation (σ) as follows:

S/N	Level of production orientation	Score range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

3.4.17 Market orientation

Market orientation refers as not only a strategy, but an organizational culture and climate that most effectively encourages the behaviour that are necessary for the creation of superior values for customers (Despande and Webster, 1989) and (Narver and Slater, 1990). The scale was included nine statements and it was measured with the help of the scale developed by Samanth (1977). For every positive answer, a score of “1” was given and a score of “0” was assigned for every negative answer. Based on the scored the farmers classified into three categories; low, medium and high-level using mean ($\bar{x}$) and (σ) standard deviation.

S/N	Level of market orientation	Score Range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

3.4.18 Innovativeness

This refers to the behaviour pattern of an individual who has interest and desire to seek changes in farming techniques and ready to introduce such changes into his operations when practical and feasible. It was measured by using the scale developed by Saharkar (1995). The scale consisted of five statements. All the positive statements were assigned the score of 3, 2, 1 and 0 for Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SDA) and vice versa for negative statements. After obtaining the total scores, the respondents were classified into three categories based on mean ($\bar{x}$) and (σ) standard deviation as follows:

S/N	Level of innovativeness	Score Range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

3.4.19 Perception towards climate change

Perception is subjective process. People perceive the same stimuli in different ways depending on the specific characteristics of the situation they choose to selectively assimilate or absorb the stimuli from, how they organize the information, and how they interpret the stimuli to understand the situation. Perception is primarily created by two factors: one is physiological and the other is psychological characteristics of the human being. Thus, perception is a far more sophisticated process incorporating psychological processes as well, through which each individual selectively assimilates and assigns meaning to the stimuli in the environment. Perception is not merely a physiological process, which is what one sees with the eyes. To measure the perception towards the climate, change the modified scale of Asrat and Simane (2018) used 25 statements were included. Each statement was assigned as “Perceived” with score 1 and “Not Perceived” with score 0. Based on the total score of each statement rank was given, and it indicate the perception towards climate change higher the rank indicates more perceive by the respondents and lower the rank indicate less perceive by the respondents.

‘Z’ value was also calculated to know the significant difference of perception towards climate change among the selected four districts.

S/N	Categories of perception	Score
1.	Perceived	1
2.	Not Perceived	0

3.4.20. Knowledge level

Knowledge occurs when an individual or other decision-making unit is exposed to an innovations existence and gains some understanding of how it functions. Knowledge seeking is initiated by an individual and is greatly influenced by one's predispositions

In the knowledge, respondents respond yes/no to given statements under the factor of agronomic practices, soil and water conservation, nutrient management, agroforestry, restoration and rehabilitation, pest control method, diseases control method and recycle management about the manner of accessing knowledge. The binary scores for each question were added together to give a knowledge score ranging of the respondents. The answer “yes” was coded as 1, while the answer “no” was coded as 0. Thus, the respondents were then classified into three categories with the help of mean ($\bar{x}$) and standard deviation (σ) are as follows:

S/N	Level of Knowledge	Score range
1	Low	Below ($\bar{x} - \sigma$)
2	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3	High	Above ($\bar{x} + \sigma$)

‘Z’ value was also calculated to know the significant difference of knowledge level among the selected four districts.

On the other hand, a knowledge index was created from the raw knowledge scores of each respondent using the formula given by

$$\text{Index of knowledge} = \frac{\text{Number of correct reponses}}{\text{Total number of knowledge observtion}} \times 100$$

Used by Aparna *et al.*, (2018).

3.4.21. Cropping pattern and Farm resources management

Cropping pattern in the study area was identified by asking to the respondents about the major cultivated crops and types of cultivated practices they followed. Seasonal calendar was developed to understand the pattern of crop and practices followed by the respondents in the selected study area.

For farm resources management major 3 cropping pattern were identified under these cropping patterns, the cultivation practices and resources management technique of respondents were recorded.

Table 3.4.21.1 Selection of respondents under cropping pattern and resource management

S/N	Cropping pattern	District	Number of respondents	Total respondents
1.	Rice-fish	Thoubal	40	120
		Imphal East	40	
		Senapati	40	
2.	Rice-mustard	Thoubal	40	120
		Imphal East	40	
		Churachandpur	40	
3.	Rice-vegetables	Senapati	40	80
		Churachandpur	40	

3.4.22 Attitude

Attitude is a situation whereby farmers behave consistently favourable or unfavourable towards an object, product or service. It is the more or less permanent feelings, thoughts and predispositions a person has about certain aspects of his environment. Attitude effect on how people think thus it has foreseeable and influential effect on individual behaviour which gives a skill to predict someone's

behaviour towards a certain object. It acts as the determinant factor by converting covert behaviour into overt action (Sahoo *et. al.*, 2019). Attitude scale was developed by using Likert (1932) technique to measure attitude towards the sustainable farming practice of farmers.

Collection of items

The attitude scale was developed as by following standard research procedure. A list of 103 statements including 39 negative statements and 64 positive statements were collected based on the idea of sustainable agriculture.

Items editing

Next step is collected items were carefully edited on the basis of 14 criteria suggested by Edwards (1957) and the chosen 83 statements were processed for refinement. After removing the unclear, lengthy, confusing and involve double negative only 68 statements were selected out of these statements (30) negative statements and (38) positive statements. So, 68 statements were included relevancy test.

Relevancy test

The total of 68 statements were sent to 55 experts with the request to examine each statement and to determine the statements relevancy on a 3 continuum i.e., Most relevant response (3 score), Relevant response (2 score) and Non-Relevant response (1 score) whereas the score is reverse for the negative statements. And the statements having relevancy percentage (>0.75), relevancy weightage

(>0.75) and mean relevancy score (> 2.30) were included for the final selection of the statements.

Selection of final items-t test

Therefore, 38 statements having 13 negative statements and 25 positive statements were selected for the T test. To study further, the statements representing the attitudes of farmers towards sustainable rice-based farming system were allotted on 27 farmers from non-sampling area to response the statements. The respondents were asked to indicate their degree of agreement or disagreement on five continuums viz., Strongly Agree (SA) with score 5, Agree (A) score with 4, Undecided (UD) score with 3, Disagree (D) score with 2 and Strongly Disagree (SDA) score with 1 respectively and the for negative statements the score is reverse *i.e.* Strongly Disagree (SDA) score with 5, Disagree (D) score with 4, Undecided (UD) score with 3, Agree (A) score with 2 and Strongly Agree (SA) with score 1. The respondents' responses were recorded and summated score for the total statements of each respondent, the maximum possible score for 38 statements was 190 and the minimum was 38. The score of the farmers were arranging of descending order. Twenty-five per cent from the highest scores (high group) and twenty-five per cent from the low score were selected for item analysis. These responses were subjected to item analysis for the selection of the items that constitute the final scale. Thus, out of the 27 respondents, 7 respondents with uppermost scores and 7 respondents with lowermost scores were used as criterion groups to evaluate individual items. Then the criterion ratio *i.e.* t-value were measured. After calculating the t-values for all the items of the attitudes scale by the

formula, the values of the statements were arranged in descending order from highest to lowest and 13 statements were selected from the scale whose value were highest with t-value more than 1.75, for both positive and negative statement. Therefore, the finale 13 statements were included in the study.

Then the criterion ratio i.e., t-value were measure of how significantly a given statement could differentiate between the high and low group of the respondents which was calculated by using formula suggested by Edwards.

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\left(\sum X_H^2 - \frac{(\sum X_H)^2}{n}\right) \times \left(\sum X_L^2 - \frac{(\sum X_L)^2}{n}\right)}{n(n-1)}}$$

Where;

$\bar{X}_H$ = The mean score on the given statement of the high group

$\bar{X}_L$ = The mean score on the given statement of the low group

$\sum X_H^2$ = Sum of square of the individual score on a given statement for high group

$\sum X_L^2$ = Sum of square of the individual score on a given statement for low group

n= Number of respondents in each group

t= The extent to which a given statement differentiate between the high and low group.

Table 3.4.22.1 List of final statements for the scale of attitude of farmers towards adoption of sustainable agricultural practices

S/N	Statement	t value
1.	Farmers should not use excessive chemicals fertilizers to avoid harmful effect on environment (+)	4.178
2.	Government should make strict rules to act on the farmer who waste the natural resources (+)	3.133
3.	Farmers should always protect natural resources at the earliest as it belongs to all generations (+)	2.683
4.	Agriculture will be sustainable by attracting young farmers to take up a career in farming (+)	2.611
5.	In my village most of the farmers believed utilization of chemical fertilizers give better crop yield. (-)	2.573
6.	Sustainable agricultural practices are costly and can be only adopted by rich farmers (-)	2.309
7.	Agricultural practices of my village are not concern about health and natural resources (-)	2.165
8.	In my village the farmers who practice sustainable farming system have a quality life (+)	2.121
9.	I look forward to participate in training and demonstration on sustainable technologies for adoption (+)	2.038
10.	I follow Integrated farming practices to maintain cash flow throughout the year and increase sustainability (+)	1.979
11.	There is a lack of social support regarding environmental issues and its protection (-)	1.943
12.	I am not aware about the importance of natural resource conservation in agricultural practices (-)	1.849
13.	Cultivation without chemicals gives nutrients rich food and good health in the society (+)	1.832

Standardization of the scale

The scale developed was further standardized by establishing its reliability and validity.

Reliability and validity of the scale

To know the reliability and validity of the attitude scale Test re-test method was followed. As validity means truthfulness, which refers to "the degree to which a

test measures, what it claims to measure" by Kerlinger (1973), content validity was used to measure the validity of the scale. The scale was found reliable and validity at 0.71 correlation coefficient indicating the high reliability of the scale.

Administration of scale

The finale scale consists of 13 statements (Table 2.) would administer to measure the attitude of farmers towards the sustainable rice-based farming system. Each statement consists of 5 continuum's as Strongly Agree (SA) with score 5, Agree (A) score with 4, Undecided (UD) score with 3, Disagree (D) score with 2 and Strongly Disagree (SDA) score with 1 respectively. For negative statements the score reversed score would be obtained of each statement *i.e.* Strongly Disagree (SDA) score with 5, Disagree (D) score with 4, Undecided (UD) score with 3, Agree (A) score with 2 and Strongly Agree (SA) with score 1. Then attitude score range on this scale from minimum 13 score to maximum 63 score indicates the farmers attitudes towards the sustainable rice-based farming practice and the less score indicate less favourable attitude and high score indicate the highly favourable attitude towards the sustainable rice-based farming practices. The score obtained of each statement were further added to arrive at the total score for each respondent and the respondents were grouped into three categories base on the mean ($\bar{x}$) and standard deviation value (σ) as follows:

S/N	Level of attitude	Score range
1.	Les favourable	Below ($\bar{x} - \sigma$)
2.	Favourable	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	Highly favourable	Above ($\bar{x} + \sigma$)

‘Z’ value was also calculated to know the significant difference in ‘Attitude’ towards sustainable rice-based farming among the selected four district of Manipur.

3.4.23 Extent of adoption of sustainable agriculture practices and sustainable rice-based farming system

In the adoption, respondents respond Adopted/ Not adopted to 32 questions about the manner of adoption of sustainable farming practices. The binary scores for each question were added together to give adoption score. The answer “Adopted” was coded as 1, while the answer “Not Adopted” was coded as 0. On the other hand, a “Adoption index” was created from the raw adoption scores of each respondent. It was used for measuring the adoption level of the respondents about the recommended technology as per the procedure by applying the formula suggested by (Veeresh and Hosmani, 2018) as given below:

$$\text{Adoption index (AI)} = \frac{\text{Total score obtained}}{\text{Maximum possible scores}} \times 100$$

Depending upon total score obtained by each of the respondents, they were categorized into three groups as low, medium and high adopter category based on the mean ($\bar{x}$) and standard deviation value (σ) as follows:

S/N	Level of adoption	Score range
1.	Low	Below ($\bar{x} - \sigma$)
2.	Medium	Between ($\bar{x} - \sigma$) and ($\bar{x} + \sigma$)
3.	High	Above ($\bar{x} + \sigma$)

‘Z’ value was also calculated to know the significant difference adoption level among the selected four districts.

3.4.24 Sustainability of rice-based farming system

The practice of cultivating and preserving food, fibre, and other agricultural products in a way that protects and enhances ecosystem production and wellness while fostering social and economic well-being is known as sustainable agriculture. It comprises integrating principles of social responsibility, economic viability, and environmental stewardship into agricultural systems. The phrase "sustainable agriculture" refers to a collection of methods and guiding ideas that support long-term social, economic, and environmental viability. Sustainable agriculture considers not only the future requirements of production increase, but also maintains the quality of environment and water and soil. Sustainable food and agriculture (SFA) contribute to all four pillars of food security-availability, access, utilization and stability and the dimensions of sustainability (environmental, social and economic).

‘Sustainability’ was measured by developing a sustainability index. First of all, it was divided into three dimensions viz., environmental sustainability, economic sustainability as well as social sustainability. Each of these dimensions was measured on the basis of indicators area suggested by (Alaoui *et al.*, 2022) and (Mungkung *et al.*, 2022). The indicators were modified for the convenient.

The indicators presented in Table 3.2.25.1 were selected to measure the environmental sustainability, economic sustainability and social sustainability under Thoubal district and Imphal East district representing valley area and Senapati district and Churachandpur district representing hill district of Manipur.

Table 3.4.24.1 Selection of indicators of sustainability

Theme	Indicators	Parameters
Environment sustainability		
Climate	Flood, drought, disasters, slope/land use	Extreme flood and drought, landslides, loss of upper soil.
Water	water harvesting, well, ponds, water source availability	Measuring and monitoring of water utilisation and Water harvesting technique, construction of ponds and well, water resource availability
Soil	Trenches, bundle, drainage system, mulching, crop residue, cover plant.	Construction of bundle/ trench in the field, construction of drainage system, management of crop residue, mulching crop, plantation of cover crop to avoid soil erosion.
Biodiversity	Preserve insect, plantation, avoid chemicals	Preservation of useful insects, IPM, INM, enrichment, planting plantation of tree, and avoid utilization of chemicals pesticides and insecticides
Recycle nutrients	Vermicompost, FYM	Setting up of vermicompost pit, setting up of compost pit, preparation of FYM.
Agronomic practice	Crop rotation, organic cultivation, mix cropping	Practice of crop rotation, mix cropping, integrated farming, relay & alley cropping, and utilization of organic matter
Social sustainability		
Quality of living	Education, household type, food availability	Status of education, living standard of people, and availability of foods
Social connection	Participation, training & awareness, extension service, knowledge.	Involvement and participation of social activities, resource conservation knowledge, social awareness and supports of stakeholders' extension services and solution of problem.
Employability	Family labour, involvement of women, wages	Involvement of family women and level of equal wages
crop production practice and management	Crop yield, adaptation practices, improved technology and risk.	Adoption of high yield crop, utilisation of ITK adaption practices, using improved technology to increase crop yield and risk management practices.
Economic sustainability		
Farm production	Profitability, Productivity, farm output and stable income	Efficiency and profitability of crop production, stable farm income and indebtedness.
Market	Marketable, stable price	Product price stability, marketing network and product quality
Finance	Subsidies, financial supports, insurance	Financial support and subsidies from the government and schemes

Sustainability index was calculated by using the following formula from (Das and Jha 2022) as follows:

$$Sustainability\ Index = \sum_{i=1}^3 \frac{\sum_{j=1}^n x_1, x_2, \dots, x_n}{\sum_{j=1}^n a_1, a_2, \dots, a_n}, \frac{\sum_{k=1}^n y_1, y_2, \dots, y_n}{\sum_{k=1}^n b_1, b_2, \dots, b_n}, \frac{\sum_{l=1}^n z_1, z_2, \dots, z_n}{\sum_{l=1}^n c_1, c_2, \dots, c_n} \times 100$$

Where;

$x_1, x_2, \dots, x_n$ = Score obtained by individual farmers in economic sustainability

$a_1, a_2, \dots, a_n$ = Maximum possible core obtained by individual farmers in economic sustainability

$y_1, y_2, \dots, y_n$ = Score obtained by individual farmers in social sustainability

$b_1, b_2, \dots, b_n$ = Maximum possible core obtained by individual farmers in social sustainability

$z_1, z_2, \dots, z_n$ = Score obtained by individual farmers in environmental sustainability

$c_1, c_2, \dots, c_n$ = Maximum possible core obtained by individual farmers in environmental sustainability

i = Economic sustainability, social sustainability & Environmental sustainability

j = Total number of farmers in economic sustainability

k = Total number of farmers in social sustainability

l = Total number of farmers in environmental sustainability

3.4.25 Determining attributes of sustainability on rice-based farming system

Linear regression analysis was used to identify the contribution of significant sustainable indicators to the data of the sustainability of rice-based farming system under the three dimensions of sustainability (environment sustainability, social sustainability and economic sustainability) which influence on the environment sustainability, social sustainability and economic sustainability on the sustainability

of rice-based farming system. Linear regression model was also developed to the sustainable indicators data under the three dimensions (environmental sustainability, social sustainability and economic sustainability) on the sustainability of rice-based farming system which influence on the environmental sustainability, social sustainability and economic sustainability of rice-based framing system. The equation for the model is given below:

In linear regression, it is considered that the frequency distribution of one variable (Y) at each of several levels of a second variable (X). Y is known as the dependent variable. X is known as the independent variable. The linear regression was calculated by using the equation (North Dakota State University US, 2023) as follow:

The equation is
$$\hat{Y} = b_0 + b_1 X$$

Where,

b_0 = Y intercept, and

b_1 = regression coefficient

X= slope of the line.

The linear model can be written as: $Y_i = \beta_0 + \beta_1 X + U_i$

Where,

U_i =standard error

X= variables

1. The specified model of environmental sustainability is as follows:

$$Y_1 = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} X_{15} + \beta_{16} X_{16} + \beta_{17} X_{17} + U_i$$

Where,

Y_1 =Environmental sustainability of rice-based farming system, $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, X_{16}$ and X_{17} are the variables which effect on the environmental sustainability, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}, \beta_{16}$, and β_{17} are regression coefficients and U_i is the stochastic error term.

2. The specified model of social sustainability is as follows:

$$Y_2 = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} X_{15} + \beta_{16} X_{16} + \beta_{17} X_{17} + U_i$$

Where,

Y_2 =Social sustainability of rice-based farming system, $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, X_{16}$ and X_{17} are the variables which effect on the social sustainability, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}, \beta_{16}$, and β_{17} are regression coefficients and U_i is the stochastic error term.

3. The specified model of economic sustainability is as follows:

$$Y_3 = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + U_i$$

Where,

Y_3 =Economic sustainability of rice-based farming system, $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}$ and X_{14} are the variables which effect on the economic sustainability, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}$ and β_{14} are regression coefficients and U_i is the stochastic error term.

3.4.26 Employment generation rice-based farming system

Employment generation under Rice-fish farming system (RFFS), Rice-mustard farming system (RMFS) and Rice-vegetables farming system (RVFS) was calculated by applying the following formula extracted from (Taylor, 2019).

$$\text{Mandays} = \frac{\text{Number of working days} \times \text{Number of working hours}}{\text{Manhours}}$$

Where,

$$1 \text{ Manhours} = 8 \text{ hours}$$

3.4.27 Estimation of income generation from rice-based farming system

Estimation of income generation from rice-based farming practices was calculated by applying the formula suggested by Indian Council of Agriculture Research, (2012) as given below:

A. Total cost of cultivation = Sum of the cost of X components

$$\text{Total cost of cultivation} = X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9$$

Where,

X_1 : Cost of land preparation, X_2 : Cost of irrigation

X_3 : Cost of seedling, X_4 : Cost of rice transplantation

X_5 : Cost of fertilizers, X_6 : Cost of feed supplements for fish

X_7 : Cost of weeding, X_8 : Cost of transportation, X_9 : Cost of harvesting

B. Gross return = Quantity of produce (kg) $\times$ Prevailing price (Rs) of produce/kg

C. Net income = Gross return - Total cost of cultivation

D. Benefit Cost Ratio = Gross return / Total cost of cultivation

3.4.28 Constraints faced by farmers in sustainable rice-based farming system

Garrett ranking method was utilized to ranking the preference mentioned by the respondents on different factors on sustainable rice-based farming system. This method was used find the most significant factor which had influenced the respondent in their practices. Major problems faced in sustainable rice-based farming system were identified. Then respondents were asked to rank the identified problems under the three factors rice-based farming system, rice-fish farming system and rice-mustard farming system based on the severity of the constraints. Three level of severity were allotted as Most severe as 3, moderate as 2 and less severe as 1. According this method, respondents were asked to specify the rank base on the severity as most severe/moderate/less severe on the identified problem. After that, the responses of the farmers were allotted to calculate the ranking. Then the assigned rank to different constraints was transformed into percentage by applying Henry Garret (1969) ranking method by using the following equation suggested by (Rao *et al.* 2019) as given below:

$$\text{Percentage position} = \frac{100(R_{ij}-0.5)}{N_j}$$

Where,

R_{ij} = Rank has been given for the i^{th} risk statement by the j^{th} respondent.

N_j = Number of risk statements ranked by the j^{th} respondent.

3.5 Formulation of Hypothesis:

Following null hypothesis were formulated to test the relationship between the dependent variables viz., ‘knowledge of sustainable rice cultivation practices, attitude of respondents towards sustainable rice cultivation practices, extent of adoption of sustainable rice cultivation practices, sustainability of rice-based

farming system and the selected personal, socio-economic and personal variables specified earlier under the heading selection and measurement of variables:

The following null hypotheses have been developed for the study:

Null Hypothesis H₀1: There is no association between the selected socio-economic and personal variables with “Knowledge of sustainable agricultural practices”.

Alternate Hypothesis H₀1a: There is association between the selected socio-economic and personal variables with “Knowledge of sustainable agricultural practices”.

Null Hypothesis H₀2: There is no association between the selected socio-economic and personal variables with “Attitude of farmers towards adoption of sustainable agricultural practices”.

Alternate Hypothesis H₀2: There is association between the selected socio-economic and personal variables with “Attitude of farmers towards adoption of sustainable agricultural practices”.

Null Hypothesis H₀3: There is no association between the selected socio-economic and personal variables with “Adoption of sustainable rice-based farming system”.

Alternate Hypothesis H₀3: There is association between the selected socio-economic and personal variables with “Adoption of sustainable rice-based farming system”.

3.6 Tools and techniques used for data collection

An interview schedule directed towards the objectives of the study was developed for data collection. The schedule was prepared with references from similar research materials from within and outside the institution.

3.6.1 Development of interview schedule

An interview schedule aimed towards the objectives of the study was developed for data collection. The schedule was prepared with references from similar research materials from within and outside the institutions.

3.6.2 Pre-testing of interview schedule

Before the actual interview, a preliminary interview was conducted in the selected villages; a sample of 20 respondents which did not constitute the respondent's sample was selected for pre-testing the schedule. Based on the pretested results, few difficulties and ambiguous questions were deleted from the draft schedule.

3.6.3 Method of data collection

For the present study, two types of data viz., primary and secondary data were collected. The primary data was collected through personal interview by the researcher using pre tested interview schedule by conducting personal interview. The secondary data was collected from various publications, magazines, relevant text books and other sources.

3.7 Analysis of data

The data collected from the respondents were scored, tabulated and analysed to calculate frequency, percentage, mean, standard deviation, correlation, 'Z' test, and factor and path analysis. Statistical analysis was done using SPSS software

3.7.1 Percentage

Percentage was calculated by frequency multiplied by 100 and divided by total number of observation of respondents in a particular category.

$$\text{Percentage} = \frac{\text{Number of observation recorded}}{\text{Total number of observation}} \times 100$$

3.7.2 Mean

It refers to the average value of the distribution which is arrived at by dividing the sum of scores in the distribution by number of observations and formula presented below

$$\bar{x} = \frac{\sum Xi}{n}$$

Where,

$\bar{X}$ = mean of the scores

$\sum X_i$ = sum of individual score

N = number of observations

3.7.3 Standard deviation

According to Karl Pearson (1896) standard deviation is also called as root mean square deviation. It is defined as the square root of the arithmetic mean of the square of the deviation of the value taken from the mean. The following formula was suggested by (Singh, 2021).

$$S = \sqrt{\sum_{i=1}^n \frac{(x_i - \bar{x})^2}{n}}$$

Where;

S = standard deviation

x = individual score

n= number of observations

3.7.4 Correlation

When an increase or decrease in one variant is accompanied by an increase or decrease in the other variable, the two are said to be correlated and phenomenon is known as correlation. The following formula was suggested (Wani *et al.*, 2019).

$$r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}}$$

Where;

X and Y = original scores in variables X

N= number of paired scores

$\sum XY$ = each X multiplied by corresponding Y, then summed

$\sum X$ = sum of X scores

$(\sum X)^2$ = each X squared, then summed

$(\sum X)^2$ = sum of X scores, squared

$\sum Y$ = sum of Y scores

$\sum Y^2$ = each Y squared, then summed

$(\sum Y)^2$ = sum of Y scores, square

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Results of the present study with relevant discussions are presented in this chapter. The data were tabulated, analysed and organized in line with the objectives of the study. The results and discussion of the study has been presented under the following headings:

4.1 Socio-economic and psychological characteristics of rice-based cultivation farmers

4.1.1 Age

Age is one of the important determinants of personal behaviour. It is the basic character of an individual linked up with his/her maturity. Hence, it may affect the sustainable technology adoption behaviour and the sustainable management of farm resources by the respondents. The results are presented in Table 4.1.1.1 and Fig 4.1.1.1

Table 4.1.1.1: Distribution of respondents according to the category of age group

S/N	Districts	THB n ₁ =80	IME n ₂ =80	SNP n ₃ =80	CCP n ₄ =80	Overall respondents n=320
	Category of Age	f(%)	f(%)	f(%)	f(%)	f(%)
1.	Young (Less than 35)	5 (6.25)	3 (3.75)	11 (13.75)	23 (28.75)	42 (13.13)
2.	Middle age (Between 35 to 55)	49 (61.25)	47 (58.75)	33 (41.25)	42 (52.50)	171 (53.43)
3.	Old age (Above 55)	26 (32.50)	30 (37.50)	36 (45.00)	15 (18.75)	107 (33.44)
4.	Total	80 (100)	80 (100)	80 (100)	80 (100)	320 (100)
5.	Mean	50.15	49.58	49.50	41.96	47.68
6.	SD	11.78	11.48	13.91	12.14	12.76

THB: Thoubal district; IME: Imphal East district; SNP: Senapati district; CCP: Churachandpur district; f: Frequency and %: Percentage

Table 4.1.1.1 and Fig 4.1.1.1 revealed that majority (61.25%) of farmers from Thoubal district belonged to middle age group (35-55 years), followed by 58.75 per cent farmers from Imphal East district, 52.50 per cent farmers from Churachandpur district and 41.25 per cent farmers from Senapati district respectively. In case of farmers above 55 years, the majority (45.00%) of the farmers following rice-based cultivation practice belonged to Senapati district followed by 37.50 per cent from Imphal East district, 32.50 per cent from Thoubal district and 18.75 per cent from Churachandpur district. Majority (28.75%) of the farmers in the age group below 35 years belonged to Churachandpur district followed by 13.75 per cent from Senapati district, 6.25 per cent from Thoubal district and 3.75 per cent from Imphal East district. From overall distribution of farmers from four districts it was found that majority (53.44%) of the farmers belonged to medium age group followed by 33.44 per cent farmers in the old age group and 13.13 per cent farmers in young age group. Mean age of farmers was 47.68 years old, implying a high proportion of medium age group farmers in the study area. The findings of the study indicates that majority farmers were below 50 years who have the potential to maximize the use of sustainable technology, enhance labour productivity, adoption of social media information sources and positive attitude towards sustainable farming. This result was in accordance with the findings of Satyam *et al.* (2021) and Asmara *et al.* (2023) who found that range of respondents was 48-55.6 years (45.00%) had the largest number and the average age of the respondents was 49 years.

Table 4.1.1.2: Comparative account of age of respondents

S/N	Districts	Age (μ)	Z Value	P value
1.	Thoubal	50.15	0.315**	< 0.01
2.	Imphal East	49.58		
3.	Churachandpur	41.96	-3.676**	< 0.01
4.	Senapati	49.50		
5.	Imphal East	49.58	0.485*	> 0.05
6.	Senapati	49.50		
7.	Imphal East	49.58	4.120**	< 0.01
8.	Churachandpur	41.96		
9.	Thoubal	50.15	0.324**	< 0.01
10.	Senapati	49.50		
11.	Thoubal	50.15	4.411**	< 0.01
12.	Churachandpur	41.96		

** significant at 1% level of probability; * significant at 5% level of probability

From Table 4.1.1.2 it was evident that the age of the respondents of all the selected districts were statistically significant at 1% level of significance.

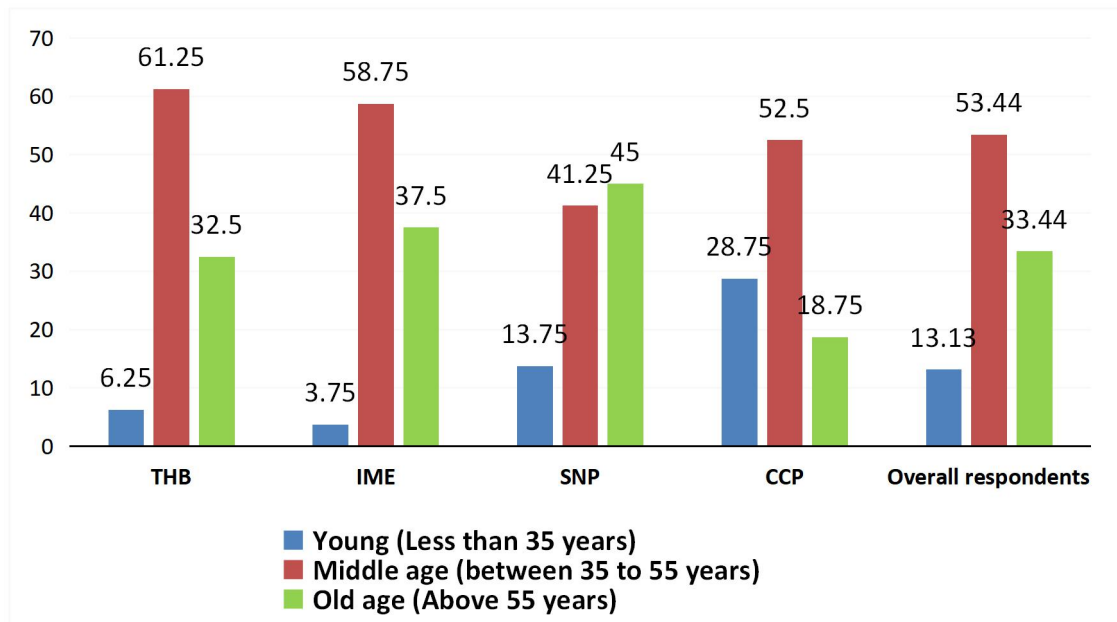


Fig 4.1.1.1: Distribution of respondents based on age

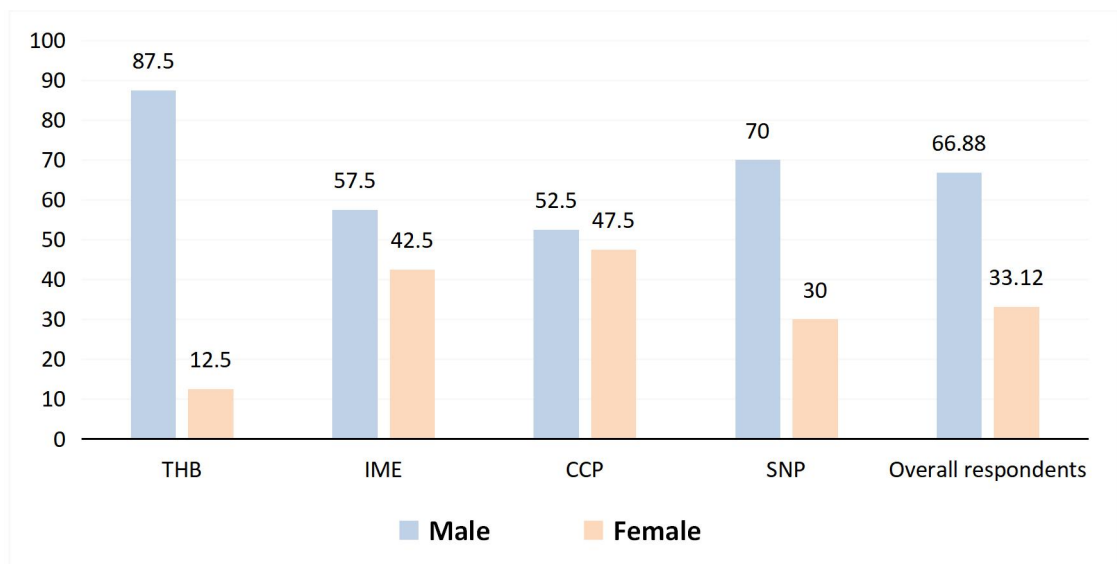


Fig 4.1.2.1: Distribution of respondents based on sex

4.1.2 Sex

Sex refers to biological features, while gender refers to personal and social expression (Wirth and Prosser, 2023). It is expressed in terms of male and female. To establish the possibility of equity participation male and female farmers in agricultural is important. Woman should have equal rights as men to access land, education, agricultural inputs, aids and incentives for agricultural expansion which will help to reach sustainable goal. The results of the study of male and female farmers are presented in Table 4.1.2.1 and Fig 4.1.2.1

Table 4.1.2.1: Distribution of respondents based on sex

S/N	Districts	THB n ₁ =80	IME n ₂ =80	SNP n ₃ =80	CCP n ₄ =80	Overall respondents n=320
	Category of sex	f (%)	f (%)	f (%)	f (%)	f (%)
1.	Male	70 (87.50)	46 (57.50)	56 (70.00)	42 (52.50)	214 (66.88)
2.	Female	10 (12.50)	34 (42.50)	24 (30.00)	38 (47.50)	106 (33.12)
3.	Total	80 (100)	80 (100)	80 (100)	80 (100)	320 (100)

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.2.1 and Fig 4.1.2.1 it was found that majority (87.50%) of the rice-based farmers from Thoubal district were male followed by 70.00 per cent male farmers from Senapati district, 57.50 per cent male farmers from Imphal East district and 52.50 per cent male farmers from Churachandpur district.

In female category, majority (47.50%) of the rice-based cultivation farmers were found as female in Churachandpur district followed by 42.50 per cent farmers from Imphal East district, 30.00 per cent farmers from Senapati district and 12.50 per cent farmers from Thoubal district were female farmers. In the overall distribution of four districts, it was found that majority 66.88 per cent were male farmers and 33.12 per cent were female farmers. The result indicates that female farmers were far less on average as compared to the male farmers. It may be due to either female own less agricultural land or lack of financial support for agricultural investment as compare with male. It can be concluded that the number of males was relatively higher among the rice-based cultivation farmers. The similar result was also found in the study of Ajibesin *et al.* (2019); Somanje, *et al.* (2021); Henry *et al.* (2020); Jha and Gupta (2021) and Begum *et al.* (2023).

4.1.3 Family type

Table 4.1.3.1: Distribution of respondents based on the family type

S/N	Districts	THB n ₁ =80	IME n ₂ =80	SNP n ₃ =80	CCP n ₄ =80	Overall respondents n=320
	Family type	f (%)	f (%)	f (%)	f (%)	f (%)
1.	Joint family	34 (42.50)	30 (37.50)	41 (51.25)	29 (36.25)	134 (41.88)
2.	Nuclear Family	46 (57.50)	50 (62.50)	39 (48.75)	51 (63.75)	186 (58.12)

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

Table 4.1.3.1 and Fig 4.1.3.1 revealed that majority (63.75%) of the farmers from Churachandpur district belonged to nuclear family type followed by 62.50 per cent farmers from Imphal East district, 57.50 per cent farmers from

Thoubal district and 51.25 per cent farmers from Senapati district belonged to joint family type. In the overall category of family type, majority (58.12%) of rice-based farmers belonged to nuclear family type and 41.88 per cent farmers belonged to joint family type. Thus, majority of the farmers belonged to nuclear family. This might be due to the fact that younger generation prefer to live in small family.

4.1.4 Family size

Table 4.1.4.1: Distribution of respondents based on the family size

Districts	THB n ₁ =80	IME n ₂ =80	SNP n ₃ =80	CCP n ₄ =80	Overall respondents n=320
Category of family size	f (%)	f (%)	f (%)	f (%)	f (%)
Small Family (< 4 members)	11 (13.75)	10 (12.50)	9 (11.25)	16 (20)	46 (14.38)
Medium family (4-7 members)	56 (70.00)	55 (68.75)	61 (76.25)	53 (66.25)	225 (70.31)
Large family (>7 members)	13 (16.25)	15 (18.75)	10 (12.50)	11 (13.75)	49 (15.31)
Total	80 (100)	80 (100)	80 (100)	80 (100)	320 (100)
Mean	4.98	4.95	5.54	5.33	5.19
SD	1.32	1.60	1.67	1.84	1.63

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.4.1 and Fig 4.1.4.1 it was revealed that majority (76.25%) of the rice-based cultivation farmers belonged to medium family (4-7 members) followed by 70.00 per cent farmers from Thoubal district, 68.75 per cent farmers from Imphal East district and 66.25 per cent farmers of Churachandpur district. In the overall category, majority (70.31%) belonged to medium family (4-7 members) followed by 15.31 per cent of large family members (>7 members) and 14.38 per cent of small family members (<4 members). The mean family size was 5.19. Thus,

majority of the farmers belonged to medium family. The result was found supported with the findings of Medhi *et al.* (2020) and Ghosh *et al.* (2020).

Table 4.1.4.2: Comparative account of family size of respondents

S/N	Districts	Family size (μ)	Z Value	P value
1.	Thoubal	4.975	0.457 ^{NS}	> 0.05
2.	Imphal East	4.950		
3.	Churachandpur	5.325	-0.765 ^{NS}	> 0.05
4.	Senapati	5.537		
5.	Imphal East	4.950	-2.470*	> 0.05
6.	Senapati	5.537		
7.	Imphal East	4.950	-1.481 ^{NS}	> 0.05
8.	Churachandpur	5.325		
9.	Thoubal	4.975	-2.177*	> 0.05
10.	Senapati	5.537		
11.	Thoubal	4.975	-1.284 ^{NS}	> 0.05
12.	Churachandpur	5.325		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.1.2 it was evident that the family size of the respondents of the selected districts were found statistically non-significant however family size in ‘Imphal East district vs Senapati district’ and that of ‘Thoubal district vs Senapati district’ were found negative and statistically significant at 5% level.

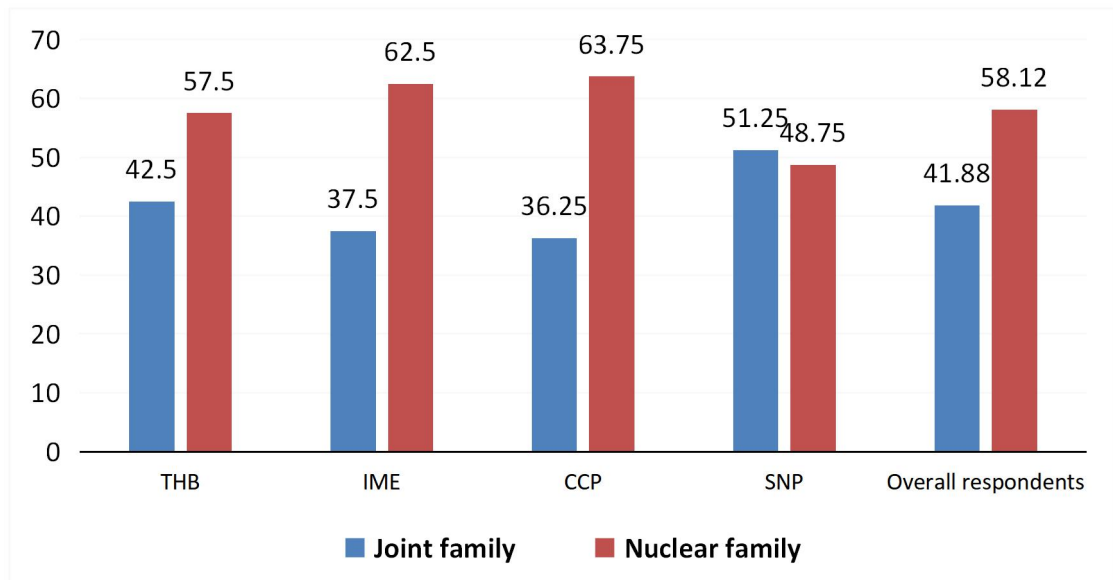


Fig 4.1.3.1: Distribution of respondents based on the family type

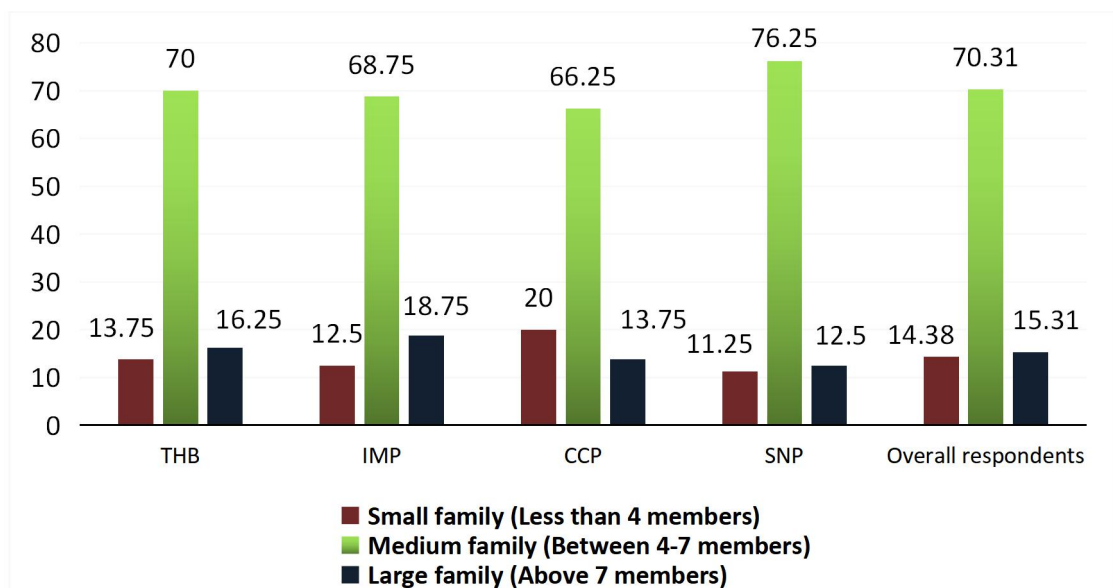


Fig 4.1.4.1: Distribution of respondents based on the family size

4.1.5 Educational level

Formal education enhances the problem solving capabilities of an individual. It helps to broaden the outlook of a person towards the new technologies. In view of the information pertaining to the level of education was collected, tabulated and analysed. The results are presented in Table 4.1.5.1 and Fig 4.1.5.1.

Table 4.1.5.1: Distribution of respondents based on their educational level

S/N	Districts	THB n ₁ =80	IME n ₂ =80	SNP n ₃ =80	CCP n ₄ =80	Overall respondents n=320
	Level of education	f (%)	f (%)	f (%)	f (%)	f (%)
1.	Illiterate	10 (12.50)	8 (10.00)	28 (35.00)	18 (22.50)	64 (20.00)
2.	Primary	6 (7.50)	5 (6.25)	6 (7.50)	15 (18.75)	32 (10.00)
3.	Secondary	29 (36.25)	27 (33.75)	34 (42.50)	23 (28.75)	113 (35.31)
4.	Higher Secondary	22 (27.50)	20 (25.00)	8 (10.00)	19 (23.75)	69 (21.56)
5.	Graduate	9 (11.25)	17 (21.25)	4 (5.00)	5 (6.25)	35 (10.94)
6.	Post graduate	4 (5.00)	3 (3.75)	0 (0.00)	0 (0.00)	7 (2.19)
7.	Total	80 (100)	80 (100)	80 (100)	80 (100)	320 (100)
8.	Mean	9.44	9.95	6.40	7.41	8.30
9.	SD	4.30	4.04	5.09	5.04	0.53

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.5.1 and Fig 4.1.5.1 it was found that majority (42.50%) of the farmer with rice-based cultivation from Senapati district had secondary level of education followed by 36.25 per cent from Thoubal district, 33.75 per cent from Imphal East district and 28.75 per cent from Churachandpur district. In the overall

category of education level in four districts, it was found that majority (35.31%) had secondary level of education followed by 21.56 per cent of higher secondary education level, 20.00 per cent of illiterate farmers, 10.94 per cent of graduation level, 10.00 per cent of primary level and only 2.19 per cent of above graduation level of education were possessed by the rice-base cultivation farmers. The result of study was found similar and supported with the findings of the following studies Chittem and Kunda (2018); Gnanasubramaniam and Hemachandra (2020); Gebaska *et al.* (2020) and Suraj (2021). Further, Imphal East district had the highest mean 9.95 in education followed by Thoubal district 9.44 mean, Churachandpur district 7.41 mean, Senapati district 5.09 mean and the overall mean (8 years) of education. This indicates that attaining a minimum threshold level of education helps farmers in ways of enhancing their skills and capabilities to collect and analyze the information and execute that on the field. It creates a conducive environment to go for adoption of sustainable technology and thereby augments the productivity. The findings of the study were found similar with Paltasingh and Goyari (2018) and Jha and Gupta (2021) as reported that the average years of schooling of the surveyed household are 8 years. Farmers should be motivated and encourage through training and demonstration by the government agencies towards sustainable farming system.

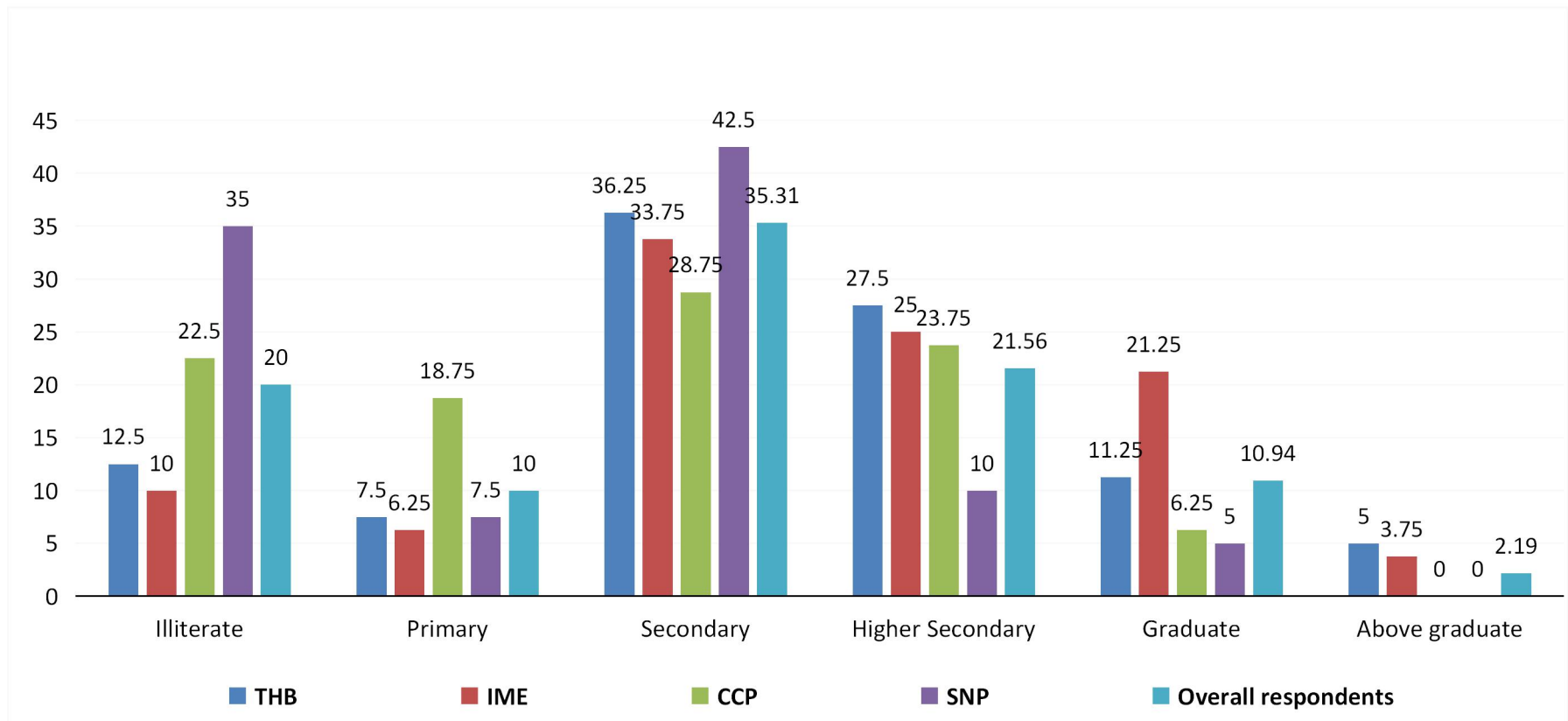


Fig 4.1.5.1: Distribution of respondents based on their educational level

Table 4.1.5.2: Comparative account of educational level of respondents

S/N	Districts	Education (μ)	Z Value	P value
1.	Thoubal	10.28	1.003 ^{NS}	> 0.05
2.	Imphal East	9.54		
3.	Churachandpur	7.76	2.886 ^{NS}	> 0.05
4.	Senapati	8.15		
5.	Imphal Esat	9.54	1.864*	< 0.05
6.	Senapati	7.76		
7.	Imphal East	9.54	2.126*	< 0.05
8.	Churachandpur	7.76		
9.	Thoubal	10.28	2.704**	< 0.01
10.	Senapati	8.15		
11.	Thoubal	10.28	3.416**	< 0.01
12.	Churachandpur	7.76		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.5.2 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% level of significance except ‘Thoubal district vs Imphal East district’ and ‘Churachandpur district vs Senapati district’ were found non significant (p-value >0.05).

4.1.6 Experience in rice-based cultivation

Table 4.1.6.1 Distribution of respondents based on their experience in rice-based farming

S/N	Districts	THB n ₁ =80	IME n ₂ =80	SNP n ₃ =80	CCP n ₄ =80	Overall respondents n=320
	Length of experience	f (%)	f (%)	f (%)	f (%)	f (%)
1.	Low (Experience below 10 years)	18 (22.50)	16 (20.00)	18 (22.50)	35 (43.75)	87 (27.19)
2.	Medium (Experience between 10-20)	10 (12.50)	32 (40.00)	26 (32.50)	27 (33.75)	95 (29.69)
3.	High (Experience above 20)	52 (65.00)	32 (40.00)	36 (45.00)	18 (22.50)	138 (43.12)
4.	Mean	19.80	23.01	20.46	14.14	15.49
5.	SD	10.92	10.86	11.90	9.55	11.27

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and %: Percentage

From Table 4.1.6.1 and Fig 4.1.6.1 revealed that majority (65.00%) of farmers from Thoubal district had high experience (experience of above 20 years) in rice-based cultivation followed by 45.00 per cent farmers from Senapati district had high experience (experience above 20 years), 43.75 per cent farmers from Churachandpur district had low experience (experience below 10 years), 40.00 per cent farmers from Imphal East district had medium experience (experience between 10-20 years) in rice-based cultivation. In the overall respondents, the experience of farmers in rice-based cultivation found that majority (43.12%) of the rice-based cultivation farmers had high experience (experience above 20 years) followed by 29.69 per cent farmers had medium experience (experience between 10-20 years) and 27.19 per cent had low experience (experience below 10 years) in rice-based cultivation. And the average number of years' experience (mean) of overall respondents in rice-based cultivation farmers was 15.49 (15years). These findings

were in accordance with the findings of Digambar *et al.* (2020); Iheke *et al.* (2021); Mugumaarhahama *et al.* (2021) and Sumo *et al.* (2022).

Table 4.1.6.2: Comparative account of experience of respondents

S/N	Districts	Experience (μ)	Z Value	P value
1.	Thoubal	19.80	1.866 ^{NS}	> 0.05
2.	Imphal East	23.01		
3.	Churachandpur	14.14	-3.708**	< 0.01
4.	Senapati	20.46		
5.	Imphal East	23.01	1.412 ^{NS}	> 0.05
6.	Senapati	20.46		
7.	Imphal East	23.01	5.474**	< 0.01
8.	Churachandpur	14.14		
9.	Thoubal	19.80	-0.368 ^{NS}	> 0.05
10.	Senapati	20.46		
11.	Thoubal	19.80	3.289**	< 0.01
12.	Churachandpur	14.14		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.6.2 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% level of significance except ‘Thoubal district vs Imphal East district’, ‘Imphal East district vs Senapati district’ and ‘Thoubal district vs Senapati district’ were found non significant (p-value >0.05).

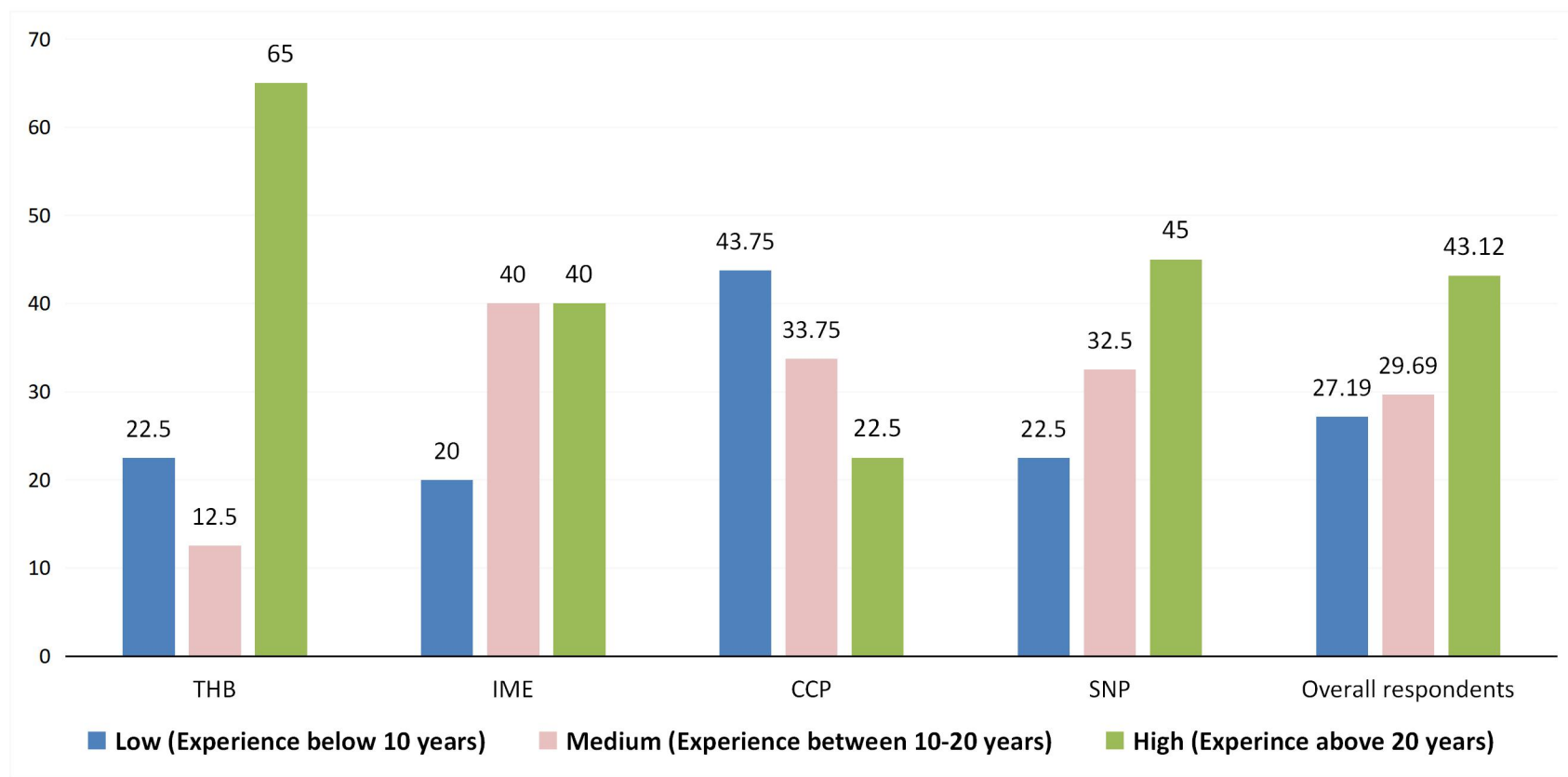


Fig 4.1.6.1 Distribution of respondents based on their experience in rice-based farming

4.1.7 Total landholding area

Landholding plays an important role in terms of economic, provides employments and generate household income. Hence, total land holding area may have direct or indirect association with sustainability and the agricultural practices followed by farmers. So, data pertaining to the total area own or rental by farmers was collected, tabulated and analysed. The results are given in Table 4.1.7.1 and Fig 4.1.7.1.

Table 4.1.7.1: Distribution of respondents based on total landholding area

S/N	Districts	THB n ₁ =80		IME n ₂ =80		CCP n ₃ =80		SNP n ₄ =80		Overall respondents n=320	
	Category of land	f	%	f	%	f	%	f	%	f	%
1.	Marginal (<1 hectare)	20	25.00	23	28.75	61	76.25	40	50.00	144	45.00
2.	Small (1-2 hectare)	48	60.00	51	63.75	19	23.75	32	40.00	150	46.88
3.	Medium (2-3 hectare)	12	15.00	6	7.50	0	0.00	8	10.00	26	8.12
4.	Mean	2.92		2.71		1.66		2.38		2.41	
5.	SD	1.27		0.93		0.82		1.19		1.17	

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.7.1 and Fig 4.1.7.1 it was revealed that majority (76.25%) from Churachandpur district belonged to marginal land holding (<1 hectare) area followed by 63.75 per cent of farmers from Imphal East belonged to small land holding size (1-2 hectare) and 15.00 per cent farmers from Thoubal district belonged medium land holding (2-3 hectare) area. In the total landholding area of

overall respondents was found that majority (46.88%) farmers had small land holding size (1-2 hectare) followed by 45.00 per cent farmers had marginal land holding (<1 hectare) area and 8.12 per cent farmers had medium land holding (2-3 hectare) area. From the result it was observed that a higher number of farm households belonged to the small landholding group (1-2 hectare). The findings of the study were found similar with the findings of the Martey *et al.* (2022); Reddy *et al.* (2022) and Sravanthand and Sundaram (2023).

4.1.7.2: Comparative account of total land holding area

S/N	Districts	Total Land Holding (μ)	Z Value	P value
1.	Thoubal	1.72	1.304 ^{NS}	> 0.05
2.	Imphal East	1.50		
3.	Churachandpur	0.99	-3.118*	< 0.01
4.	Senapati	1.19		
5.	Imphal East	1.50	1.393 ^{NS}	> 0.05
6.	Senapati	1.19		
7.	Imphal East	1.50	5.643**	< 0.01
8.	Churachandpur	0.99		
9.	Thoubal	1.72	2.296*	< 0.05
10.	Senapati	1.19		
11.	Thoubal	1.72	5.544**	< 0.01
12.	Churachandpur	0.99		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.7.2 it was evident that From Table 4.1.8.2 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% and 5% level of significance except ‘Thoubal district vs Imphal East district’ and ‘Imphal East district vs Senapati district’ (p-value >0.05).

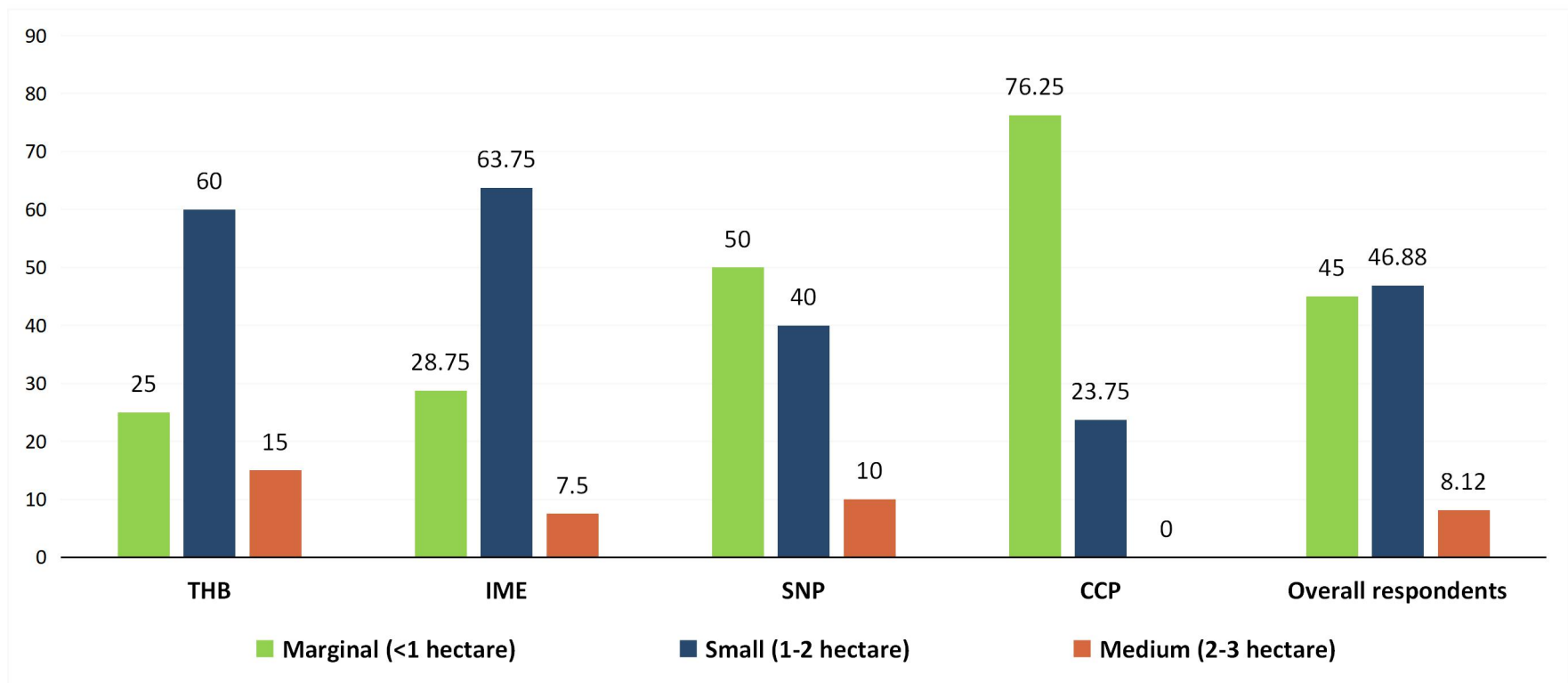


Fig 4.1.7.1: Distribution of respondents based on total landholding area

4.1.8 Area under rice-based farming system

Area under rice-based farming system is an indication of their managing capacity as well as production level of the particular crop. This represent the area on which crop are cultivated more or once during the agriculture year. So, data pertaining to the total area own or rental by farmers was collected, tabulated and analysed. The results are given in Table 4.1.8.1 and Fig 4.1.8.1

Table 4.1.8.1: Distribution of respondents based on the area under rice-based farming system

S/N	Districts	THB n ₁ =80		IME n ₂ =80		CCP n ₃ =80		SNP n ₄ =80		Overall respondents n=320	
	Category of land area	f	%	f	%	f	%	f	%	f	%
1.	Land area (<1acre)	32	38.75	30	42.50	69	73.75	59	86.25	193	60.31
2.	Land area (Between 1- 2 acre)	40	53.75	45	48.75	8	26.25	17	10.00	111	34.69
3.	Land area (Between 2- 3 acre)	8	7.50	5	8.75	3	0.00	2	3.75	16	5.00
4.	Mean	1.18		1.19		0.65		0.74		0.94	
5.	SD	0.58		0.56		0.51		0.42		0.58	

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.8.1 and Fig 4.1.8.1 it was revealed that majority (86.25%) rice-based farmers from Senapati district had land area (<1 acre) followed by 53.75 per cent farmers from Thoubal district who had land area (between 1-2 acre), 8.75 per cent farmers from Imphal East district had land area (between 2-3 acres). Overall, majority (60.31%) of the farmers had land area (<1 acre) followed by 34.69 per cent farmers belonged to land area (between 1-2 acre) and 5 per cent of them had land area (between 2-3 acre). Overall mean area under rice-based cultivation was 0.94. It can be concluded that majority respondents belonged to the marginal land holding size

below 1 acre. Thus, it can be inferred that a majority of the farmers had marginal size of land under rice-based farming system. This might be due to low economic condition to own the land or due to division of inherited property among their children. Another reason could be due to overpopulation in India has led to increase agricultural land causing it fragmented landholding. The findings of the study were found similar with the findings of the Tran *et al.* (2022).

Table 4.1.8.2: Comparative account of area under rice-based farming system

S/N	Districts	(μ)	Z Value	P value
1.	Thoubal	1.182	-0.051 ^{NS}	> 0.05
2.	Imphal East	1.187		
3.	Churachandpur	0.650	-1.198 ^{NS}	> 0.05
4.	Senapati	0.738		
5.	Imphal East	1.187	5.712 ^{**}	< 0.01
6.	Senapati	0.738		
7.	Imphal East	1.187	6.290 ^{**}	< 0.01
8.	Churachandpur	0.650		
9.	Thoubal	1.182	5.558 ^{**}	< 0.01
10.	Senapati	0.738		
11.	Thoubal	1.182	6.147 ^{**}	< 0.01
12.	Churachandpur	0.650		

^{**} significant at 1% level of probability, ^{*} significant at 5% level of probability

From Table 4.1.8.2 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% level of significance except 'Thoubal district vs Imphal East district' and Churachandpur district vs Imphal East district' were found non significant (p-value >0.05).

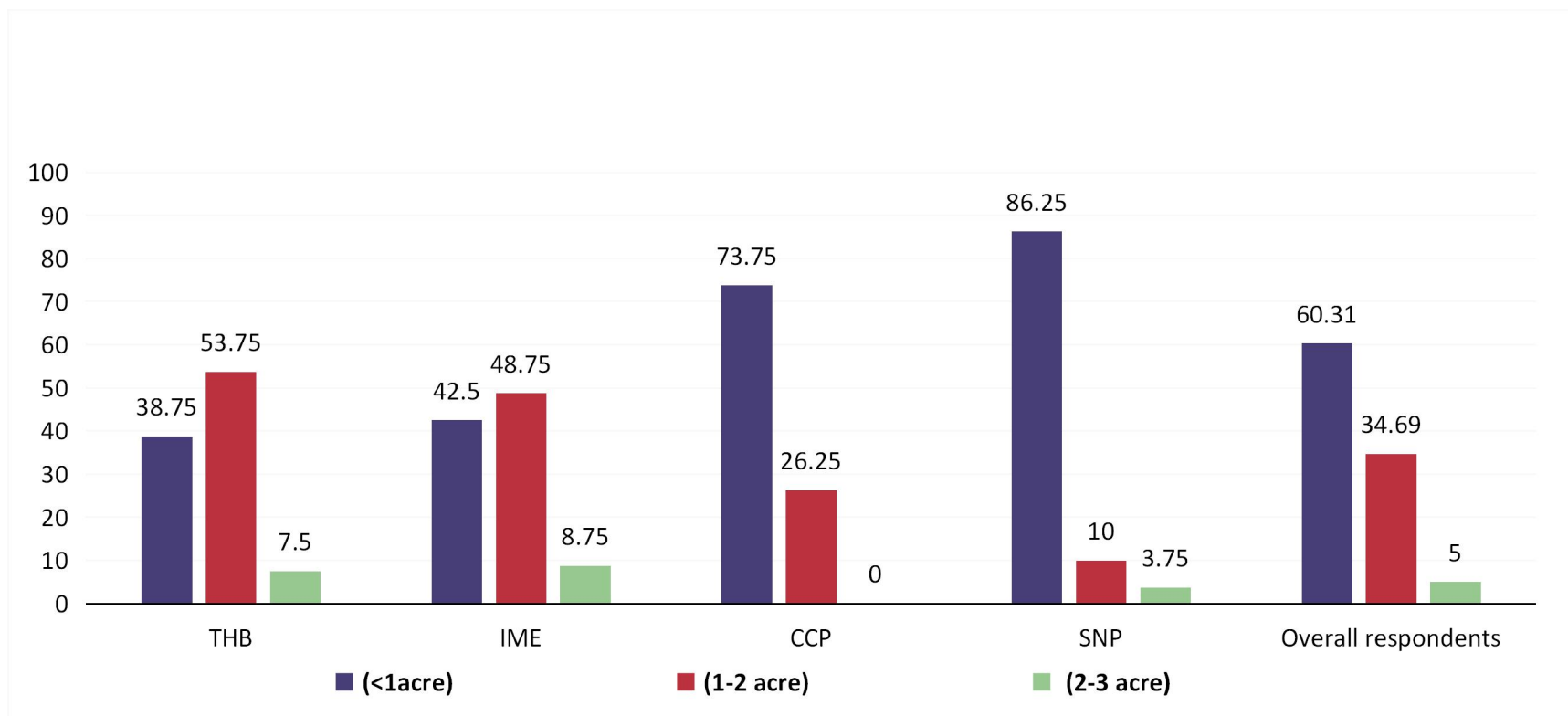


Fig 4.1.8.1: Distribution of respondents based on the area under rice-based farming system

4.1.9 Annual Income

Income level of the farmers may be directly or indirectly be associated with sustainable farming practices. So, the information regarding annual income of the respondent was collected, tabulated and analysed. The results are given in Table 4.1.9.1 and Fig 4.1.9.1

Table 4.1.9.1: Distribution of respondents based on the annual income

Districts	THB n ₁ =80		IME n ₂ =80		SNP n ₃ =80		CCP n ₄ =80		Overall respondents n=320	
Size of area	Average income	f (%)	Average income	f (%)	Average Income	f (%)	Average income	f (%)	Average income	f (%)
(Less than 1 acre)	68806.47	31 (38.75)	62558.49	34 (42.50)	38748.64	69 (86.25)	51346.38	59 (73.75)	40269.59	193 (60.31)
(1-2 acre)	120871.90	43 (53.75)	108545.9	39 (48.75)	51557.89	8 (10.00)	81492.46	21 (26.25)	80543.12	111 (34.69)
(2-3 acre)	172460	6 (7.50)	166236.2	7 (8.75)	105625	3 (3.75)	0.00	0.00	128444.50	16 (5.00)
Mean	119005.2		89423.59		46242.46		58626.67		73288.97	
SD	64915.52		109540.4		34136.15		19759.94		39718.56	

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

Table 4.1.9.1 and Fig 4.1.9.1 presented the annual income of the rice-based cultivation farmers of four district of Manipur. Table 4.1.9.1 revealed that majority of the (86.25%) farmers from Senapati district had income of Rs. 38748.64 under the cultivated area (less than 1 acre) followed by 53.75 per cent farmers from Thoubal district had income of Rs. 120871.90 under the cultivated area (1-2 acre) and 8.75 per cent farmers from Imphal East district had income of Rs. 166236.20 under the cultivated area (2-3 acre). Overall, majority (60.31%) of the farmers had income of Rs. 40269.59 under the cultivated area (less than 1 acre) followed by 34.69 per cent farmers had income of Rs. 80543.12 under the cultivated area (1-2 acre) and 5.00 per cent farmers had income of Rs. 128444.50 under the cultivated area (2-3 acre).

Average income of the overall respondents of four districts was Rs. 73288.97. From the result it can be inferred that the average income of the farmers cultivated rice-based farming system was Rs. 73288.97. Thus, the income of the farmers can be improved more by reducing cultivation risk through proper farm resources management and inputs utilization with the adoption of improved methods.

Table 4.1.9.2: Comparative account of annual income

S/N	Districts	Total Land Holding (μ)	Z Value	P value
1.	Thoubal	133057.50	1.630 ^{NS}	> 0.05
2.	Imphal East	109849.12		
3.	Churachandpur	58307.50	-0.701 ^{NS}	> 0.05
4.	Senapati	61890.87		
5.	Imphal East	109849.12	10.757**	< 0.01
6.	Senapati	61890.87		
7.	Imphal East	109849.12	9.470 ^{NS}	> 0.05
8.	Churachandpur	58307.50		
9.	Thoubal	133057.50	9.385**	< 0.01
10.	Senapati	61890.80		
11.	Thoubal	133057.50	9.115**	< 0.01
12.	Churachandpur	58626.67		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.9.2 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% level of significance except 'Churachandpur district vs Senapati district' and 'Thoubal district vs Senapati district' (p-value >0.05).

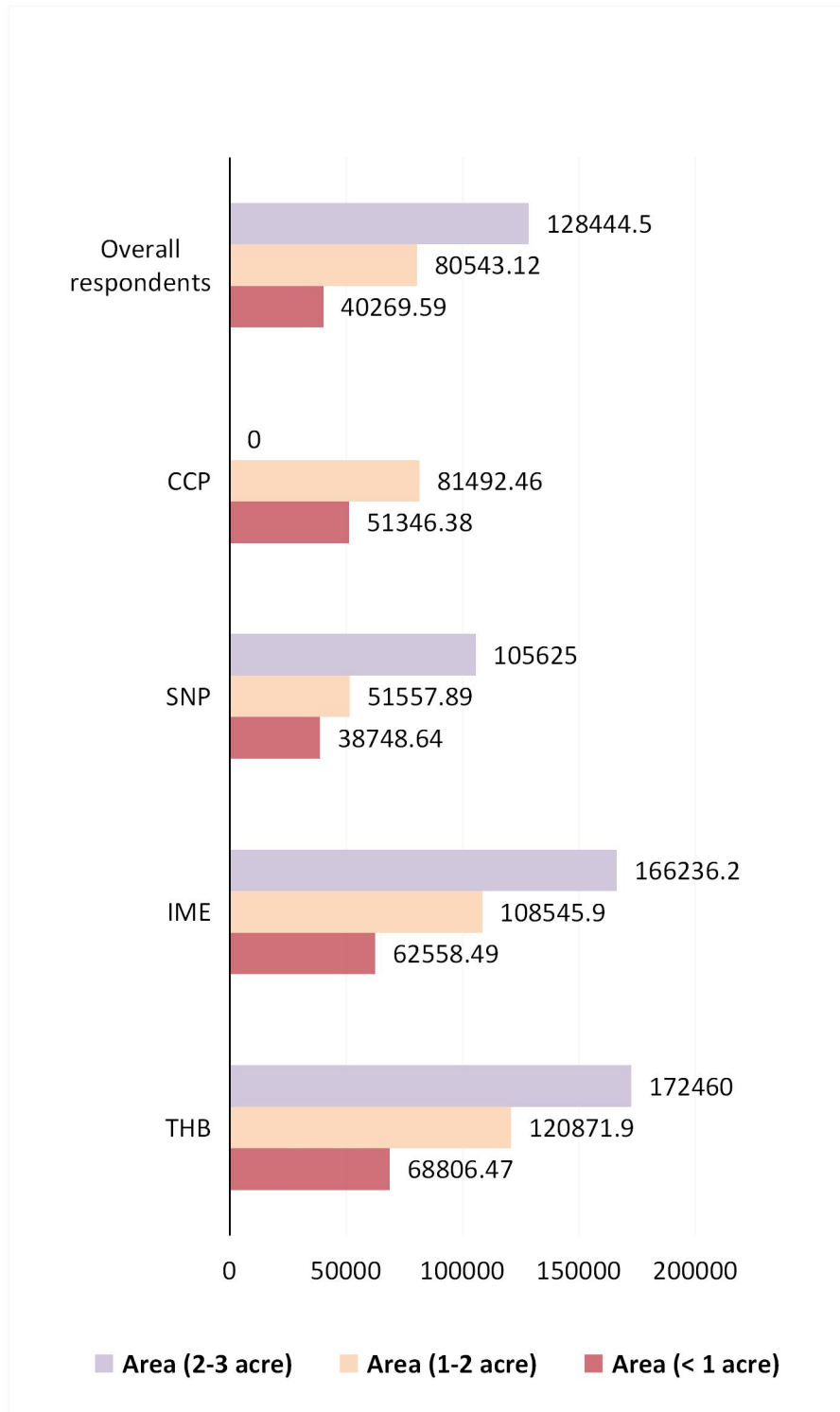


Fig 4.1.9.1: Distribution of respondents based on annual income

4.1.10 Income from rice-based farming system

Table 4.1.10.1: Distribution of respondents based on income from rice-based farming system

Districts	THB n ₁ =80		IME n ₂ =80		SNP n ₃ =80		CCP n ₄ =80		Overall respondents n=320	
Size of area	Average income	f (%)	Average Income	f (%)	Average income	f (%)	Average income	f (%)	Average Income	f (%)
(<1 acre)	56784.21	19 (23.75)	58392.73	23 (28.75)	41407.3	51 (63.75)	38791.96	56 (70.00)	48844.05	135 (42.19)
(1-2 acres)	90241.67	35 (43.75)	97953.81	37 (46.25)	62969.44	21 (33.7)	54500.00	16 (20.00)	76416.23	117 (36.56)
(2-3 acres)	140615.8	20 (25.00)	145085.7	20 (25.00)	91416.67	12 (15.00)	84125.00	8 (10.00)	115310.80	55 (15.28)
(>3 acres)	257466.7	6 (7.50)	262960.0	6 (7.50)	153500.0	4 (5.00)	0.00	0.00	168481.66	13 (4.06)
Mean	136277.18		141098.06		87323.36		44354.24		102263.19	
SD	72144.64		87407.33		38410.95		33757.00		22688.62	

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.10.1 and Fig 4.1.10.1 it was evident that majority of the (70.00%) farmers from Churachandpur district had income of Rs. 38791.96 under the land area (<1 acre) followed by 46.25 per cent farmers from Imphal East district had income of Rs. 97953.81 under the land area (1-2 acre), 25.00 per cent farmers Imphal East district had income of Rs. 145085.70 and 25.00 per cent farmers from Thoubal district had income of Rs. 140615.80 under the land area (2-3 acre) and 7.50 per cent farmers from Imphal East district had income of Rs. 262960.00 and 7.50 per cent farmers from Thoubal district had income of Rs. 257466.70 under the land area (>3 acres). Overall, majority (42.19%) of the farmers had income of Rs. 48844.05 under the land area (<1 acre) followed by 36.56 per cent farmers had income of Rs. 76416.23 under the land area (1-2 acre), 15.28 per cent farmers had income of Rs. 115310.80 under the land area (2-3 acre) and 4.06 per cent farmers had income of Rs. 168481.66 under the land area (>3 acres). The average income of all farmers under rice-based farming system was Rs. 102263.19. The result indicate that the financial stability of the farmers is improved in rice-based farming system as compare with conventional monoculture farming system. It may be due to crop diversification reduce the risk of income loss, implementation of sustainable farming reduces inputs cost like pesticides, chemicals fertilizers thereby increase farmers income. The findings of the study were found similar with the findings of the Digambar *et al.* (2020).

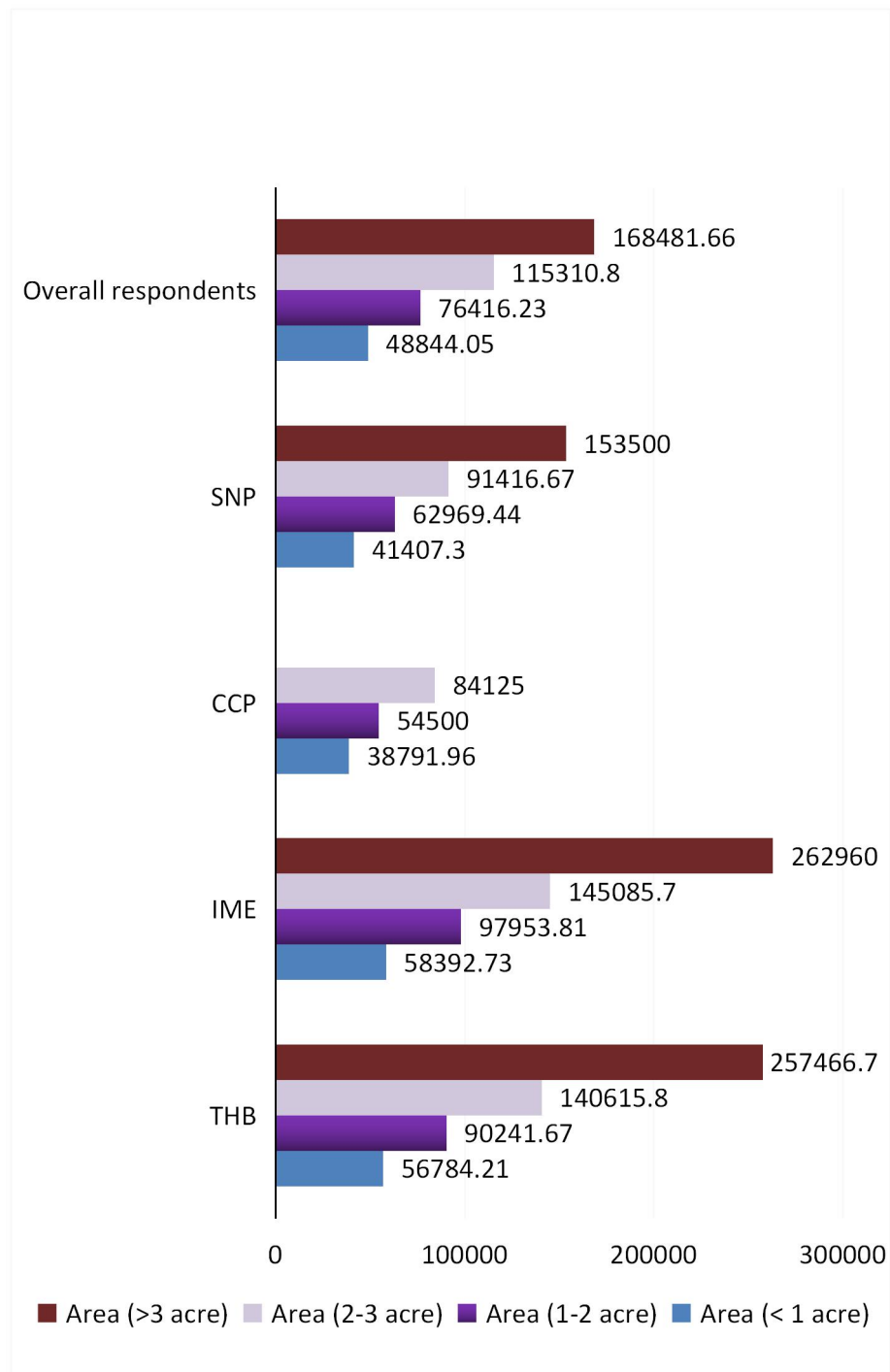


Fig 4.1.10.1: Distribution of respondents based on income from rice-based farming system

4.1.11 Training exposure

Training is an effective instrument to equip the extension workers in acquiring communication skills. One of the effective means of transforming agricultural potentials into reality is implementation of training through efficient agricultural extension system (Aremu *et al.*, 2019). The results is presented in Table 4.1.11.1 and Fig 4.1.11.1.

Table 4.1.11.1: Distribution of respondents based on training exposure

S/N	Training exposure	THB n ₁ =80		IME n ₂ =80		SNP n ₃ =80		CCP n ₄ =80		Overall respondents n=320	
1.	No. of days of training attended by farmers	f	%	f	%	f	%	f	%	f	%
2.	Training attended (Upto 1- 3 days)	5	6.25	7	8.75	13	16.25	20	25.00	45	14.06
3.	Training attended (3 to 5 days)	4	5.00	9	11.25	1	1.25	5	6.25	19	5.94
4.	Training attended (Above 5 days)	2	2.50	4	5.00	0	0.00	2	2.50	9	2.81
5.	Training never attended by farmers	69	87.50	62	77.50	66	82.50	43	53.75	247	77.19

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

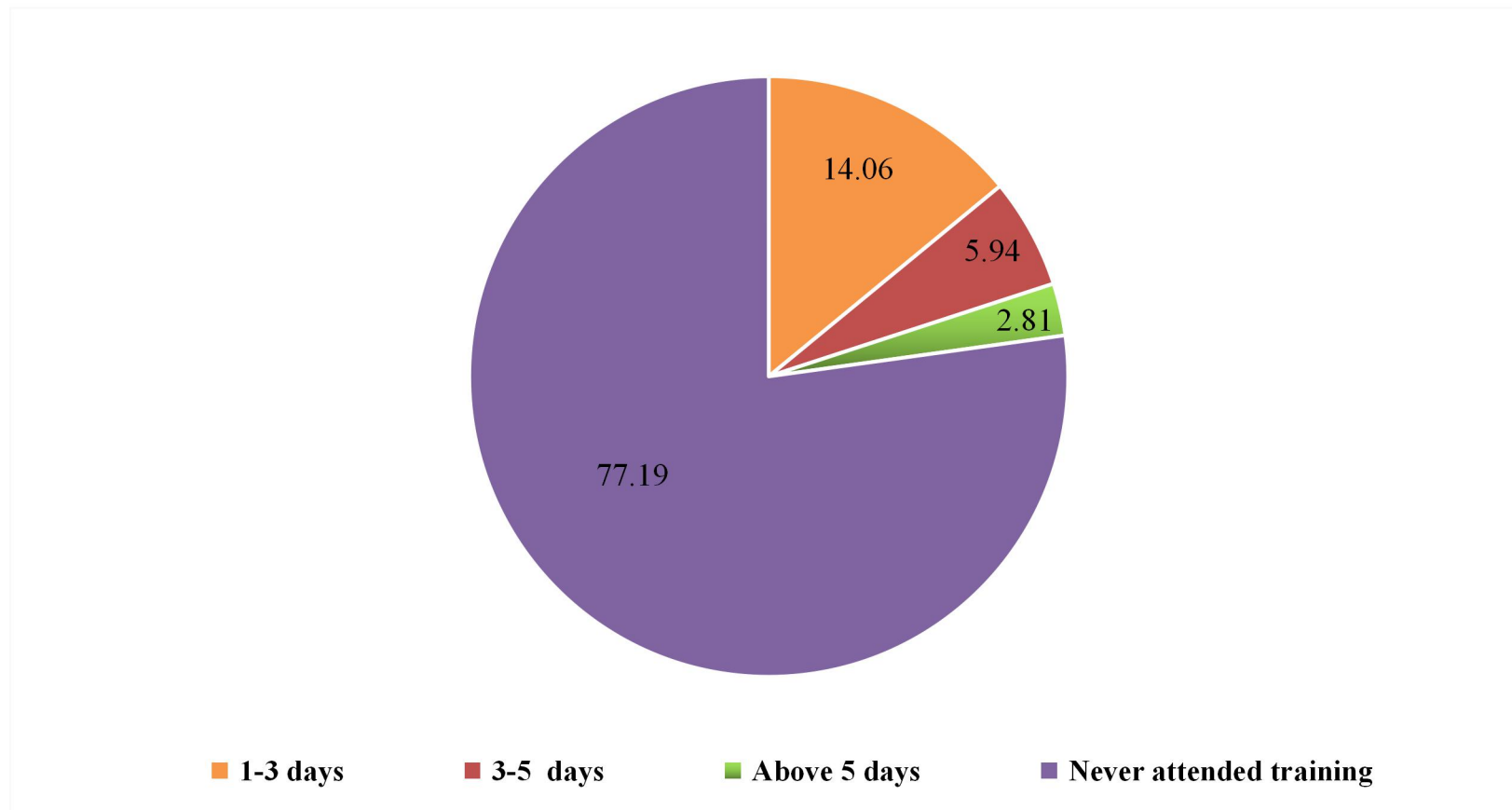


Fig 4.1.11.1: Distribution of overall respondents based on the training exposure

Table 4.1.11.1 and Fig 4.1.11.1 revealed that majority 87.50 per cent of the farmers from Thoubal district had never attended training followed by 25.00 per cent farmers from Churachandpur district attended training (Upto 1-3 days), 11.25 per cent farmers from Imphal East district had attended training (3 to 5 days) and 5.00 per cent farmers attended training (Above 5 days). In overall respondents' majority 77.19 per cent farmers had never attended training followed by 14.06 per cent farmers attended training (Upto 1- 3 days), 5.94 per cent farmers attended training for (3 to 5 days) and 2.81 per cent farmers attended training (Above 5 days). From the results it can be inferred that more than 70% farmers had not had not received any training course. The probable reason of the above findings may be due to lack of personal incentives to attend training, according to Dev *et al.*, (2017) farmers were not willing to attend long session training without monetary support and another reason could be lack of adequate training resources and funding supports. This finding was found similar with the findings of the Gebaska *et al.* (2020); Mgendi *et al.* (2021) and Tran *et al.* (2022).

4.1.12 Training need

Training need is the differences between what is and what ought to be (Leagan, 1971). This implies a gap between the two conditions i.e what the farmer knows and what he is expected to know. The results have been presented in Table 4.1.12.1 and Fig 4.1.12.1.

Table 4.1.12.1: Distribution of respondents based on the training needs

S/N	Districts	THB n ₁ =80	IME n ₂ =80	SNP n ₃ =80	CCP n ₄ =80	Overall respondents n=320	Mean	Rank
	Dimensions of training need	f (%)	f (%)	f (%)	f (%)	f (%)		
1.	TINM-Farmers require training about INM	53 (66.25)	48 (60.00)	66 (82.50)	45 (56.25)	212 (66.25)	0.66	III
2.	TIPM-Farmers require training about IPM	62 (77.50)	55 (68.75)	52 (65.00)	70 (87.50)	239 (74.69)	0.74	I
3.	TWM-Farmers require training about water management	37 (46.25)	29 (36.25)	46 (57.50)	58 (72.50)	170 (53.12)	0.53	VI
4.	TIT-Farmers require training about improved technology	44 (55.00)	49 (61.25)	55 (68.75)	52 (65.00)	200 (62.50)	0.62	IV
5.	TRBF-Farmers require training about rice based farming	60 (75.00)	54 (67.50)	43 (53.75)	64 (80.00)	221 (69.06)	0.69	II
6.	TNP-Farmers require training about nursery production	37 (46.25)	31 (38.75)	51 (63.75)	67 (83.75)	186 (58.12)	0.58	V

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

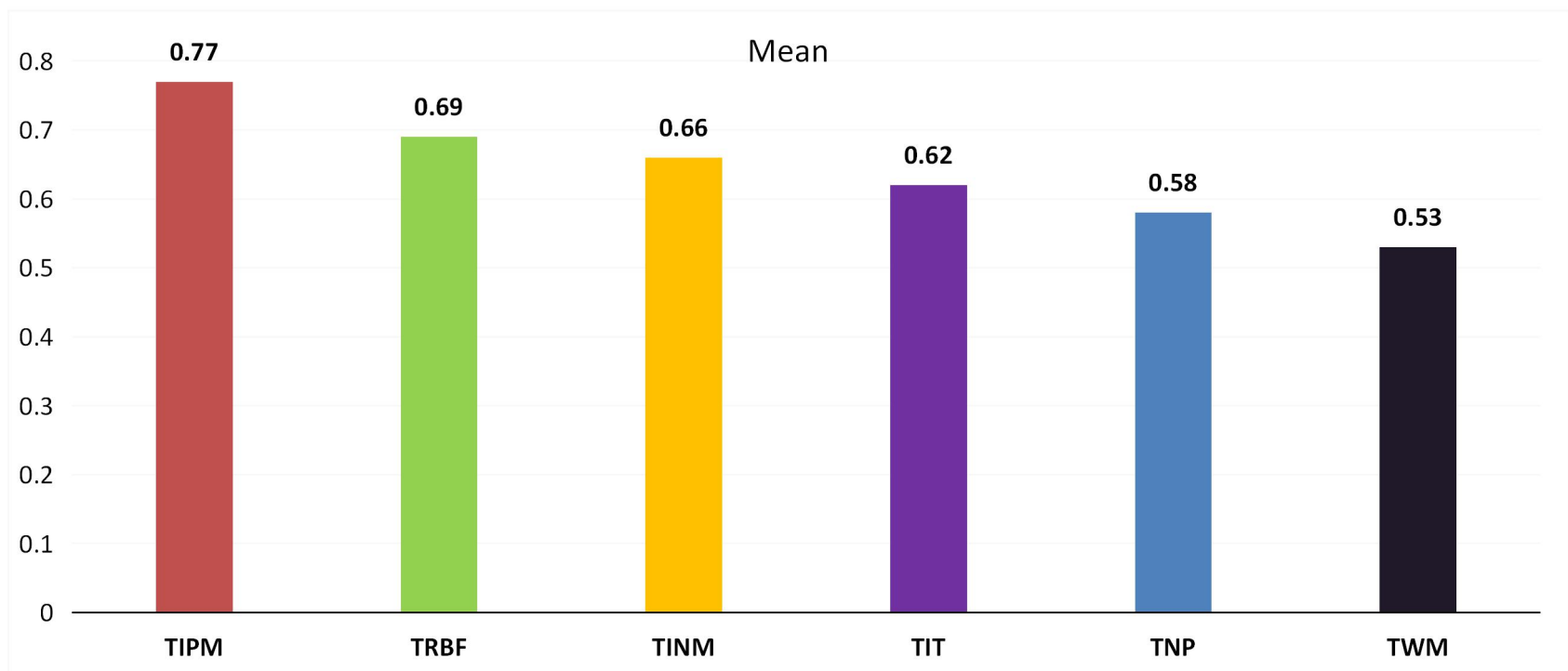


Fig 4.1.12.1: Distribution of mean based on the training needs

From Table 4.1.12.1 and Fig 4.1.12.1 it was revealed majority (87.50%) farmers from Churachandpur district required training on TIPM followed by 82.50 per cent farmers from Senapati district who required training on TINM, 77.50 per cent farmers from Thoubal district and 68.75 per cent farmers from Imphal East district required training about TIPM. Overall, majority (74.69%) of the farmers require training on TIPM having rank I with 0.74 mean followed by 69.06 per cent farmers required training on TRBF having rank II with mean score of 0.69, 66.25 per cent farmers require training on TINM having rank III with mean score of 0.66, 62.50 per cent farmers required training on TIT having rank IV with mean score of 0.62, 58.12 per cent farmers required training on TNP having rank V with mean score of 0.58 and 53.12 per cent farmers required training on TWM having rank VI with mean score of 0.53.

From the findings it can be inferred that the most important training need areas included IPM and training on rice-based farming system. It indicates that most of the farmers were engaged in rice-based farming system and farmers needed training on insect and pest management to minimize crop damage.

4.1.13. Extension contacts

Extension is an activity that works with farmers and farm families in order to improve the economic and social conditions by developing their ability to take responsibility for their own future development. Extension officers act as a channel for transfer of technology from lab to land. And the inability of farmers to benefit from extension programmes usually lead to information gap which invariably results in poor performance of farmers and attendant unimpressive farm output. Therefore, extension contact was considered as an important variable to study the level of

extension contact by the respondents. The results have been presented in Table 4.1.13.1 and Fig 4.1.13.1.

Table 4.1.13.1: Distribution of respondents based on the level of extension contact

S/N.	Districts	Level	f	%	Mean	SD
1.	THB n₁=80	Low (<0.52)	12	15.00	2.14	1.61
		Medium (0.52-3.61)	48	60.00		
		High (>3.61)	20	25.00		
2.	IME n₂=80	Low (<0.68)	9	11.25	2.16	1.47
		Medium (0.68-3.62)	47	58.75		
		High (>3.62)	24	30.00		
3.	CCP n₃=80	Low (<0.04)	26	32.50	1.60	1.56
		Medium (0.04-3.16)	45	56.25		
		High (>3.16)	9	11.25		
4.	SNP n₄=80	Low (<0.62)	8	10.00	1.73	1.10
		Medium (0.62-2.83)	55	68.75		
		High (>2.83)	17	21.25		
5.	Overall n=320	Low (<0.47)	55	17.19	1.91	1.44
		Medium (0.47-3.34)	195	60.94		
		High (>3.34)	70	21.87		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

Table 4.1.13.1 and Fig 4.1.13.1 revealed that majority (68.75%) of the farmers of Senapati district had medium level of extension contact followed by 21.25 per cent high level of extension contact and 10.00 per cent of low level of extension contact. In Thoubal district, majority (60.00%) farmers had medium level of extension contact followed by 25.00 per cent farmers had high level of extension contact and 15.00 per cent of low level of extension contact. In Imphal East district, majority (58.75%) farmers had medium level of extension contact followed by 30.00 per cent farmers had high level of extension contact and 11.25 per cent of low level of extension contact. In Churachandpur district, majority (56.25%) farmers had medium level of extension contact followed by 11.25 per cent had high level of

extension contact and 32.50 per cent had low level of extension contact. In the overall respondent's performance of extension contact, majority (60.94%) farmers had medium level of extension contact followed by 21.87 per cent had high level of extension contact and 17.19 per cent of low level of extension contact. And the average mean of the overall extension contact was 1.91. It can be infer that majority farmers had medium level of extension contact followed by high and low level of extension contact.

Regular contact with extension workers may help to assist farmers in making decisions, sharing knowledge and information enable them to take action by using own resources of farmers. The information may be about prices and markets, about the availability of credit and inputs. Providing training on extension experts about the scientific studies on sustainable farming are required in order to give strong emphasis on sustainable farming which could motivate farmers for further contact with experts thereby increase farmers skills on sustainable farming practices, and add to their knowledge. Therefore, more scientific studies on sustainable farming are required to obtain research-based facts in this field is recommended. These findings were found supported with the findings of Jamanal *et al.* (2020) and Kumar *et al.* (2021).

Table1 4.1.13.2: Comparative account on the level of extension

S/N	Districts	Total information source utilization (μ)	Z Value	P value
1.	Thoubal	2.14	-0.102 ^{NS}	> 0.05
2.	Imphal East	2.16		
3.	Churachandpur	1.60	-0.697 ^{NS}	> 0.05
4.	Senapati	1.73		
5.	Imphal East	2.16	-2.132*	< 0.05
6.	Senapati	1.73		
7.	Imphal East	2.16	-0.584 ^{NS}	> 0.05
8.	Churachandpur	1.60		
9.	Thoubal	2.14	2.139*	< 0.05
10.	Senapati	1.73		
11.	Thoubal	2.14	1.890 ^{NS}	> 0.05
12.	Churachandpur	1.60		

** significant at 1% level of probability, * significant at 5% level of probability

From Table1 4.1.13.2 it was evident that selected districts were found non-significant (p-value>0.05) except ‘Imphal East district vs Senapati district’ and ‘Thoubal district and Senapati district’ found significant level at 1% level of significance.

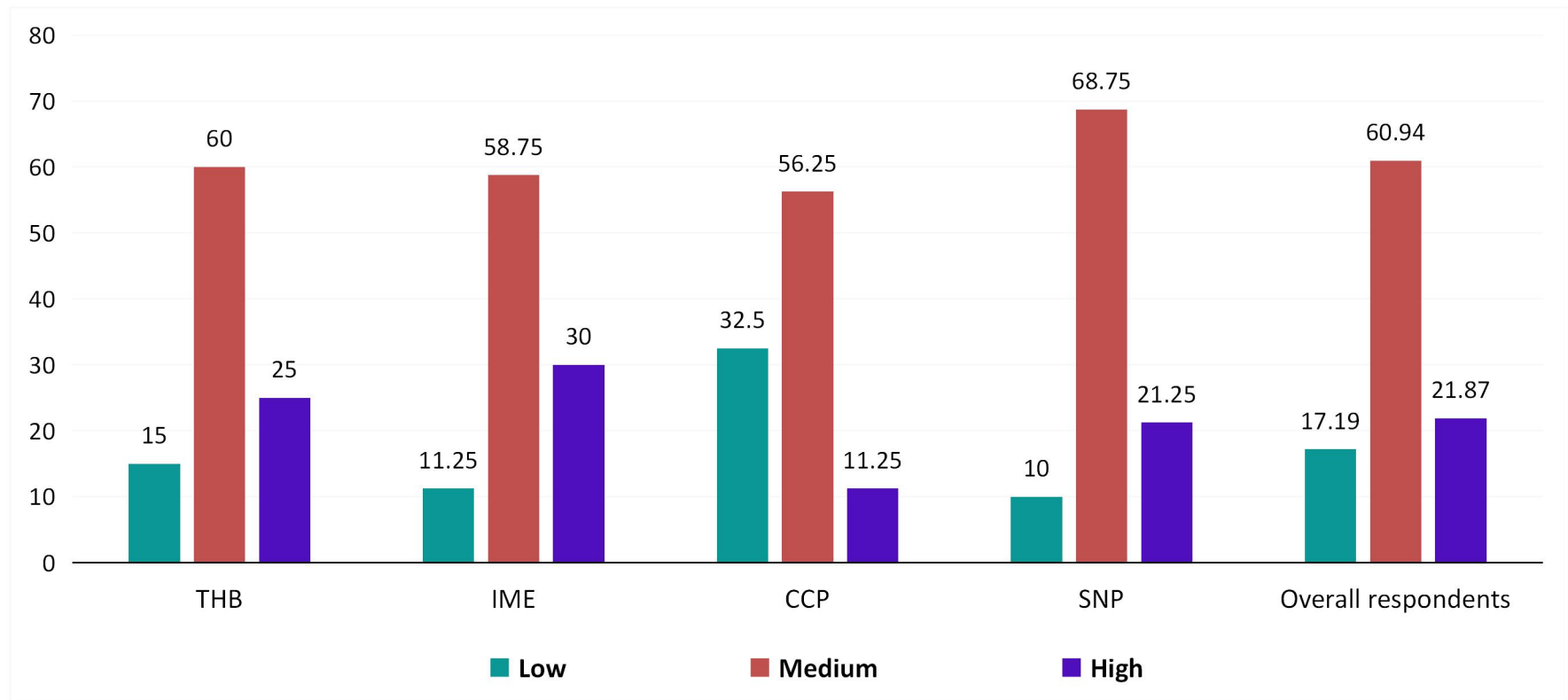


Fig 4.1.13.1: Distribution of respondents based on the level of extension contact

4.1.14.1 Formal information sources

Table 4.1.14.1.1: Distribution of respondents based on formal information sources

S/N	Types of formal information sources	THB district (n ₁ =80)						Mean	SD	IME district (n ₂ =80)						Mean	SD
		Frequency of use								Frequency of use							
		MS		S		N				MS		S		N			
		f	%	f	%	f	%			f	%	f	%	f	%		
1.	VEW	0	0.00	12	15.00	68	85.00	0.73	1.21	0	0.00	7	8.75	73	91.25	0.78	1.20
2.	AO/SDO/ SO	2	2.50	9	11.25	69	86.25			4	5.00	10	12.50	66	82.50		
3.	NGOS	3	3.75	10	12.50	67	83.75			2	2.50	8	10.00	70	87.50		
4.	KVK (SMS)	5	6.25	8	10.00	65	81.25			2	2.50	14	17.50	64	80.00		
5.	ICAR/AU	0	0.00	0	0.00	80	100			0	0.00	4	5.00	76	95.00		
S/N	Types of formal information sources	CCP district (n ₃ =80)						Mean	SD	SNP district (n ₄ =80)						Mean	SD
		MS		S		N				MS		S		N			
		f	%	f	%	f	%			f	%	f	%	f	%		
		1.	VEW	0	0.00	9	11.25			71	88.75	0	0.00	7	8.75		
2.	AO/SDO/ SO	3	3.75	6	7.50	71	88.75	4	5.00	4	5.00	72	90.00				
3.	NGOS	2	2.50	2	2.50	76	95.00	2	2.50	8	10.00	70	87.50				
4.	KVK (SMS)	3	3.75	11	13.75	66	82.50	5	6.25	9	11.25	66	82.50				
5.	ICAR/AU	0	0.00	0	0.00	80	100	0	0.00	2	2.50	78	97.50				

THB: Thoubal district; **IME:** Imphal East district; **SNP:**Senapati district; **CCP:** Churachandpur district; f: Frequency and %: Percentage

Table 4.1.14.1.1 presented the information pattern utilized by rice-based cultivation farmers and in the formal information pattern utilized it was revealed that majority (100%) farmers were 'never' utilized ICAR/AU formal information followed by 15.00 per cent were 'sometimes' used VEW and 6.25 per cent were 'most often' used KVK (SMS) information in Thoubal district. In the formal information pattern utilized by the rice-based cultivation farmers of Imphal East district, it was revealed that majority (95.00%) were 'never' utilized ICAR/AU formal information followed by 17.50 per cent were 'sometimes' used KVK (SMS) and 5.00 per cent were 'most often' used AO/SDO/SO formal information. In the formal information pattern utilized in Churachandpur district it was revealed that majority (100%) were 'never' utilized ICAR/AU formal information followed by 13.75 per cent were 'sometimes' used KVK(SMS) and 3.75 per cent were 'most often' used of AO/SDO/SO and 3.70 per cent were 'most often' used of KVK(SMS) information. In Senapati district it was further revealed that majority (97.50%) were 'never' utilized ICAR/AU formal information sources followed by 11.25 per cent 'sometimes' used KVK (SMS) and 6.25 per cent were 'most often' used KVK (SMS) information in Senapati district.

From Table 4.1.14.1.1 it was also revealed the mean score of four district in the utilization pattern of formal information sources that Imphal East district received that highest mean value with 0.78 followed by Thoubal district with mean value 0.73, Senapati district with mean value 0.63 and Churachandpur district with mean value 0.54. According to the findings, Imphal East district had greater interaction with formal information sources than other districts.

Table 4.1.14.1.2: Distribution of respondents based on overall utilization of formal information sources

S/N	Types of formal information sources	Overall						Mean	SD
		Frequency of use							
		Most often		Sometimes		Never			
		f	%	f	%	f	%		
1.	VEW	0	0.00	35	10.94	285	89.06	1.52	2.02
2.	AO/SDO/ SO	13	4.06	29	9.06	278	86.88		
3.	NGOS	9	2.81	28	8.75	283	88.44		
4.	KVK (SMS)	15	4.69	42	13.13	261	81.56		
5.	ICAR/AU	0	0.00	6	1.88	285	89.06		

f: Frequency and **%:** Percentage

Table 4.1.14.1.2 presented the overall utilization of formal information source and it was revealed that majority (89.06%) were ‘never’ utilized the formal information VEW and ICAR/AU followed by 13.13 per cent ‘sometimes’ utilized KVK (SMS) and 4.69 per cent were ‘most often’ utilized KVK (SMS). It can be inferred that the rice-based cultivation farmers used formal information sources not so often and the highest information gap was observed in the utilization of VEW and ICAR/AU. The overall mean value utilization of formal information sources was 1.52. The above findings may be due to the fact that either respondents were not aware about the importance of getting required information from the formal sectors or experts were unable to contact each farmer because of lack of manpower resources. According to Thangjam and Jha, (2020) also reported that higher information gap in formal information sources may be due to weak institutional farmers’ linkage as a part of required policy, infrastructural support system or lack of technical support due to challenges faced on account of required human resources.

4.1.14.2 Informal sources of information

Table 4.1.14.2.1: Distribution of respondents based on the utilization of informal information sources

Districts	Types of informal information	Frequency of use						Mean	SD
		Most often		Sometimes		Never			
		f	%	f	%	f	%		
THB n ₁ =80	Friends	33	41.25	35	47.50	12	15.00	3.67	1.34
	Relative	18	22.50	30	37.50	32	40.00		
	Neighbours	25	31.25	40	56.25	15	18.75		
	Progressive farmers	6	7.50	16	18.75	58	72.50		
IME n ₂ =80	Friends	19	23.75	52	65.00	9	11.25	3.24	1.67
	Relative	15	18.75	29	36.25	36	45.00		
	Neighbours	12	15.00	38	47.50	30	37.50		
	Progressive farmers	11	20.00	20	31.25	49	61.25		
CCP n ₃ =80	Friends	20	26.25	55	68.75	5	6.25	3.91	1.08
	Relative	22	27.50	48	60.00	10	12.50		
	Neighbours	24	28.75	40	61.25	16	20.00		
	Progressive farmers	4	6.25	14	25.00	62	77.50		
SNP n ₄ =80	Friends	27	33.75	46	60.00	7	8.75	3.69	1.34
	Relative	21	26.25	37	46.25	22	27.50		
	Neighbours	20	25.00	49	61.25	11	13.75		
	Progressive farmers	6	10.00	17	21.25	57	71.25		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; f: Frequency and %: Percentage

Table 4.1.14.2.1 presented the informal information pattern utilized by rice-based cultivation farmers and the informal information pattern utilized by rice-based cultivation farmers of Thoubal district was revealed that majority (72.50%) were 'never' utilized the informal information source progressive farmers followed by 56.25 per cent 'sometimes' utilized the informal information source 'neighbour and 41.25 per cent 'most often' utilized the informal information source 'friends'. In Imphal East district, it was revealed that majority (65.00%) were 'sometimes' utilized the informal information source 'friends' followed by 61.25 per cent 'never' utilized the informal information source 'progressive farmers' and 23.75 per cent 'most often' utilized the informal information source 'friends. In Churachandpur district, majority (77.50%) of Charuchandpur district farmers 'never' utilized "Progressive farmers," followed by 68.75 per cent 'sometimes' utilized the informal information source 'friends' and 28.75 per cent 'most often' utilized the informal information source 'neighbour. In Senapati district, majority (71.25%) were 'never' utilizing the informal information source 'progressive farmers' followed by 60.00 per cent 'sometimes' utilized and 33.75 per cent 'most often' utilized the informal information source 'friends. From the above result it was found that the least contacted informal information sources were progressive farmers.

The results presented in Table 4.1.12.1 and Fig 4.1.12.1 further revealed that Churachandpur district had the highest mean value 3.91 followed by Senapati district with mean value 3.69, Thoubal district with mean value 3.67 and Imphal East with 3.24 mean. According to the findings, Imphal East district had least mean 3.24 it may due to the less interaction with the informal information sources as compare with

other districts however Churachandpur district had the highest mean 3.91 it may due to the greater interaction with informal information sources.

Table 4.1.14.2.2: Distribution of respondents based on the overall utilization of informal information sources

S/N	Types of informal information	Frequency of use (n=320)						Mean	SD
		Most often		Sometimes		Never			
		f	%	f	%	f	%		
1.	Friends	97	30.31	193	60.31	30	9.38	3.62	1.42
2.	Relative	76	23.75	144	45.00	100	31.25		
3.	Neighbours	83	25.94	181	56.56	59	18.44		
4.	Progressive farmers	35	10.94	82	25.63	213	66.56		

f: Frequency and **%:** Percentage

From Table 4.1.14.2.2 it was evident that the majority (66.56%) ‘never’ utilized the informal information source ‘progressive farmers’, followed by 60.31 percent ‘sometimes’ utilized the informal information sources ‘friends’ and 30.31 percent ‘most often’ utilized the informal information source ‘friends. The mean of overall utilization of informal information sources was 3.62. The result indicate that respondents were least contacted by the progressive farmers as compare with the other information sources like friend, relatives and neighbour. The probable reason of the above findings may be either due to poor communications skills of progressive farmers or they were not active in encouraging young farmers to adopt improved technology.

4.1.14.3 Mass media information sources

Table 4.1.14.3.1: Distribution of respondents based on the utilization of mass media information sources

Districts	Types of mass media information	Frequency of use						Mean	SD
		Most often		Sometimes		Never			
		f	%	f	%	f	%		
THB n ₁ =80	SMS based services	12	15.00	20	25.00	48	60.00	3.69	1.55
	Smart phones	15	18.75	25	31.25	40	50.00		
	Radio	17	21.25	23	28.75	40	50.00		
	TV	18	22.50	35	43.75	27	33.75		
	Leaflet/folder	4	5.00	13	16.25	63	78.75		
	Newspaper	9	11.25	20	25.00	51	63.75		
	Exhibition	2	2.50	4	5.00	74	92.50		
IME n ₂ =80	SMS based services	16	20.00	24	30.00	40	50.00	3.91	1.92
	Smart phones	11	13.75	31	38.75	38	47.50		
	Radio	9	11.25	26	32.50	45	56.25		
	TV	20	25.00	38	47.50	22	27.50		
	Leaflet/folder	2	2.50	16	20.00	62	77.50		
	Newspaper	19	23.75	25	31.25	36	45.00		
	Exhibition	1	1.25	8	10.00	71	88.75		
SNP n ₃ =80	SMS based services	5	6.25	14	17.50	61	76.25	3.59	2.00
	Smart phones	13	16.25	32	40.00	35	43.75		
	Radio	22	27.50	29	36.25	29	36.25		
	TV	18	22.50	26	32.50	36	45.00		
	Leaflet/folder	3	3.75	15	18.75	62	77.50		
	Newspaper	10	12.50	17	21.25	53	66.25		
	Exhibitions	2	2.5	10	12.5	68	85.00		
CCP n ₄ =80	SMS based services	9	11.25	16	20.00	55	68.75	3.19	1.74
	Smart phones	17	21.25	28	35.00	35	43.75		
	Radio	24	30.00	30	37.50	26	32.50		
	TV	16	20.00	26	32.50	38	47.50		
	Leaflet/folder	2	2.50	9	11.25	69	86.25		
	Newspaper	12	15.00	20	25.00	48	60.00		
	Exhibition	0	0.00	3	3.75	77	96.25		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:**

Churachandpur district; f: Frequency and %: Percentage

Table 4.1.14.3.1 revealed that majority (92.50%) of the rice-based farmers in Thoubal district ‘never’ utilized ‘exhibition’ as mass media information sources followed by 43.75 per cent ‘sometimes’ utilized ‘TV’ and 22.50 per cent ‘most often’ utilized ‘TV’ mass media information sources. In Imphal East district, majority (88.75%) farmers were ‘never’ utilized exhibition mass media information sources followed by 47.50 per cent ‘sometimes’ utilized ‘TV’ and 25.00 per cent ‘most often’ utilised ‘TV’ mass media information sources. In Senapati district, majority (85.00%) farmers were ‘never’ utilized ‘exhibition’ mass media information sources followed by 40.00 per cent ‘sometimes’ utilized smartphone and 27.50 per cent ‘most often’ utilized ‘radio’ mass media information sources. In Churachandpur district, majority (96.25%) farmers were ‘never’ utilized ‘exhibition’ followed by 37.50 per cent ‘sometimes’ and 30.00 per cent ‘most often’ utilized ‘radio’ were mass media information sources.

Further it was revealed that Imphal East district had the highest mean value 3.91 followed by Thoubal district with mean value 3.69, Senapati district with mean value 3.59 and Churachandpur district with mean value 3.19. According to the findings, Imphal East district had the highest 3.91 mean it may due to the higher interaction with the mass media information sources as compare with other districts however Churachandpur district had the least mean 3.19 it may due to the less interaction with mass media information sources.

Table 4.1.14.3.2: Distribution of respondents based on the overall utilization of mass-media information sources

S/N	Types of mass media information	Frequency of use (n=320)						Mean	SD
		Most often		Sometimes		Never			
		f	%	f	%	f	%		
1.	SMS based services	42	13.13	74	23.13	204	63.75	3.59	1.82
2.	Smart phones	56	17.50	116	36.25	148	46.25		
3.	Radio	72	22.50	108	33.75	140	43.75		
4.	TV	72	22.50	125	39.06	123	38.44		
5.	Leaflet/folder	25	7.81	53	16.56	256	80.00		
6.	Newspaper	50	15.63	82	25.63	188	58.75		
7.	Exhibition	5	1.56	21	6.56	290	90.63		

f: Frequency; **%:** Percentage

From Table 4.1.14.3.2 it was revealed that majority (90.63%) farmers ‘never’ utilized ‘exhibition’ mass-media information sources followed by 39.06 per cent ‘sometimes’ utilized ‘TV’ mass-media information sources, 22.50 per cent ‘most often’ utilized ‘radio’ mass-media information sources and 22.50 per cent ‘most often’ utilized ‘TV’ mass-media information sources. The above findings indicates that the least information sources contacted by farmers were exhibitions and most often contacted information sources were TV. It is recommended that agricultural exhibition should be promoted with the aim of developing farmers to exchange their idea on the event. Exhibitions brings knowledge of various agricultural scheme, government initiatives, new age technology and success stories of the farmers that allows farmers to get informed about new technology. So mass media play a very vital role in developing the knowledge of farmers. According to Nikam *et al.*, (2022) access to information from public sources and mass media had a significant positive impact on cotton output. Mass media sources played a significant role in increasing the value of output per unit area. Most of the respondents showed more interest in radio and TV and it was envisaged as a helpful medium for them.

4.1.14.4 Social media information sources

Table 4.1.14.4.1: Distribution of respondents based on the utilization of social-media information sources

Districts	Types of social media information	Frequency of use						Mean	SD
		Most often		Sometimes		Never			
		f	%	f	%	f	%		
THB n ₁ =80	Facebook	15	18.75	24	30.00	41	51.25	1.50	1.36
	WhatsApp	11	13.75	20	25.00	49	61.25		
	Instagram	0	0.00	1	1.25	79	98.75		
	Twitter	0	0.00	0	0.00	80	100		
	YouTube	10	12.50	30	37.50	40	50.00		
IME n ₂ =80	Facebook	16	20.00	26	32.50	38	47.50	2.31	1.51
	WhatsApp	13	16.25	20	25.00	47	58.75		
	Instagram	0	0.00	2	2.50	78	97.50		
	Twitter	0	0.00	0	0.00	80	100		
	YouTube	12	15.00	26	32.50	42	52.0		
SNP n ₃ =80	Facebook	10	12.50	23	28.75	47	58.75	1.51	1.81
	WhatsApp	4	5.00	29	36.25	47	58.75		
	Instagram	0	0.00	0	0.00	80	100		
	Twitter	0	0.00	0	0.00	80	100		
	YouTube	7	8.75	18	22.50	55	68.75		
CCP n ₄ =80	Facebook	14	17.50	21	26.25	45	56.25	1.39	1.57
	WhatsApp	11	27.50	22	27.50	47	58.75		
	Instagram	0	0.00	0	0.00	80	100		
	Twitter	0	0.00	0	0.00	80	100		
	YouTube	9	22.50	19	23.75	52	65.00		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.14.4.1 it was revealed that majority (100%) farmers from Thoubal district ‘never’ utilized ‘Twitter’ information sources followed by 37.50 per cent ‘sometimes’ utilized ‘YouTube’ and 18.75 per cent ‘most often’ utilised ‘Facebook’ information sources. In Imphal East district, 100 per cent farmers were ‘never’ utilised ‘Twitter’ information sources followed by 32.50 per cent farmers ‘sometimes’ utilized ‘Facebook’ information sources and 32.50 per cent farmers ‘sometimes’ utilized ‘YouTube’ information sources and 20.00 per cent farmers

‘most often’ utilized ‘Facebook’ information sources. In Senapati district, majority (100%) farmers were never utilized ‘Twitter’ and ‘Instagram’ information sources followed by 36.25 per cent ‘sometimes’ utilized ‘Whatsapp’ information sources and 12.50 per cent ‘most often’ utilized ‘Facebook’ information sources. In Churachandpur district, majority, majority (100%) farmers were never utilized ‘Twitter’ and ‘Instagram’ information sources followed by 27.50 per cent ‘sometimes’ utilized ‘Whatsapp’ information sources and 17.50 per cent ‘most often’ utilized ‘Facebook’ information sources.

Further it was revealed that Imphal East district had the highest mean value 2.31 followed by Senapati district with mean value 1.51, Thoubal district with mean value 1.50 and Churachandpur district with mean value 1.39. According to the findings, Imphal East district had the highest 2.31 mean it may due to the higher interaction with the social media information sources as compare with other districts however Churachandpur district had the least mean 1.39 it may due to the less interaction with social media information sources.

Table 4.1.14.4.2: Distribution of respondents based on the overall utilization of social media of information sources

S/N	Types of social media information	Frequency of use (n=320)						Mean	SD
		Most often		Sometimes		Never			
		f	%	f	%	f	%		
1.	Facebook	55	17.19	94	29.38	171	53.43	1.67	1.45
2.	WhatsApp	39	12.19	91	28.43	190	59.37		
3.	Instagram	0	0.00	3	0.93	317	99.07		
4.	Twitter	0	0.00	0	0.00	320	100.00		
5.	YouTube	38	11.87	93	29.06	189	59.06		

f: Frequency and **%:** Percentage

From Table 4.1.14.4.2 it was revealed that majority (100%) farmers had ‘never’ utilized “Twitter” information sources followed 29.38 per cent ‘sometimes’ utilized “Facebook” information sources and 17.19 per cent ‘most often’ utilized

“Facebook” information sources. From the findings it can be inferred that majority farmers were utilized “Facebook” as a main source of information among the social media. According to Mishra *et al.*, (2022) it was reported that YouTube was found to be most preferred social media by farmers followed by WhatsApp and Facebook. It can be inferred that most of the farmers used social media as online chatting, entertainment, news, networking and browsing however few farmers used social media as a tool for sharing information and learning through interaction with others. Further, it can be concluded that most of the farmers were lack proper knowledge of social media use in the field of agriculture.

Table 4.1.14.5: Distribution of overall respondents based on the level of information sources utilization pattern

Districts	Level of information sources utilized	f	%	Mean	SD
THB n₁=80	Low (<4.43)	12	15.00	7.86	3.43
	Medium (4.43-11.29)	52	65.00		
	High (>11.29)	16	20.00		
IME n₂=80	Low (<5.32)	10	12.50	9.40	4.08
	Medium (5.32-13.48)	49	61.25		
	High (>13.48)	21	26.25		
CCP n₃=80	Low (<3.45)	24	30.00	6.63	3.18
	Medium (3.45-9.81)	46	57.50		
	High (>9.81)	10	12.50		
SNP n₄=80	Low (<3.37)	20	25.00	7.01	3.64
	Medium (3.37-10.65)	48	60.00		
	High (>10.65)	12	15.00		
Overall n=320	Low (<4.14)	66	20.62	7.73	3.59
	Medium (4.14-11.32)	195	60.94		
	High (>11.32)	59	18.44		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; f: Frequency and %: Percentage

From Table 4.1.14.5 it was revealed that 65.00 per cent of the respondents from Thoubal district had medium level of information sources utilization followed by 20.00 per cent of them had high level of information sources utilisation and

15.00 per cent had low level of information sources utilization respectively. In Imphal East district, majority (61.25%) of the respondents had medium level of information sources utilization followed by 26.25 per cent had high level of information sources utilisation and 12.50 per cent had low level of information sources utilization. In Churachandpur district, majority (57.50%) of them had medium level of information sources utilization followed by 30.00 per cent had low level of information sources utilisation and 12.50 per cent had high level of information sources utilization respectively. In Senapati district, majority (60.00%) of the respondents had medium level of information sources utilization followed by 25.00 per cent had low level of information sources utilisation and 18.44 per cent of them had high level of information sources utilization.

Further revealed the overall information sources utilisation, majority (60.94%) of the respondents had medium level of information sources utilization followed by 20.62 per cent had low level of information sources and 17.19 per cent had high level of information sources utilization.

Table1 4.1.14.6: Comparative account of information sources utilized by the respondents

S/N	Districts	Total information source utilization (μ)	Z Value	P value
1.	Thoubal	7.86	-2.569*	< 0.05
2.	Imphal East	9.40		
3.	Churachandpur	6.63	-0.697 ^{NS}	> 0.05
4.	Senapati	7.01		
5.	Imphal East	9.40	3.942**	< 0.01
6.	Senapati	7.01		
7.	Imphal East	9.40	4.817**	< 0.01
8.	Churachandpur	6.63		
9.	Thoubal	7.86	1.571 ^{NS}	> 0.05
10.	Senapati	7.01		
11.	Thoubal	7.86	2.399*	< 0.05
12.	Churachandpur	6.63		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.14.6 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% level of significance except 'Churachandpur district vs Senapati district' and 'Thoubal district vs Senapati district' (p-value >0.05).

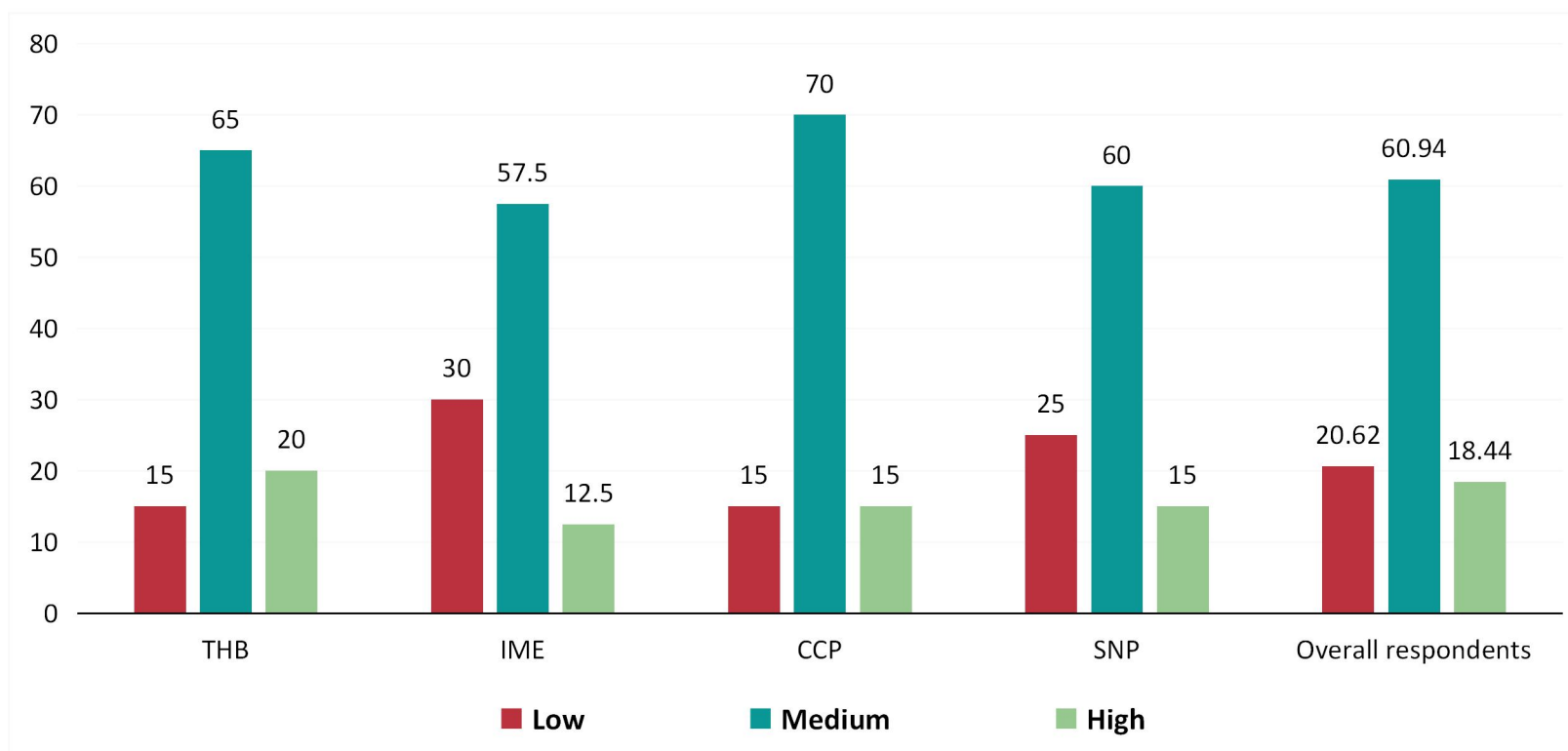


Fig 4.1.14.5: Distribution of respondents based on the overall level of information sources utilization

4.1.15 Knowledge level

Table 4.1.15.1 Distribution of respondents based on the knowledge level of sustainable agricultural practices in valley districts

Factors	Dimensions of Sustainability practice	Thoubal District (n ₁ =80)		Imphal East District (n ₂ =80)	
		Knowledge Index			
		%	Rank	%	Rank
Agronomic practice	Improved variety	56.25	V	52.50	IV
	Crop rotation	75.00	II	70.00	II
	Inter-cropping	43.75	VII	50.00	VI
Soil and water conservation	Conservation tillage	40.00	IX	37.50	XII
	Water harvesting in ponds	57.50	IV	51.25	V
	Mulching	42.50	VIII	50.00	VI
Nutrient Management	Plantation of cover crop	37.50	X	38.75	XI
	Green manure	33.75	XII	37.50	XII
	Organic fertilizer	47.50	VI	43.75	IX
Agroforestry	Agri silviculture	0.00	XVII	0.00	XVII
	Silvipostoral	0.00	XVII	0.00	XVII
Restoration and rehabilitation	Enrichment planting	18.75	XVI	12.50	XVI
	Fire Management	0.00	XVII	0.00	XVII
	Natural Regeneration	28.75	XIV	25.00	XIV
Pest control method	Physical control	40.00	IX	48.75	VII
	Biological control	23.75	XV	41.25	X
	Cultural control	30.00	XIII	15.00	XVI
Diseases control method	Physical control	43.75	VII	37.50	XII
	Biological control	36.25	XI	46.25	VIII
	Cultural control	30.00	XIII	35.00	XIII
Recycle management	Field waste	78.75	I	76.25	I
	Animal waste	36.25	XI	18.75	XV
	Plant waste	62.50	III	57.50	III

?: Percentage

From the Table 4.1.15.1 it was observed that majority (78.75%) of rice-based cultivation farmers from Thoubal district have knowledge on management of ‘field waste’ having I rank followed by 75 per cent on ‘crop rotation’ having rank II,

62.50 per cent on management of ‘plant waste’ having rank III, 57.50 per cent on ‘water harvesting in ponds’ having rank IV, 56.25 per cent on ‘improved variety’ having rank V, 47.50 per cent on ‘organic fertilizer’ having rank VI, 43.75 per cent on ‘inter-cropping’ having rank VII, 42.50 per cent on ‘mulching’ having rank VIII, 40 per cent on ‘conservation tillage’ having rank IX, 37.50 per cent on ‘cover crop plantation’ having rank X, 36.35 per cent on ‘biological control’ of diseases management having rank XI, 36.25 per cent on ‘animal waste’ management having rank XI, 33.75 per cent on ‘green manure’ having rank XII, 30.00 per cent on ‘cultural control of diseases, and ‘cultural control of pest’ having rank XIII, 28.75 per cent on ‘natural regeneration’ having rank XIV, 23.75 per cent on ‘biological control of pest’ having rank XV, 18.75 per cent on ‘enrichment planting’ and no farmers have knowledge on ‘agrisilviculture’, and ‘silvipostoral’ having rank XVII.

From Table 4.1.15.1 it was observed that majority (76.25%) of the farmers from Imphal East district have knowledge on ‘field waste’ management having rank I followed by 70.00 per cent farmers have knowledge on ‘crop rotation’ having rank II, 57.50 per cent have knowledge on ‘plant waste’ management having rank III, 52.50 per cent farmers on ‘improved variety’ having rank IV, 51.25 per cent on ‘water harvesting in ponds’ having rank V, 50.00 per cent on ‘mulching’ and 50.00 per cent on inter-cropping having rank VI, 48.25 per cent on ‘physical control’ of pest having rank VII, 46.75 per cent on ‘biological control’ of diseases having rank VIII, 43.75 per cent on ‘organic fertilizers’ having rank IX, 41.25 per cent on ‘biological control’ of pest having rank X, 38.75 per cent on ‘plantation of cover crop’ plantation having rank XI, 37.50 per cent on ‘green manure’ having rank XII,

35.00 per cent on ‘cultural control method’ on diseases management having rank XIII, 25 per cent on ‘natural regeneration’ having rank XIV, 18.75 per cent on ‘animal waste’ management having rank XV, 12.50 per cent on ‘enrichment planting’ having rank XVI and no farmers have knowledge on ‘fire management’, ‘agrisilviculture’ and ‘silvipostoral’ having rank XVII.

From the above findings it was observed that most of the farmers from Thoubal district and Imphal East district had knowledge on recycle management and agronomic practices whereas most of the farmers had least knowledge about regeneration and rehabilitation and agroforestry. Residue like rice stalk burning was practiced widely by the farmers as burning reduces soil-borne disease infestations as it destroys the inoculum present in the crop residues. However, this practice is not environmentally sustainable, leading to GHG (CO₂, CH₄, and N₂O) and particulate matter emissions that cause global warming, air pollution, and climate change (Yodkhum *et al.*, 2018; Mathur and Srivastava 2019; Kaur *et al.*, 2022) and appreciable losses of essential plant nutrients (Lohan *et al.*, 2018). Farmer used paddy straw for mulching or spreading residues on the soil surface to enhances water and nitrogen use efficiency and reduces weed growth. It also reduces loss of water vapor, regulates soil temperature, reduces soil erosion, and improves soil health, thus improving long-term crop productivity. However, farmers don’t have knowledge on restoration and rehabilitation, it is recommended that concern department should take necessary actions to make farmers aware about the role and importance of regeneration planting and diversity of plant to mitigate climate change. The diversity of plants creates biomass throughout the year, fertilizing the soil and increasing crop yields while providing fodder for livestock.

Moreover, planting trees on a farm protects crops from wind and sunlight. This could curb climate change on a major scale.

Table 4.1.15.2 Distribution of respondents based on the knowledge level of sustainable agricultural practices in hill districts

Factors	Dimensions of Sustainability practice	Senapati District (n ₃ =80)		Churachandpur District (n ₄ =80)	
		Knowledge Index			
		%	Rank	%	Rank
Agronomic practice	Improved variety	35.00	VI	30.00	VIII
	Crop rotation	62.50	I	62.50	II
	Inter-cropping	47.50	III	70.00	I
Soil and water conservation	Conservation tillage	22.50	XI	37.50	V
	Water harvesting in ponds	23.75	X	11.25	XX
	Mulching	30.00	VIII	33.75	VII
Nutrient Management	Plantation of cover crop	40.00	V	28.75	IX
	Green manure	23.75	X	20.00	XIV
	Organic fertilizer	31.25	VII	41.25	III
Agroforestry	Agri silviculture	10.00	XVI	13.75	XVI
	Silvipostoral	1.25	XVIII	0.00	XIX
Restoration and rehabilitation	Enrichment planting	7.50	XVII	12.50	XVII
	Fire Management	15.00	XIV	25.00	XI
	Natural Regeneration	30.00	VIII	26.25	X
Pest control method	Physical control	13.75	XV	21.25	XIII
	Biological control	6.25	XVII	10.00	XVIII
	Cultural control	18.75	XII	22.50	XII
Diseases control method	Physical control	28.75	IX	36.25	VI
	Biological control	6.25	XVII	12.50	XVII
	Cultural control	16.25	XIII	18.75	XV
Recycle management	Field waste	41.25	IV	37.50	V
	Animal waste	35.00	VI	30.00	VIII
	Plant waste	61.25	II	40.00	IV

From Table 4.1.15.2 it was observed that majority (62.50%) of the farmers from Senapati district have knowledge on 'crop rotation' having rank I, followed by 61.25 per cent have knowledge on 'plant waste' management having rank II, 47.50 per cent farmers have knowledge on 'inter-cropping' having rank III, 41.25 per cent farmers on 'field waste' management having rank IV, 40 per cent farmers on 'plantation of cover crop' having rank V, 35.00 per cent on 'animal waste' management having rank VI, 31.25 per cent on 'organic farming' having rank VII, 30.00 per cent on 'mulching' having rank VIII, 38.75 per cent on 'physical control' of diseases management having rank IX, 23.75 per cent on 'green manure' having rank X, 22.50 per cent on 'conservation tillage' having rank XI, 18.75 per cent on 'cultural control method' of pest having rank XII, 16.25 per cent on 'cultural control method' of diseases having rank XIII, 15.00 per cent on 'fire management' having rank XIV, 13.75 per cent on 'physical control' of pest having rank XV, 10.00 per cent on 'Agri silviculture' having rank XVI, 6.25 per cent on 'biological control' of pest and 6.25 per cent on 'biological control' of disease having rank XVII and 1.25 per cent on 'silvipostoral' having rank XVIII.

From Table 4.1.15.2it was observed that majority (70.00%) farmers of Churachandpur district have knowledge on inter-cropping having rank I, followed by 62.50 per cent have knowledge on 'crop rotation' having rank II, 41.25 per cent have knowledge on 'organic fertilizer' having rank III, 40.00 per cent on 'plant waste' management having rank IV, 37.50 per cent on 'field waste' management having rank V, 36.50 per cent on 'physical control' of diseases having rank VI, 33.75 per cent on 'mulching' having rank VII, 30.00 per cent on 'animal waste' management having rank VIII, 28.75 per cent on 'plantation of cover crop' having

rank IX, 26.25 per cent on 'nutrient regeneration' having rank X, 25.00 per cent on 'fire management' having rank XI, 22.50 per cent on 'cultural control' of pest having rank XII, 21.25 per cent on 'physical control' of pest having rank XIII, 20.00 per cent 'green manure' having rank XIV, 18.75 per cent on 'cultural disease control' having rank XV, 13.75 per cent on 'Agri silviculture' having rank XVI, 12.50 per cent on 'enrichment planting' and 12.50 per cent 'biological control disease' having rank XVII and 10.00 per cent on 'biological pest control' having rank XVIII.

From the above findings it was found that in Senapati district and Churachandpur district most of the farmers doesn't have knowledge on agroforestry, pest control method and disease control method however farmers have knowledge on agronomic practices and recycle management. Farmers from both the district farmers used crop residue for preparing vermicompost, mulching, paddy straw was also used to feed animals and the crop residue remain in the field was incorporated with the next season cropping system. Based on the findings of the study it is recommended that concern department should take the necessary actions to integrate agroforestry system especially in the hill region which offer opportunities for economic gain, livelihood nutrition, conserve and protect natural environment.

Table 4.1.15.3: Distribution of overall knowledge index on the sustainable agricultural practices

S/N	Factors	Sustainability practice	n=320				
			Knowledge Index	Mean	SD	Mean	Rank
1.	Agronomical practices	Improved variety	43.44	0.43	0.49	0.54	I
		Crop rotation	65.31	0.65	0.49		
		Inter-cropping	52.81	0.53	0.50		
2.	Soil and water conservation	Conservation tillage	34.38	0.34	0.48	0.36	III
		Water storage in ponds	35.94	0.36	0.47		
		Mulching	39.06	0.39	0.48		
3.	Nutrient Management	Plantation of cover crop	35.00	0.35	0.47	0.35	IV
		Green manure	28.75	0.29	0.44		
		Organic fertilizer	40.94	0.41	0.49		
4.	Agroforestry	Agri silviculture	5.00	0.05	0.24	0.02	VII
		Silvipostoral	0.31	0.00	0.06		
5.	Restoration and rehabilitation	Enrichment planting	12.81	0.13	0.30	0.17	VI
		Fire Management	10.00	0.10	0.29		
		Natural Regeneration	27.50	0.27	0.44		
6.	Pest control method	Physical control	49.69	0.49	0.50	0.30	V
		Biological control	20.31	0.20	0.40		
		Cultural control	21.25	0.21	0.43		
7.	Diseases control method	Physical control	39.38	0.39	0.48	0.30	V
		Biological control	25.31	0.25	0.40		
		Cultural control	25.00	0.25	0.44		
8.	Recycle management	Field waste	58.44	0.58	0.50	0.48	II
		Animal waste	30.00	0.30	0.46		
		Plant waste	55.31	0.55	0.50		

Table 4.1.15.3 presented the overall knowledge on sustainable agriculture practices and it was reported that 65.31 per cent have knowledge on ‘crop rotation’ with mean score 0.65 followed by 58.44 per cent have knowledge on ‘field waste’ management with 0.58 mean score, 55.31 per cent have knowledge on plant waste management with 0.55 mean score, 52.81 per cent on ‘inter-cropping’ with 0.53 mean score, 49.69 per cent on ‘physical control’ of pest with 0.49 mean score, 43.44 per cent on ‘improved variety’ with 0.43 mean score, 40.94 per cent have ‘organic fertilizer’ with 0.41 mean score, 39.38 per cent have ‘physical control of disease’ with 0.39 mean score, 39.06 per cent on ‘mulching’ with 0.39 mean score, 35.94 per cent have ‘water harvesting in ponds’ with 0.36 mean score, 35.00 per cent on ‘plantation cover crop’ with 0.35 mean score, 34.38 per cent on ‘conservation tillage’ with 0.34 mean score, 30.00 per cent on ‘animal waste’ with 0.30 mean score, 28.75 per cent on green manure with 0.29 mean score, 27.50 per cent on ‘natural regeneration’ with mean score 0.28, 25.31 per cent on ‘biological control’ of diseases with 0.25 mean value having rank XVI, 25.00 per cent on ‘cultural method’ of diseases with mean score 0.25, 21.25 per cent on ‘cultural method’ of pest with mean score 0.21, 20.31 per cent have knowledge on ‘biological control’ of pest with mean score 0.20, 12.81 per cent on ‘enrichment planting’ with mean score 0.13, 10.00 per cent on ‘fire management’ with mean score 0.10, 5.00 per cent on agrisilviculture mean score 0.05 and 0.31 per cent on silvipastoral with 0.00 mean score.

Table 4.1.15.3 presented the ranking of knowledge on sustainable agriculture practices and it was revealed that the ‘agronomical practice’ sustainable agriculture practices had rank 1 with 0.54 mean score followed by ‘recycled management’

sustainable agriculture practices had rank II with 0.48 mean score, ‘soil and water conservation’ sustainable agriculture practices had rank III with 0.36 mean score, ‘nutrient management’ sustainable agriculture practices had rank IV with 0.35 mean score, pest control method and diseases control method had rank V with 0.30 mean score, ‘restoration and rehabilitation’ sustainable agriculture practices had rank VI with 0.17 mean score and ‘agroforestry’ sustainable agriculture practices had rank VII with 0.02 mean score.

Table 4.1.15.4: Distribution of overall respondents based on the knowledge level of sustainable agricultural practices

Districts	Level of knowledge	f	%	Mean	SD
THB n₁=80	Low (<4.49)	14	17.50	8.00	3.51
	Medium (4.49-11.51)	50	62.50		
	High (>11.51)	16	20.00		
IME n₂=80	Low (< 5.10)	17	21.25	7.87	2.77
	Medium (5.10-10.64)	46	57.50		
	High (>10.64)	17	21.25		
CCP n₃=80	Low (<2.58)	13	16.25	5.99	3.41
	Medium (2.58-9.40)	52	65.00		
	High (>9.40)	15	18.75		
SNP n₄=80	Low (< 4.16)	17	21.25	6.57	2.41
	Medium (4.16-8.98)	48	60.00		
	High (> 8.98)	15	18.75		
Overall n=320	Low (<7.24)	61	19.06	7.87	0.63
	Medium (7.24-8.50)	196	61.25		
	High (>8.50)	63	19.69		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

From Table 4.1.15.4 and Fig 4.1.15.4 it was observed that majority (65.00%) farmers from Churachandpur district belonged to medium knowledge level

followed by 18.75 per cent had high knowledge level and 16.25 per cent had low knowledge level towards the sustainable practices of agriculture. In Thoubal district, majority (62.50%) farmers belonged to medium knowledge level followed by 20.00 per cent had high knowledge level and 17.50 per cent had low knowledge level towards the sustainable practices of agriculture. In Imphal East district, majority (57.50%) farmers belonged to medium knowledge level followed by 21.25 per cent had high knowledge level and 21.25 per cent had low knowledge level towards the sustainable practices of agriculture.

In Senapati district, majority (60.00%) farmers belonged to medium knowledge level followed by 21.25 per cent had low knowledge level and 18.75 per cent had high knowledge level towards the sustainable practices of agriculture. In case of overall knowledge level, it was revealed that majority (61.25%) farmers belonged to medium knowledge level followed by 19.69 per cent farmers had high knowledge level and 19.06 per cent farmers had low knowledge level towards the sustainable practices of agriculture. Further revealed that Thoubal district have the highest mean score with 8.00 mean value followed by Imphal East district with 7.87 mean value, Senapati district with 6.57 mean value and Churachandpur district with 5.99 mean value. And the mean score of the overall knowledge level towards the sustainable agriculture was 7.87.

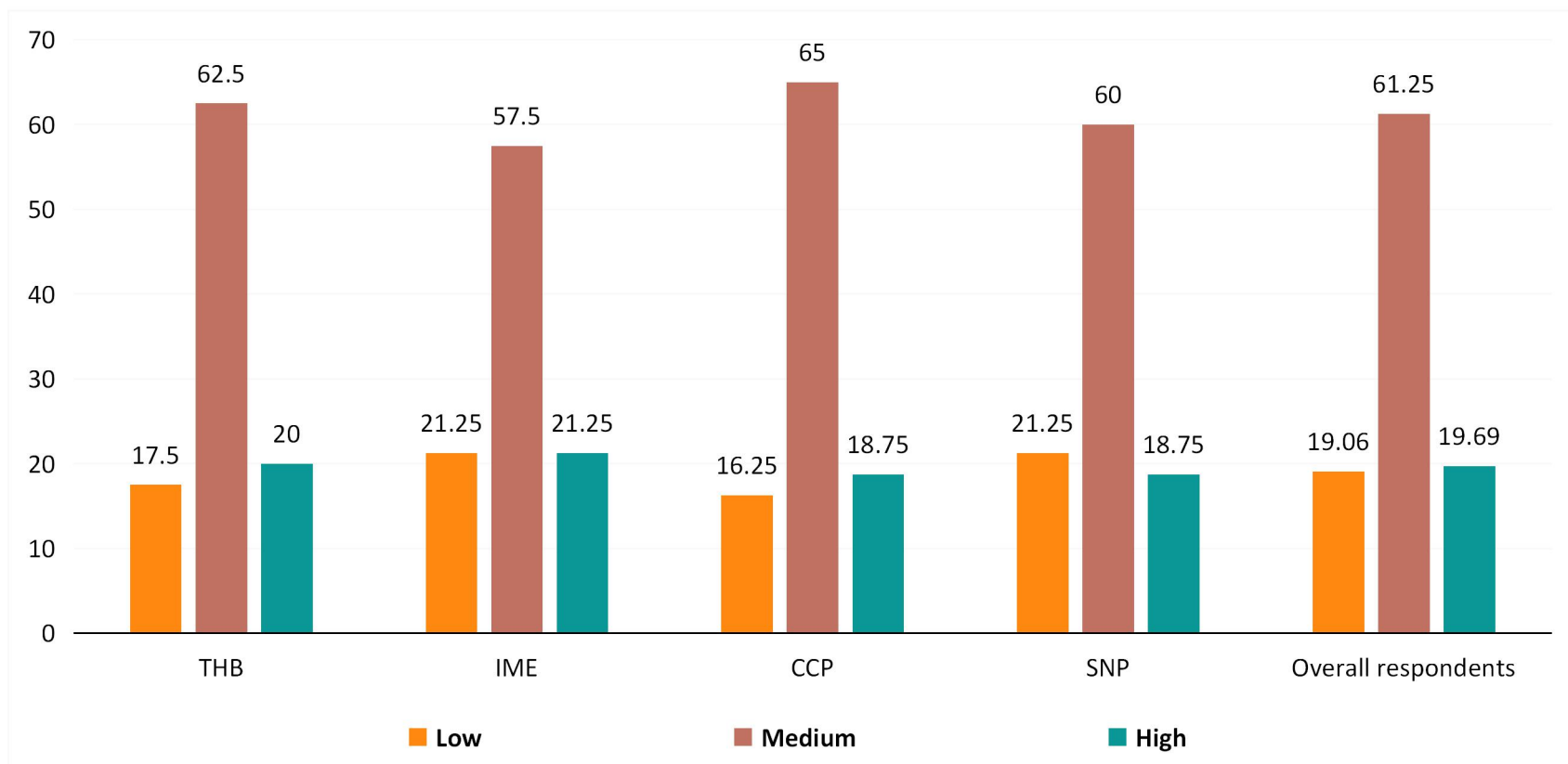


Fig 4.1.15.4: Distribution of respondents based on overall knowledge level of sustainable agricultural practices

Table 4.1.15.5: Comparative account of knowledge level on sustainable agricultural practices

S/N	Districts	Total information source utilization(μ)	Z Value	P value
1.	Thoubal	10.438	0.446 ^{NS}	> 0.05
2.	Imphal East	10.163		
3.	Churachandpur	7.975	-3.650**	< 0.01
4.	Senapati	10.275		
5.	Imphal East	10.163	-0.188 ^{NS}	> 0.05
6.	Senapati	10.275		
7.	Imphal East	10.163	3.496**	< 0.01
8.	Churachandpur	7.975		
9.	Thoubal	10.438	0.261 ^{NS}	> 0.05
10.	Senapati	10.275		
11.	Thoubal	10.438	3.793**	< 0.01
12.	Churachandpur	7.975		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.15.5 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% level of significance except Thoubal district vs Imphal East district, Imphal East district vs Senapati district and Thoubal district vs Senapati district (p-value >0.05).

Table 4.1.15.6: Correlation of socio-economic and psychological characteristics with their knowledge on sustainable agricultural practices

The coefficient of correlation between the selected socio-economic and psychological characteristics with their knowledge score were presented in Table 4.1.15.6.

S/N	Independents variables	Correlation coefficient (r)	P value
1.	Age	0.077	0.171
3.	Education	0.018	0.748
4.	Family size	0.102	0.069
5.	Family type	0.087	0.12
6.	Experienced in agriculture	0.057	0.31
7.	Experienced in rice-based farming	-0.016	0.771
8.	Total landholding area	0.218**	0.00
9.	Size of land under riced-based farming system	0.207**	0.00
10.	Annual income	0.176**	0.002
11.	Income from rice-based farming system	0.149**	0.008
12.	Training exposure	0.033	0.556
13.	Extension contacts	-0.002	0.978
14.	Formal information sources	0.011	0.848
15.	Informal information sources	0.082	0.143
16.	Mass media information sources	0.179**	0.001
17.	Social media information sources	0.030	0.594
19.	Perception towards climate change	.0162**	0.004
20.	Market orientation	0.107	0.056
21.	Production orientation	0.131*	0.019
22.	Risk orientation	-0.079	0.156
23.	Innovativeness	0.013	0.814

** significant at the 0.01 level (2-tailed), ** significant at the 0.05 level (2-tailed)

From the Table 4.1.15.6 it was reported that the variable total landholding area ($r=0.218^{**}$), size of land under riced-based farming system ($r=0.207^{**}$), annual income ($r=0.176^{**}$), income from rice-based farming system ($r=0.149^{**}$), mass media information sources ($r=0.179^{**}$) and perception towards climate change ($r=0.162^{**}$) had positive and significant association with knowledge on sustainable agriculture practices at 1% level of significance. Similar finding was found by

Gautam and Shahare (2020) that size of landholding and socio-economic were found positive and significant with the farmers knowledge. Kankarne *et al.*, (2017) also reported that herd size, annual income and information sources used by farmers were found positive and significant with the farmers knowledge level. The variable production orientation ($r=0.131^*$) had positive and significant association with i.e., knowledge on sustainable agriculture practices at 5% level of significance.

Variable's age, education, family size, family type, experience in agriculture, experience in rice-based farming system, training exposure, extension contact, formal information sources, informal information source, social media information sources, market orientation, risk orientation and innovativeness had non-significant association with '**knowledge on sustainable agriculture practices**'. Based upon the findings the null hypothesis (H_{01a}) was rejected:

H_{01a}: There is no association between the variables total landholding area, size of land under rice-based farming system, annual income, income from rice-based farming system, mass media information sources and perception towards climate change and production orientation

The variables age, education, family size, family type, experience in agriculture, experience in rice-based farming system, training exposure, extension contact, formal information sources, informal information source, social media information sources, market orientation, risk orientation and innovativeness had non-significant association with '**knowledge on sustainable agriculture practices**'. Therefore the following null hypothesis **H_{01b}** was accepted:

H_{01b}: There is association between the variables age, education, family size, family type, experience in agriculture, experience in rice-based farming system,

training exposure, extension contact, formal information sources, informal information source, social media information sources, market orientation, risk orientation and innovativeness with ‘**knowledge on sustainable agriculture practices**’ was accepted.

4.1.16 Scientific orientation

Table 4.1.16.1: Distribution of respondents based on scientific orientation

Districts	Level of scientific orientation	f	%	Mean	SD
THB n₁=80	Low (<12.84)	5	6.25	17.27	4.43
	Medium (12.84-21.70)	58	72.50		
	High (>21.70)	17	21.25		
IME n₂=80	Low (<15.77)	7	8.75	18.52	2.75
	Medium (15.77-21.27)	54	67.50		
	High (>21.27)	19	23.75		
CCP n₃=80	Low (<11.18)	4	5.00	14.57	3.39
	Medium (11.18-17.96)	62	77.50		
	High (>17.96)	14	17.50		
SNP n₄=80	Low (<10.47)	12	15.00	13.79	3.32
	Medium (10.47-17.11)	60	75.00		
	High (>17.11)	8	10.00		
Overall n=320	Low (<12.07)	28	8.75	15.49	3.42
	Medium (12.07-18.91)	234	73.13		
	High (>18.91)	58	18.12		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

Table 4.1.16.1 and Fig 4.1.16.1 shows the distribution of respondents based on their scientific orientation towards sustainable cultivation practices. It was observed that majority (77.50%) of the farmers from Churachandpur district had medium level of scientific orientation followed by 75.00 per cent farmers from Senapati district, 72.50 per cent farmers from Thoubal district and 67.50 per cent farmers from Imphal East district. Further it revealed that majority (67.50%) of the

respondents had medium level of scientific orientation followed by high level 23.75 per cent of scientific orientation and 8.75 per cent low level of scientific orientation. The above findings were in line according with the findings of Verma *et al.* (2017).

Table 4.1.16.2: Comparative account of scientific orientation on rice-based farming system

S/N	Districts	Scientific orientation (μ)	Z Value	P value
1.	Thoubal	17.275	-2.144*	< 0.05
2.	Imphal East	18.525		
3.	Churachandpur	14.575	1.483 ^{NS}	> 0.05
4.	Senapati	13.788		
5.	Imphal East	18.525	9.825**	< 0.01
6.	Senapati	13.788		
7.	Imphal East	18.525	8.093**	< 0.01
8.	Churachandpur	14.575		
9.	Thoubal	17.275	6.566**	< 0.01
10.	Senapati	17.275		
11.	Thoubal	13.788	4.326**	< 0.01
12.	Churachandpur	14.575		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.16.2 it was evident that all the selected districts were significantly different at 1% level of significance except Thoubal district vs Imphal East district (p-value >0.05).

4.1.17 Innovativeness

Table 4.1.17.1: Distribution of farmers based on the innovativeness on sustainable agricultural practices

Districts	Level of innovativeness	f	%	Mean	SD
THB n₁=80	Low (<14.02)	10	12.50	16.75	2.73
	Medium (14.02-19.48)	48	60.00		
	High (>19.48)	22	27.50		
IME n₂=80	Low (<11.72)	8	10.00	14.91	3.19
	Medium (11.72-18.10)	62	77.50		
	High (>18.10)	10	12.50		
CCP n₃=80	Low (<11.72)	11	13.75	13.66	1.94
	Medium (11.72-15.60)	65	81.25		
	High (>15.60)	4	5.00		
SNP n₄=80	Low (<13.02)	9	11.25	15.22	2.20
	Medium (13.02-17.42)	60	75.00		
	High (>17.42)	11	13.75		
Overall n=320	Low (<14.62)	38	11.88	15.18	0.56
	Medium (14.62-15.74)	235	73.44		
	High (>15.74)	47	14.68		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; f: Frequency and %: Percentage

Table 4.1.17.1 and Fig 4.1.17.1 presented the innovativeness of rice-based cultivation farmers in the study area. It was revealed that 81.25 per cent farmers from Churachandpur district had medium level innovativeness followed by 13.75 per cent farmers had low level of innovativeness and only 5.00 per cent farmers had high level of innovativeness. In Imphal East district, 77.50 per cent farmers had medium level of innovativeness followed by 12.50 per cent farmers had high level innovativeness and 10.00 per cent farmers had low level of innovativeness. In Senapati district, 75.00 per cent farmers had medium level of innovativeness followed by 13.75 per cent farmers had high level of innovativeness and 11.25 per

cent farmers had low level of innovativeness. Further, in Thoubal district 60.00 per cent farmers had medium level of innovativeness followed by 27.50 per cent farmers had high level innovativeness and 12.50 per cent farmers had low level of innovativeness. In overall, category majority (73.44%) had medium level of innovativeness followed by 14.68 per cent farmers had high level innovativeness and 11.88 per cent farmers had low level of innovativeness. These findings were in line with the findings of Medhi *et al.*, (2020) and Podikunju and Arathy (2022).

Table 4.1.17.2: Comparative account of innovativeness on sustainable agricultural practices

S/N	Districts	Innovativeness (μ)	Z Value	P value
1.	Thoubal	16.750	3.913**	< 0.01
2.	Imphal East	14.913		
3.	Churachandpur	13.663	-4.764**	< 0.01
4.	Senapati	15.225		
5.	Imphal East	14.913	-0.721 ^{NS}	> 0.05
6.	Senapati	15.225		
7.	Imphal East	14.913	2.990**	< 0.01
8.	Churachandpur	13.663		
9.	Thoubal	16.750	3.895**	< 0.01
10.	Senapati	15.225		
11.	Thoubal	16.750	8.251**	< 0.01
12.	Churachandpur	13.663		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.17.2 it was evident that farmers in all the selected districts were significantly different with respect to innovativeness at 1% level of significance except Imphal East district vs Senapati district (p-value >0.05).

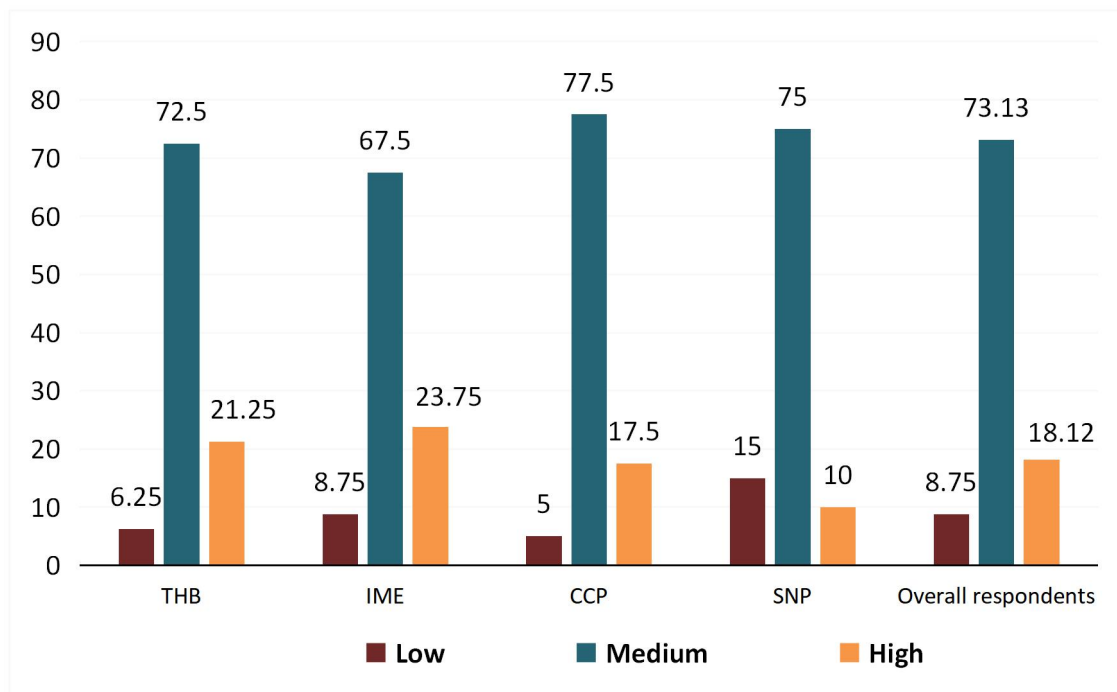


Fig 4.1.16.1: Distribution of respondents based on scientific orientation

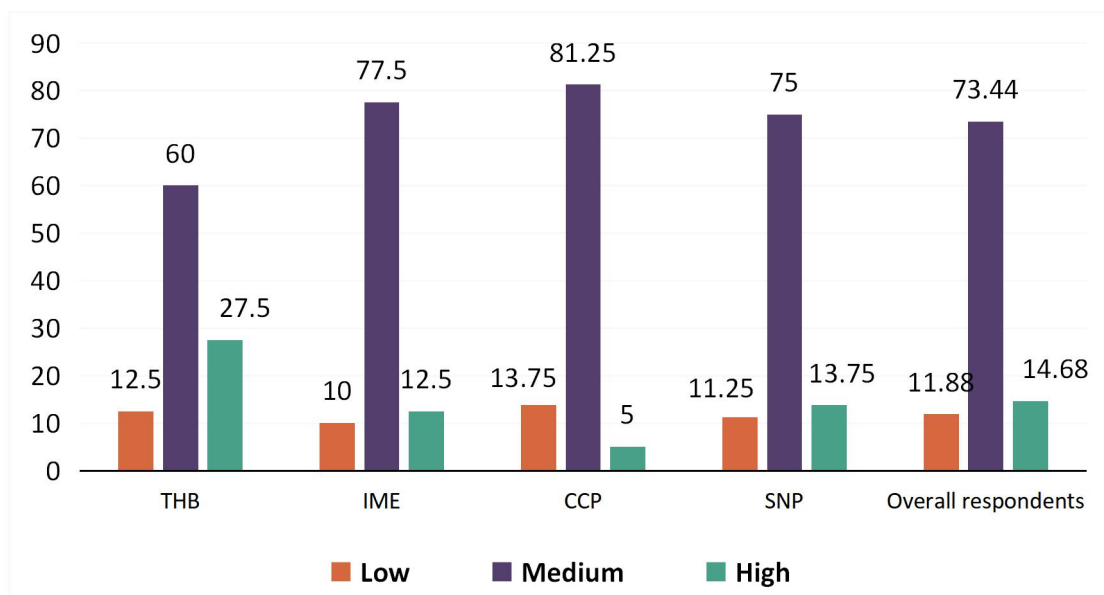


Fig 4.1.17.1: Distribution of farmers based on the innovativeness

4.1.18 Risk orientation

Table 4.1.18.1: Distribution of respondents based on risk orientation

Districts	Level of risk orientation	f	%	Mean	SD
THB n₁=80	Low (<14.14)	12	15.00	18.71	4.57
	Medium (14.14-23.28)	50	62.50		
	High (>23.28)	18	22.50		
IME n₂=80	Low (<12.50)	6	7.50	15.89	3.39
	Medium (12.50-19.28)	60	75.00		
	High (>19.28)	14	17.50		
CCP n₃=80	Low (<14.61)	15	18.75	17.31	2.70
	Medium (14.61-20.01)	59	73.75		
	High (>20.01)	6	7.50		
SNP n₄=80	Low (<13.90)	13	16.25	16.85	2.95
	Medium (13.90-19.80)	56	70.00		
	High (>19.80)	11	13.75		
Overall n=320	Low (<13.58)	46	14.38	17.19	3.61
	Medium (13.58-20.80)	225	70.31		
	High (>20.80)	49	15.31		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; f: Frequency and %: Percentage

Table 4.1.18.1 and Fig 4.1.18.1 presented the risk orientation of rice-based cultivation farmers in the four districts of Manipur. It was revealed that majority (75.00%) of farmers from Imphal East district had medium level of risk orientation followed by 17.50 per cent farmers had high level of risk orientation and 7.50 per cent farmers had low level of risk orientation. In Churachandpur district, majority (73.75%) of the farmers had medium level of risk orientation followed by 18.75 per cent farmers had low level of risk orientation and 7.50 per cent farmers had high level of risk orientation. In Senapati district, 70.00 per cent farmers had medium level of risk orientation followed by 16.25 per cent farmers had low level of risk orientation and 13.75 per cent farmers had high level of risk orientation. In Thoubal

district, 62.50 per cent farmers had medium level of risk orientation followed by 22.50 per cent farmers had high level of risk orientation and 15.00 per cent farmers had low level of risk orientation. In overall, category majority (70.31%) farmers had medium level of risk orientation followed by 15.31 per cent farmers had high level of risk orientation and 14.38 per cent farmers had low level of risk orientation. These findings were found supported with the findings of Digambar *et al.*, (2020) and Podikunju and Arathy (2022).

Table 4.1.18.2: Comparative account on risk orientation

S/N	Districts	Risk orientation (μ)	Z Value	P value
1.	Thoubal	18.713	4.442**	< 0.01
2.	Imphal East	15.888		
3.	Churachandpur	17.313	-1.034 ^{NS}	> 0.05
4.	Senapati	16.850		
5.	Imphal East	15.888	-1.916*	< 0.05
6.	Senapati	16.850		
7.	Imphal East	15.888	-2.940**	< 0.01
8.	Churachandpur	17.313		
9.	Thoubal	18.713	3.064**	< 0.01
10.	Senapati	16.850		
11.	Thoubal	18.713	2.359*	< 0.05
12.	Churachandpur	17.313		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.18.2 it was evident that farmers in all the selected districts were significantly different with respect to risk orientation at 1% level of significance except Churachandpur vs Senapati district (p-value >0.05).

4.1.19 Production orientation

Table 4.1.19.1: Distribution of respondents based on the production orientation

Districts	Level of product orientation	f	%	Mean	SD
THB n₁=80	Low (<15.95)	9	11.25	20.01	4.06
	Medium (15.95-24.07)	64	80.00		
	High (>24.07)	7	8.75		
IME n₂=80	Low (<17.64)	8	10.00	21.01	3.34
	Medium (17.64-24.35)	66	82.50		
	High (>24.35)	6	7.50		
CCP n₃=80	Low (<15.02)	10	12.5	17.99	2.97
	Medium (15.02-20.96)	64	80.00		
	High (>20.96)	6	7.50		
SNP n₄=80	Low (<14.83)	3	3.75	18.54	3.71
	Medium (14.83-22.25)	68	85.00		
	High (>22.25)	9	11.25		
Overall n=320	Low (<15.66)	30	9.375	19.39	3.73
	Medium (15.66-23.12)	262	81.87		
	High (>23.12)	28	8.75		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; f: Frequency and %: Percentage

Table 4.1.19.1 and Fig 4.1.19.1 presented the production orientation of rice-based cultivation farmers in the four districts of Manipur. It was revealed that 80.00 per cent farmers from Churachandpur district had medium level product orientation followed by 12.50 per cent farmers had low level of product orientation and 7.50 per cent farmers had high level of product orientation. In Imphal East district, 82.50 per cent farmers had medium level of product orientation followed by 10.00 per cent farmers had low level product orientation and 7.50 per cent farmers had high level of product orientation. In Senapati district, 85.00 per cent farmers had medium level of product orientation followed by 11.25 per cent farmers had high level of product orientation and 3.75 per cent farmers had low level of product

orientation. It was further revealed that, in Thoubal district 80.00 per cent farmers had medium level of production orientation followed by 11.25 per cent farmers had low level production orientation and 8.75 per cent farmers had high level of production orientation. Imphal East district had the highest mean value with 21.01 in product orientation followed by Thoubal district with mean value 20.01, Senapati district with 18.54 mean value and Churachandpur district with 17.99 mean value. The finding can be inferred that Imphal East district had highest production orientation in rice base farming system as compared with other three districts.

Table 4.1.19.2: Comparative account of production orientation

S/N	Districts	Product orientation (μ)	Z Value	P value
1.	Thoubal	20.013	-1.700 ^{NS}	> 0.05
2.	Imphal East	21.013		
3.	Churachandpur	17.988	-1.034 ^{NS}	> 0.05
4.	Senapati	18.538		
5.	Imphal East	21.013	4.434**	< 0.01
6.	Senapati	18.538		
7.	Imphal East	21.013	6.050**	< 0.01
8.	Churachandpur	17.988		
9.	Thoubal	20.013	2.397*	< 0.05
10.	Senapati	18.538		
11.	Thoubal	20.013	3.596**	< 0.01
12.	Churachandpur	17.988		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.19.2 it was evident that farmers in all the selected districts were significantly different with respect to product orientation at 1% level of significance and 5% level of significant whereas ‘Imphal East district vs Thoubal district’ and ‘Churachandpur district vs Senapati district’ were found statistically non-significant (p-value>0.05).

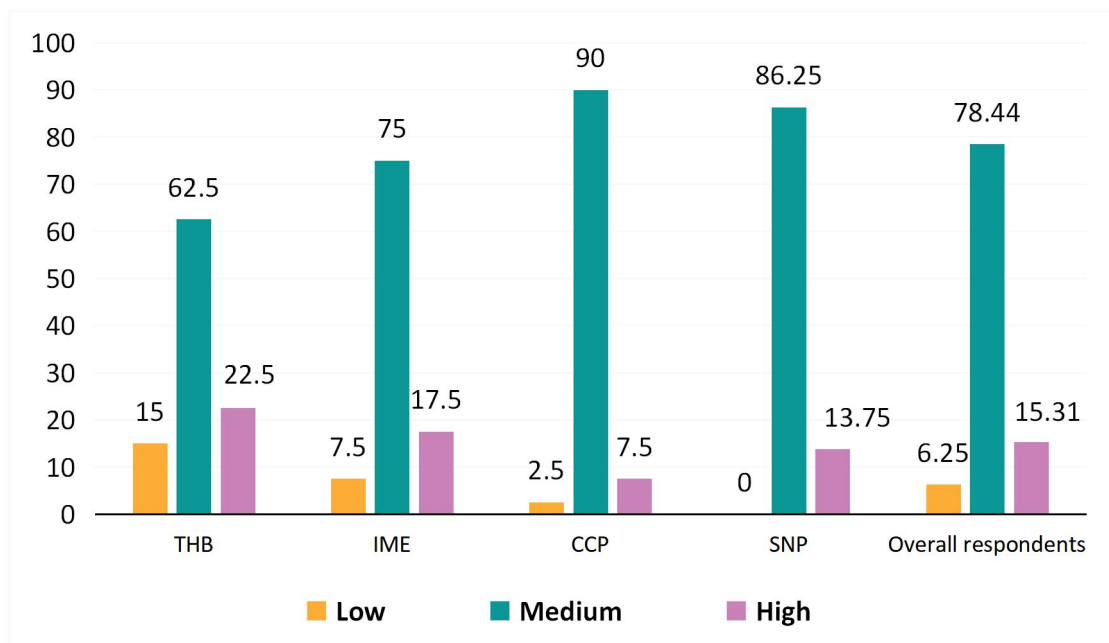


Fig 4.1.18.1: Distribution of respondents based on risk orientation

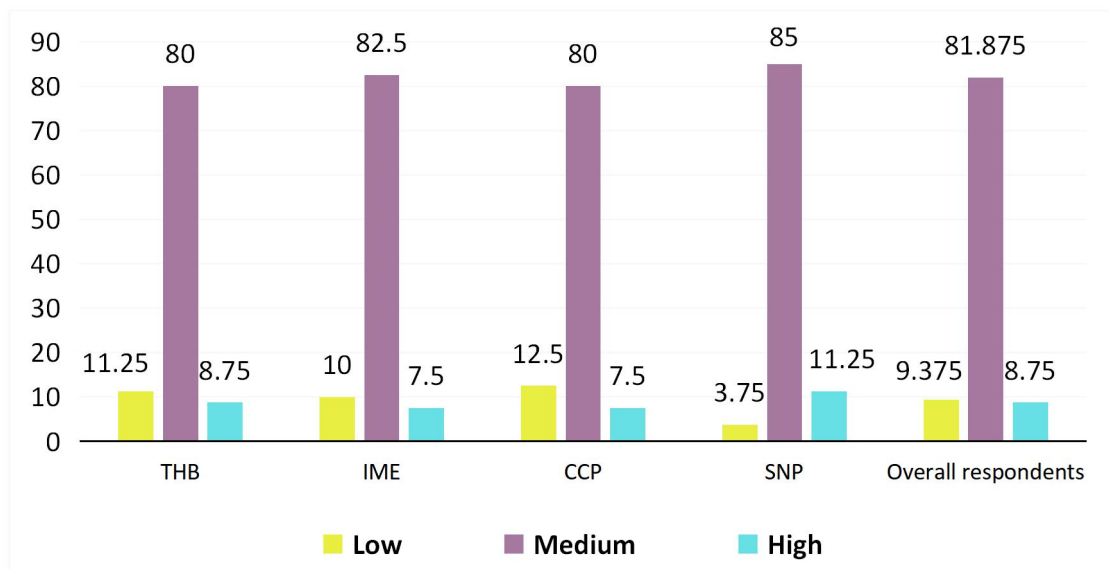


Fig 4.1.19.1: Distribution of respondents based on the production orientation

4.1.20 Market orientation

Table 4.1.20.1: Distribution of respondents based on market orientation

Districts	Level of market orientation	f	%	Mean	SD
THB n₁=80	Low (<19.84)	4	11.25	22.20	2.36
	Medium (19.84-24.56)	64	66.25		
	High (>24.56)	12	22.50		
IME n₂=80	Low (<17.18)	5	10.00	20.70	3.52
	Medium (17.18-24.22)	66	61.25		
	High (>24.22)	9	28.75		
CCP n₃=80	Low (<14.27)	8	5.00	18.90	4.63
	Medium (14.27-23.53)	55	81.25		
	High (>23.53)	17	13.75		
SNP n₄=80	Low (<14.03)	9	3.75	18.06	4.03
	Medium (14.03-22.09)	59	73.75		
	High (>22.09)	12	22.50		
Overall n=320	Low (<15.92)	26	7.50	19.97	4.05
	Medium (15.92-24.02)	244	70.63		
	High (>24.02)	50	21.88		

THB: Thoubal district; **IME:** Imphal East district; **SNP:** Senapati district; **CCP:** Churachandpur district; **f:** Frequency and **%:** Percentage

Table 4.1.20.1 and Fig 4.1.20.1 presented the market orientation of rice-based cultivation farmers in the four districts of Manipur. It was revealed that 81.25 per cent farmers from Churachandpur district had medium level market orientation followed by 13.75 per cent farmers had high level of market orientation and 5.00 per cent farmers had low level of market orientation. In Senapati district, 73.75 per cent of the farmers had medium level of market orientation followed by 22.50 per cent farmers had high level of product orientation and only 3.75 per cent farmers had low level of market orientation. In Thoubal district, 66.25 per cent farmers had medium level of market orientation followed by 22.50 per cent farmers had high level market orientation and 11.25 per cent farmers had low level of market orientation. Further,

in Imphal East district 61.25 per cent farmers had medium level of market orientation followed by 28.75 per cent farmers had high level market orientation and 10.00 per cent farmers had low level of market orientation. Thoubal district had the highest mean value with 22.20 followed by Imphal East district with mean value 20.70, Churachandpur district with 18.90 mean value and Senapati district with 18.06 mean value. Thus, it can be inferred that Thoubal district had the highest production orientation in rice base farming system as compared with other three district.

Table 4.1.20.2 Comparative account of market orientation

S/N	Districts	Market orientation (μ)	Z Value	P value
1.	Thoubal	22.20	3.165**	< 0.01
2.	Imphal East	20.70		
3.	Churachandpur	18.90	1.219 ^{NS}	> 0.05
4.	Senapati	18.06		
5.	Imphal East	20.70	4.403**	< 0.01
6.	Senapati	18.06		
7.	Imphal East	20.70	2.766**	< 0.01
8.	Churachandpur	18.90		
9.	Thoubal	22.20	7.615**	< 0.01
10.	Senapati	18.06		
11.	Thoubal	22.20	5.679**	< 0.01
12.	Churachandpur	18.90		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.20.2 it was evident that farmers in all the selected districts were significantly different with respect to market orientation at 1% level of significance except 'Churachandpur district and Senapati district' which was found statistically non-significant ($p\text{-value} > 0.05$).

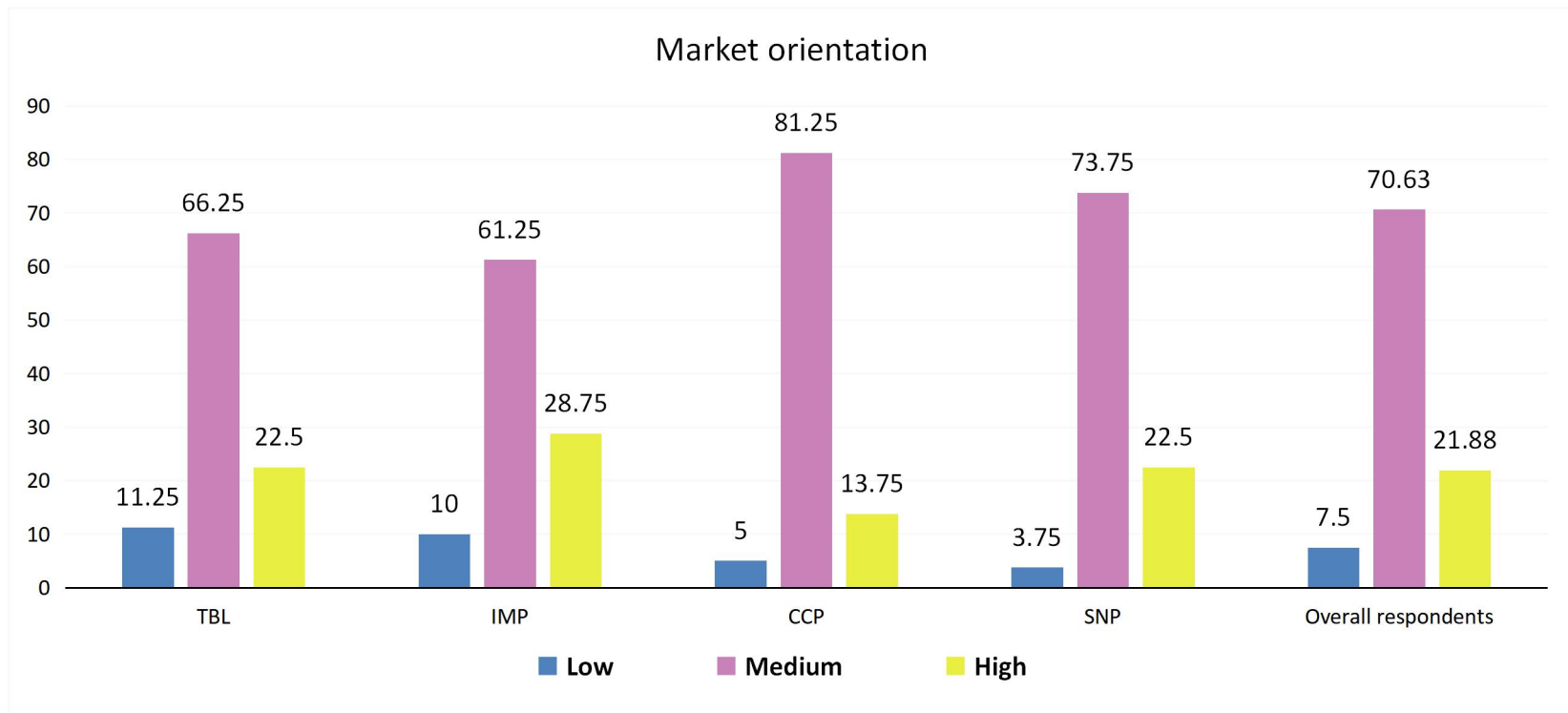


Fig 4.1.20.1: Distribution of respondents based on market orientation

4.1.21 Perception towards climate change

Examining farmers' perceptions toward organic farming may also provide useful insights into the barriers faced by them in adopting organic practices.

Table 4.1.21.1 Distribution of farmers based on perception towards climate change in valley districts

S/N	Districts	THB n ₁ =80		IME n ₂ =80	
	Dimensions of perception towards climate change	Perceived %	Not perceived %	Perceived %	Not perceived %
1.	Frequent drought	12 (15.00)	68 (85.00)	40 (50.00)	40 (50.00)
2.	Frequent flood	39 (48.75)	41 (51.25)	45 (56.25)	35 (43.75)
3.	Increased temperature during summer	80 (100)	0 (0.00)	80 (100)	0 (0.00)
4.	Heavy hailstorm	8 (10.00)	72 (90.00)	12 (15.00)	68 (85.00)
5.	Frequent cold wave	46 (57.50)	34 (42.50)	40 (50.00)	40 (50.00)
6.	Frequent heat wave	33 (41.25)	47 (58.75)	49 (61.25)	31 (38.75)
7.	Decrease in temperature during winter	42 (52.50)	38 (47.50)	45 (56.25)	35 (43.75)
8.	Heavy rainfall	50 (62.50)	30 (37.50)	39 (48.75)	41 (51.25)
9.	Unseasonal rainfall	60 (75.00)	20 (25.00)	65 (81.25)	15 (18.75)
10.	Low rainfall during rainy season	48 (60.00)	32 (40.00)	50 (62.50)	30 (37.50)
11.	More windy	54 (67.50)	26 (32.50)	50 (62.50)	30 (37.50)
12.	Shift in Monsoon period	57 (71.25)	23 (28.75)	63 (78.75)	17 (21.25)

***Percentage has been mentioned in bracket**

Table 4.1.21.1 revealed that 100 per cent of the farmers perceived increase temperature during summer, 75.00 per cent perceived unseasonal rainfall, 71.25 per cent perceived monsoon shifting, 67.50 per cent perceived windy, 60 percent per cent low rainfall, 62.50 per cent perceived heavy rainfall at a time, 57.50 per cent perceived cold wave, 52.50 per cent perceived decreased temperature during winter, 4.75 per cent perceived flood, 41.25 per cent perceived heat wave, 15.00 per cent

perceived drought and 10.00 per cent perceived hailstorm in Thoubal district. However, in Thoubal district 90.00 per cent farmers did not noticed hailstorm, 85.00 per cent did not noticed drought, 58.75 per cent did not notice heat wave, 51.25 per cent did not noticed flood, 47.50 per cent farmers did not notice decrease temperature during winter, 42.50 percent farmers did not perceived cold wave, 40.00 per cent did not noticed low rainfall, 37.50 per cent did not noticed heavy rainfall at a time, 32.50 per cent did not noticed windy, 28.75 per cent did not noticed monsoon shifting and 25.00 per cent did not noticed unseasonal rainfall.

In case of Imphal East district, 100 per cent farmers perceived increase in temperature during summer, 81.25 per cent farmers perceived unseasonal rainfall, 78.75 per cent perceived monsoon shifting, 62.50 per cent perceived windy and low rainfall, 61.25 perceived heat wave, 56.25 per cent perceived decreased temperature during winter and flood, 50.00 per cent perceived cold wave and drought, 48.75 per cent heavy rainfall at a time, and 15 per cent perceived hailstorm. However, 85.00 per cent farmers did not notice hailstorm, 51.25 per cent farmers did not notice heavy rainfall at a time, 50 per cent farmer did not notice cold wave and drought, 43.75 per cent farmers did not notice flood and decrease in temperature during winter, 38.75 per cent farmer did not notice heat wave, 37.50 per cent did not notice low rainfall and windy, 21.25 per cent farmers did not notice monsoon shifting and 18.75 per cent farmer did not notice unseasonal rainfall.

From from the Table 4.1.21.1 it was reported that 86.25 per cent farmers from Senapati district perceived cold wave, 77.50 per cent perceive decrease temperature, 73.75 per cent perceived unseasonal rainfall, 66.25 per cent perceived increase temperature during summer, 61.25 per cent perceived windy, 46.25 per cent perceived drought, 43.75 per cent perceived heavy rainfall, 40.00 per cent perceived monsoon shifting, 32.50 per cent perceived low rainfall, 6.25 per cent perceived hailstorm, 5.00 per cent perceived flood and 2.50 per cent perceived heat wave. However, 97.50 percent heat wave, 95.00 per cent did not noticed flood, 93.75 per cent did not notice hailstorm, 67.50 per cent did not notice low rainfall, 56.25 per cent did not notice heavy rainfall, 53.75 per cent did not notice drought, 38.75 per cent did not notice windy, 33.75 per cent did not notice increase temperature during summer, 26.25 per cent did not notice unseasonal rainfall,

22.50 per cent did not notice decrease in temperature during winter and 13.75 per cent did not notice cold wave.

Table 4.1.21.2: Distribution of farmers based on perception towards climate change in hill districts

S/N	Districts	SNP n ₃ =80		CCP n ₄ =80	
	Dimensions of perception towards climate change	Perceived %	Not perceived %	Perceived %	Not perceived %
1.	Frequent drought	37 (46.25)	43 (53.75)	48 (60.00)	32 (40.00)
2.	Frequent flood	4 (5.00)	76 (95.00)	0 (0.00)	80 (100)
3.	Increased temperature during summer	53 (66.25)	27 (33.75)	60 (75.00)	20 (25.00)
4.	Heavy hailstorm	5 (6.25)	75 (93.75)	4 (5.00)	76 (95.00)
5.	Frequent cold wave	69 (86.25)	11 (13.75)	59 (73.75)	21 (26.25)
6.	Frequent heat wave	2 (2.50)	78 (97.50)	13 (16.25)	67 (83.75)
7.	Decrease in temperature during winter	62 (77.50)	18 (22.50)	55 (68.75)	25 (31.25)
8.	Heavy rainfall	35 (43.75)	45 (56.25)	39 (48.75)	41 (51.25)
9.	Unseasonal rainfall	59 (73.75)	21 (26.25)	53 (66.25)	27 (33.75)
10.	Low rainfall during rainy season	26 (32.50)	54 (67.50)	47 (58.75)	33 (41.25)
11.	Windy	49 (61.25)	31 (38.75)	45 (56.25)	35 (43.75)
12.	Shift in Monsoon period	32 (40.00)	48 (60.00)	56 (70.00)	24 (30.00)

*(percentage expressed within bracket)

From the Table 4.1.21.2 it was reported that 75.00 per cent farmers perceived increase in temperature during summer, 73.75 per cent perceived cold wave, 70.00 per cent perceived monsoon shifting, 68.75 per cent perceived decrease in temperature during winter, 66.25 per cent perceived unseasonal rainfall, 60.00 per cent perceived drought, 58.75 percent of them perceived low rainfall, 56.25 per cent perceived windy, 48.75 per cent perceived heavy rainfall, 16.25 per cent as increase in heat wave, 5 per cent perceived hailstorm. However, 100 per cent

farmers did not notice flood, 95 per cent farmers did not notice hailstorm, 83.75 per cent farmers did not notice heat wave, 51.25 per cent farmers did not notice heavy rainfall, 43.75 per cent did not notice windy season , 41.25 per cent did not notice low rainfall, 40.00 per cent did not notice drought, 33.75 per cent did not notice unseasonal rainfall, 30.00 per cent farmers did not notice monsoon shifting, 31.25 per cent did not notice decrease in temperature during winter, 25.00 per cent did not notice increase in temperature during summer and 26.25 per cent did not notice cold wave.

Table 4.1.21.3: Distribution of overall respondents based on the perception towards the impact of climate change

S/N	Districts	Overall respondents n=320				Rank	Mean
	Dimensions of perception towards climate change	Perceived	%	Not Perceived	%		
1.	Increased temperature during summer	273	85.31	47	14.69	I	0.78
2.	Unseasonal rainfall	237	74.06	83	25.94	II	0.77
3.	Frequent cold wave	214	66.88	106	33.13	III	0.75
4.	Shift in monsoon period	208	65.00	112	35.00	IV	0.73
5.	Decrease in temperature during winter	204	63.75	116	36.25	V	0.69
6.	Windy	198	61.88	122	38.13	VI	0.65
7.	Low rainfall during rainy season	171	53.44	149	46.56	VII	0.60
8.	Heavy rainfall	163	50.94	157	49.06	VIII	0.51
9.	Frequent drought	137	42.81	183	57.19	IX	0.43
10.	Frequent heat wave	97	30.31	223	69.69	X	0.28
11.	Frequent flood	88	27.50	232	72.50	XI	0.24
12.	Heavy hailstorm	29	9.06	291	90.94	XII	0.17

From Table 4.1.21.3 it was revealed that majority (85.31%) of the farmers perceived increase in temperature during summer, 74.06 per cent of them perceived unseasonal rainfall, 66.88 per cent of them perceived frequent cold wave, 65.00 per cent of them perceived monsoon shifting, 63.75 per cent of them perceived decrease in temperature during winter, 61.88 per cent of the farmers perceived windy environment, 53.44 per cent of them perceived low rainfall during rainy season, 50.94 per cent of them perceived heavy rainfall, 30.31 per cent of them perceived frequent heat wave, 27.50 per cent of them perceived frequent flood and 9.06 per cent of them perceived heavy hailstorm. Further, 90.94 per cent of the farmers did not notice hailstorm, 72.50 per cent did not notice frequent flood, 69.69 per cent did not notice frequent heat wave, 57.19 per cent of them did not notice frequent drought, 49.06 per cent did not notice heavy rainfall, 46.56 per cent did not notice low rainfall during rainy season, 38.13 per cent did not notice windy season, 36.25 per cent did not notice decrease in temperature during winter, 33.13 per cent did not notice frequent cold wave, 25.94 per cent of them did not notice unseasonal rainfall and 14.69 per cent of them did not notice increase in temperature during the summer.

From Table 4.1.21.3 it was revealed that most of the farmers perceived increase in temperature during summer having 1st rank with the highest (0.78) mean score followed by unseasonal rainfall having 2nd rank with (0.77) mean score, frequent cold wave having 3rd rank with (0.75) mean score, shift in monsoon period having 4th rank with (0.73) mean score, decrease in temperature during winter having 5th rank with (0.69) mean score, windy having 6th rank with (0.65) mean score, low rainfall during rainy season having 7th rank with (0.60) mean score, heavy rainfall having 8th rank with (0.51) mean score, frequent drought having 9th rank with (0.43) mean score, frequent heat wave having 10th rank with (0.28) mean score, frequent flood having 11th rank with (0.24) mean score and heavy hailstorm having 12th rank with (0.17) mean score.

Table 4.1.21.4: Comparative account on perception towards the impact of climate change

S/N	Districts	Perception towards climate change (μ)	Z Value	P value
1.	Thoubal	7.888	-1.290 ^{NS}	> 0.05
2.	Imphal East	8.275		
3.	Churachandpur	5.513	2.328 ^{NS}	> 0.05
4.	Senapati	4.500		
5.	Imphal East	8.275	11.185**	< 0.01
6.	Senapati	4.500		
7.	Imphal East	8.275	6.758**	< 0.01
8.	Churachandpur	5.513		
9.	Thoubal	7.888	10.107**	< 0.01
10.	Senapati	4.500		
11.	Thoubal	7.888	5.838**	< 0.01
12.	Churachandpur	5.513		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.1.21.4 it was evident that farmers in all the selected districts were significantly different with respect to perception of the impact of climate change at 1% level of significance except ‘Thoubal district and Imphal East district’ which found statistically non-significant (p-value>0.05).

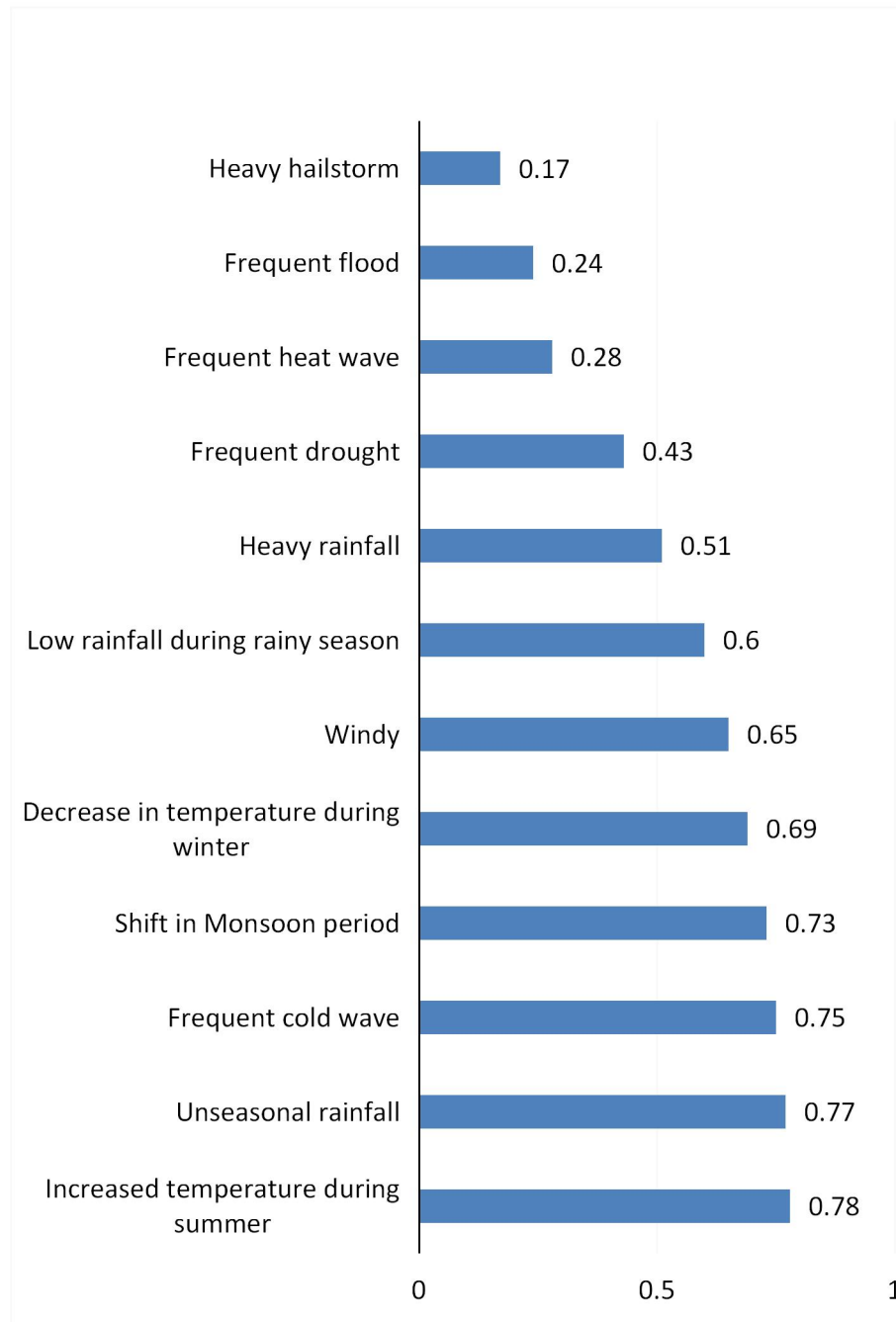


Fig 4.1.21.3: Distribution based on the mean (ranking) of perception towards of climate change

4.2 Examine the cropping pattern and farm resource management under rice-based farming system followed by the respondents

Table 4.2.1: Crop calendar indicating the major rice-based cropping pattern found in the four selected districts of Manipur

Region based on district	Cropping pattern	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Season
Valley region Thoubal & Imphal East	RFFS-I		Pre-kharif rice					Kharif rice						Pre kharif Kharif
				Fish in rice field					Fish in rice field					
	RFFS-II							Kharif rice						Kharif
			Fish in rice field						Fish in rice field					Kharif Rabi
Hill region Senapati	RFFS							Kharif rice						Kharif
			Fish in rice field						Fish in rice field					Kharif Rabi
Valley region Thoubal & Imphal East	RMFS							Kharif rice						Kharif
			Mustard in rice field											Rabi
Hill region Churachandpur	RMFS							Kharif rice						Kharif
			Mustard in rice field											Rabi
Hill region Churachandpur & Senapati	RVFS							Kharif rice						Kharif
			Vegetables in rice field											Rabi

Rice ■ Fish ■ Mustard ■ Vegetables ■

The crop calendar presented in Table 4.2 indicates the major rice-based cropping pattern found in the selected four districts (Thoubal district, Imphal East district, Churachandpur district, and Senapati district) of Manipur. The crop calendar (Table 4.2.1) shown that farmers in Thoubal district and Imphal East district were engaged with rice-fish farming systems (RFFS) and rice-mustard farming systems (RMFS). In Senapati district and Churachandpur district, farmers were engaged with rice-fish farming system (RFFS), the rice-mustard farming system (RMFS), and the rice-vegetable farming system (RVFS).

Rice fish farming system (RFFS): As shown in Table 4.2 in Thoubal district, Imphal East district and Senapati district, two methods of RFFS were observed. First method was cultivated in both pre-kharif season (Feb-May) and kharif season (July-Nov). In this method fish farming was integrated with rice crop which is also known as simultaneous method. In second method rice and fish farming was done separately *i.e.* rice crop was cultivated in kharif season (July-Nov) and fish farming was done after harvesting the kharif rice. This method is known as rotational method. Farmers were engaged in rice-fish farming system (RFFS) throughout the year. However, some leisure months were available viz., (June, December, and January) under first method of RFFS and (May and June) under second method of RFFS. During these months, farmers were busy with soil management, land preparation and construction of bunds in the field.

Rice mustard farming system (RMFS): As shown in Table 4.2 rice-mustard farming system (RMFS) was found as one of the major cropping patterns commonly practiced by the farmers in three districts *i.e.* Thoubal district, Imphal East districts and Churachandpur district. In RMFS, rice crop was cultivated in the kharif season (June–November) and mustard crop was cultivated in the rabi season (Nov–Mar), followed by rice cultivation. Farmers were engaged in most of the months however, some leisure months were available viz., (April and May) under RMFS. During these months farmers were busy with collecting firewoods from forest, plantation of trees, selling fruits and vegetables, soil management, land preparation and construction of bunds. These leisure months may be also utilized for training on farm nutrient management, protection

measure of pest and diseases, application of improved technology that enable minimum inputs utilization and sustainable.

Rice vegetable farming system (RVFS): As shown in Table 4.2 rice-vegetable farming system (RVFS) was found as one of the major cropping patterns commonly practiced by the farmers of Senapati districts and Churachandpur district. In RVFS, rice crop was cultivated in the kharif season (June–November) and vegetables crops were cultivated in the rabi season (Nov–Mar), followed by rice cultivation. Farmers were engaged in agriculture throughout the year however only one month *i.e.* April found as leisure month under RVFS. During this month farmers were busy with cleaning field, poughing, bed preparation, seeds collections and collection of animal manure. Under this farming system, majority farmers were reported that they require training on nursery production. Raising healthy nursery requires skills and knowledge about the scientific management so it is recommended that training on the technique of healthy seedling production and off-season vegetables nursery production should be conducted.

Table 4.2.2 Distribution of respondents based on the major cropping pattern of rice-based farming system

Rice-based farming practice	Districts								Overall (n=320)	
	Thoubal (n ₁ =80)		Imphal East (n ₂ =80)		Churachandpur (n ₃ =80)		Senapati (n ₄ =80)			
	f %		f	%	f	%	f	%	f	%
Farming system-I: Rice-fish farming system (RFFS)	40	12.50	40	12.50	0	0.00	40	12.50	120	37.50
Farming system-II: Rice-mustard farming system (RMFS)	40	12.50	40	12.50	40	12.50	0	0.00	120	37.50
Farming system-III: Rice-vegetable farming system (RVFS)	0	0.00	0	0.00	40	12.50	40	12.50	80	25.00
Total									320	100

f: Frequency; %:Percentage

Table 4.2.2 showed the distribution of respondents based on the major cropping patterns found in Thoubal district, Imphal East district, Churachandpur district, and Senapati district under the rice-based farming system (RBFS). It was revealed that in Thoubal district, 12.50 percent of the respondents practiced rice-fish farming system (RFFS) and 12.50 percent respondents practiced rice-mustard farming system (RMFS). In Imphal East district, 12.50 percent of the respondents practiced a rice-fish farming system (RFFS), and 12.50 percent practiced a rice-mustard farming system (RMFS). In Churachandpur district, 12.50 percent of the respondents practiced rice-mustard farming system (RMFS) and 12.50 percent of them rice-vegetable farming system (RVFS). In Senapati district, 12.50 percent of respondents practiced rice-mustard farming system (RMFS) and 12.50 per cent of them practiced rice-vegetable farming system (RVFS). Overall, 37.50 percent of respondents practiced a rice-fish farming system (RFFS), 37.50 percent of respondents practiced a rice-mustard farming system (RMFS), and 25.00 percent of respondents practiced a rice-vegetable farming system (RVFS). It can be inferred that rice-vegetable farming system (RVFS) was the least cultivated rice-based farming system (RBFS) in the selected four districts. It may be due to rice-vegetable farming system required (RVFS) higher investment and more labourer for bed preparation and nursery transplantation, price fluctuation of vegetables in the market, post-harvest losses and lack of proper storage facilities.

4.2.3 Resources management

Table 4.2.3.1 Distribution of respondents based on the farm management practices under rice-based farming system (RBFS) of Thoubal district

S/N	District	Thoubal district				Overall (n ₁ =80)	
	Particulars	RFFS (n=40)		RMFS (n=40)			
		f	%	f	%	f	%
1.	Land preparation						
	Only Manual	0	0.00	0	0	0	0.00
	Both (Machine & manual)	40	100	40	100	80	100
2.	Variety of crop						
	Only local indigenous	10	25.00	6	15.00	16	20.00
	Only HYV	8	20.00	14	35.00	22	27.50
	Both (local & HYV)	22	55.00	20	50.00	42	52.50
3.	Nutrient Management	29	72.50	15	37.50	44	55.00
	Only Organic	11	27.50	25	62.50	36	45.00
	Both (Chemical & organic)						
4.	Water management						
	Rainfed	5	12.50	28	70.00	33	41.25
	Both (rainfed & irrigated)	35	87.50	12	30.00	47	58.75
5.	Weed management						
	Manual	8	20.00	12	30.00	20	25.00
	Chemical control	0	0.00	4	10.00	4	5.00
	Cultural control	32	80.00	24	60.00	56	70.00
6.	Pest management						
	Chemical control	0	0.00	11	27.50	11	13.75
	Biological control	14	35.00	10	25.00	24	30.00
	Physical control	6	15.00	9	22.50	15	18.75
	Cultural control	20	50.00	10	25.00	30	37.50
7.	Diseases management						
	Chemical control	0	0.00	12	30.00	12	15.00
	Biological control	18	45.00	16	40.00	34	42.50
	Physical control	5	12.50	2	5.00	7	8.75
	Cultural control	17	42.50	10	25.00	27	33.75
8.	Harvesting						
	Manual	40	100	0	0.00	40	50.00
	Machine	0	0.00	0	0.00	0	0.00
	Both (Manual & machine)	0	0.00	40	100	40	50.00
9.	Post-harvest management						
	Not process for sell	5	12.25	2	5.00	7	8.75
	Process and refine for sell	35	87.50	38	95.00	73	91.25
10.	Crop residue management						
	Surface mulch & in situ incorporation of residues in soil	0	0.00	40	100	40	50.00
	Crop residue as feed and plant nutrients	40	100	0	0.00	40	50.00

Table 4.2.3.1 presents the farm management under the rice-based farming system (RBFS) of Thoubal district, and it was revealed that in land preparation 100 percent farmers utilized ‘both manual and machine’ in the cultivation of the rice-fish farming system (RFFS) and the rice-mustard farming system (RMFS). In the selection of varieties, the majority (55.00%) farmers used ‘both local and HYV varieties’ in RFFS, and 50.00 percent of them used ‘both local and HYV varieties’ in RMFS. In nutrient management, the majority (72.50%) farmers used ‘only organic fertilizers’ in RFFS, and 62.50 percent farmers used ‘both organic and chemical fertilizers’ in RMFS. In water management, the majority (87.50%) farmers used ‘both rainfed and irrigated’ in the RFFS, and 70.00 percent farmers used ‘only rainfed irrigation’ in the RMFS. In weed management, the majority (80.00%) of the farmers used ‘cultural control’ weeds management in RFFS, and 60.00 percent farmers used ‘cultural control’ in the RMFS. In pest management, the majority (50.00%) of farmers used ‘cultural control’ in RFFS, and 27.50 percent of farmers used ‘chemical control’ of pest management in RMFS. In disease management, the majority (45.00%) farmers used ‘biological control’ in the RFFS, and 40.00 percent farmers used ‘biological control’ in the RMFS. In the cultivation practices of harvesting, 100 percent farmers practiced 'manual harvesting' in RFFS, and 100 percent of them used ‘both manual and machine’ for harvesting in the RMFS. In post-harvest management, 87.50 percent of farmers practice ‘processing and refinement for sale’ in RFFS, and 95.00 percent followed ‘processing and refinement for sale’ in RMFS. In crop residue management, 100 percent of farmers used ‘crop residue as feed and plant nutrients’ in the RFFS, and 100 percent farmers used 'surface mulch and in situ incorporation of residues in soil' in RMFS.

Overall, majority (100%) farmers practiced ‘both manual & machine’ in land preparation, 52.50 per cent selected ‘both HYV & local variety’, 55.00 per cent farmers used ‘organic fertilizers’ in nutrient management, 58.75 per cent farmers practiced ‘both rainfed & irrigated’ in water management, 70.00 per cent farmers practiced ‘cultural control’ in weed management, 37.50 per cent farmers practiced ‘biological control’ in pest management, 42.50 per cent used ‘biological control’ in

diseases management, 50 per cent farmers used ‘manual’ and 50 per cent farmers used ‘both machine & manual’ in harvesting, 91.25 per cent farmers followed ‘processing and refinement for sell’. In post-harvest management, 50.00 percent of farmers practiced ‘surface mulch and in situ incorporation of residues in soil’, and 50.00 percent of farmers practiced ‘crop residue as feed and plant nutrients’.

Table 4.2.3.1 presents the farm management under the rice-based farming system (RBFS) of Thoubal district, and it was revealed that 100 percent of farmers utilized ‘both manual and machine’ for land preparation in the cultivation practices of the rice-fish farming system (RFFS) and the rice-mustard farming system (RMFS). In the selection of varieties, the majority (55.00%) of farmers used ‘both local and HYV varieties’ in the rice-fish farming system, and 50.00 percent of farmers used ‘both local and HYV varieties’ in the RMFS. In nutrient management, the majority (72.50%) of farmers used ‘only organic fertilizers’ in RFFS, and 62.50 percent of farmers used ‘both organic and chemical fertilizers’ in RMFS. In water management, the majority (87.50%) of farmers used ‘both rainfed and irrigated’ in the RFFS, and 70.00 percent of farmers used ‘only rainfed irrigation’ in the RMFS. In weed management, the majority (80.00%) of farmers practiced ‘cultural control’ of weeds in RFFS, and 60.00 percent of farmers practiced ‘cultural control’ in the RMFS. In pest management, the majority (50.00%) of farmers used ‘cultural control’ in RFFS, and 27.50 percent of farmers used ‘chemical control’ of pest management in RMFS. In disease management, the majority (45.00%) of farmers practiced ‘biological control’ in the RFFS, and 40.00 percent of farmers practiced ‘biological control’ in the RMFS. In the cultivation practices of harvesting, 100 percent of farmers practiced 'manual' in the RFFS, and 100 percent of farmers used ‘both manual and machine’ for harvesting in the RMFS. In post-harvest management, 87.50 percent of farmers practice ‘processing and refinement for sale’ in RFFS, and 95.00 percent followed ‘processing and refinement for sale’ in RMFS. In crop residue management, 100 percent of farmers used ‘crop residue as feed and plant nutrients’ in the RFFS, and 100 percent of farmers used 'surface mulch and in situ incorporation of residues in soil’ RMFS.

Table 4.2.3.2 Distribution of respondents based on the farm management practices under rice-based farming system (RBFS) of Imphal East district

S/N	District	Imphal East district				Overall (n ₂ =80)	
	Particulars	RFFS (n=40)		RMFS (n=40)			
		f	%	f	%	f	%
1.	Land preparation						
	Only Manual	0	0.00	0	0.00	0	0
	Both (Machine & manual)	40	100	40	100	80	100
2.	Variety of crop						
	Only local indigenous	9	22.50	4	10.00	13	32.50
	Only HYV	15	37.50	19	47.50	34	85.00
	Both (Local & HYV)	16	40.00	17	42.50	33	82.50
3.	Nutrient Management						
	Only Organic	25	62.50	20	50.00	45	56.25
	Both (Chemical & organic)	15	37.50	20	50.00	35	43.75
4.	Water management						
	Rainfed	2	5.00	28	70.00	30	37.50
	Both (Rainfed & irrigated)	38	95.00	12	30.00	50	62.50
5.	Weed management						
	Manual	2	5.00	5	12.50	7	8.75
	Chemical control	0	0.00	8	20.00	8	10.00
	Cultural control	38	95.00	27	67.50	65	81.25
6.	Pest management						
	Chemical control	0	0.00	13	32.50	13	32.50
	Biological control	18	45.00	14	35.00	32	40.00
	Physical control	2	5.00	5	12.50	7	8.75
	Cultural control	20	50.00	8	20.00	28	35.00
7.	Diseases management						
	Chemical control	0	0.00	12	30.00	12	30.00
	Biological control	18	45.00	16	40.00	34	42.50
	Physical control	5	12.50	2	5.00	7	8.75
	Cultural control	17	42.50	10	25.00	27	33.75
8.	Harvesting						
	Manual	40	100	0	0.00	40	50.00
	Machine	0	0.00	0	0.00	0	0
	Both (manual & machine)	0	0.00	40	100	40	50.00
9.	Post-harvest management						
	Not follow processing for sell	5	12.50	4	10.00	4	5.00
	Follow processing and refinement for sell	35	87.50	36	90.00	76	95.00
10.	Crop residue management						
	Surface mulch & in situ incorporation of residues in soil	0	0.00	40	100	40	50.00
	Crop residue as feed and plant nutrients	40	100	0	0.00	40	50.00

Table 4.2.3.2 presented the farm management under rice base farming system (RBFS) of Imphal East district and it was reported that 100 per cent farmers used ‘both machine and manual’ for land preparation in rice-fish farming system (RFFS) and rice-mustard farming system (RMFS). In the selection of variety, majority (40.00%) farmers used ‘both HYV and local variety’ in RFFS and 47.50 per cent farmers used ‘only HYV’ in RMFS. In nutrient management, majority (62.50%) farmers used ‘organic fertilizers’ in RFFS and 50.00 per cent farmers used ‘organic fertilizers’ in RMFS. In water management, majority (95.00%) used ‘both rainfed and irrigated’ in RFFS and 70.00 per cent used rainfed water in RMFS. In weed management, majority (95.00%) farmers used ‘cultural control’ in RFFS and 67.50 per cent farmers used ‘cultural control’ in RMFS. In pest management, majority (50.00%) used ‘cultural control’ in RFFS and 35.00 per cent used ‘biological control’ in RMFS. In diseases management, majority (45.00%) farmers used ‘biological control’ in RFFS and 40.00 per cent farmers used ‘biological control’ in RMFS. In harvesting, 100 per cent farmers used ‘manual’ harvesting in RFFS and 100 per cent farmers used ‘both manual & machine’ for harvesting in RMFS. In post-harvest management, majority (87.50%) farmers followed ‘processing and refinement for sell’ in RFFS and 90.00 per cent farmers followed ‘processing and refinement for sell’ in RMFS. In crop residue management, 100 per cent farmers used ‘crop residue as feed and plant nutrients’ in RFFS and 100 per cent farmers used ‘surface mulch & in situ incorporation of residues in soil’ in RMFS. In overall category of farm management, majority (100%) farmers practiced ‘both manual & machine’ in land preparation practices, in selection of variety 85.00 per cent farmers selected ‘HYV’, in nutrient management 56.25 per cent farmers used ‘organic fertilizers’, in water management 62.50 per cent farmers practiced ‘both rainfed & irrigated’, in weed management 81.25 per cent farmers practiced ‘cultural control’, in pest management 40.00 per cent farmers used ‘biological control’, in diseases management 42.50 per cent farmers used ‘biological control’, in harvesting 50 per cent farmers used ‘manual’ and 50 per cent farmers used ‘both machine & manual’, in crop residue management 50.00 per cent farmers practiced ‘surface mulch & in situ incorporation of residues in soil’ and 50.00 per cent farmers practiced ‘crop residue as feed and plant nutrients’.

Table 4.2.3.3 Distribution of respondents based on the farm management practices under rice-based farming system (RBFS) of Churachandpur district

S/N	District	Churachandpur district				Overall (n ₄ =80)	
	Particulars	RMFS (n=40)		RVFS (n=40)			
		f	%	f	%	f	%
1.	Land preparation						
	Only manual	40	100	40	100	80	100
	Machine & manual	0	0.00	0	0.00	0	0.00
2.	Variety of crop						
	Only local indigenous	14	35.00	7	17.50	21	26.25
	Only HYV	7	17.50	2	5.00	9	11.25
	Both (Local & HYV)	19	47.50	31	77.50	50	62.50
3.	Nutrient Management						
	Only Organic	40	100	31	77.50	71	88.75
	Both (Chemical & organic)	0	0.00	9	22.50	9	22.50
		0					
4.	Water management						
	Rainfed	36	90.00	32	80.00	68	85.00
	Both (rainfed & irrigated)	4	10.00	8	20.00	12	15.00
5.	Weed management						
	Manual	16	40.00	35	87.50	51	63.75
	Chemical control	0	0.00	0	0.00	0	0.00
	Cultural control	24	60.00	5	12.50	29	36.25
6.	Pest management						
	Chemical control	0	0.00	0	0.00	0	0.00
	Biological control	2	5.00	6	15.00	8	10.00
	Physical control	10	25.00	9	22.50	19	23.75
	Cultural control	28	70.00	25	62.50	53	66.25
7.	Diseases management						
	Chemical control	0	0.00	4	10.00	4	5.00
	Biological control	2	5.00	2	5.00	4	5.00
	Physical control	12	30.00	15	37.50	27	33.75
	Cultural control	26	65.00	19	42.50	45	56.25
8.	Harvesting						
	Manual	40	100	40	100	80	100
	Machine	0	0.00	0	0.00	0	0.00
	Both (manual & machine)	0	0.00	0	0.00	0	0.00
9.	Post-harvest management						
	Not process for sell	6	15.00	17	42.50	23	28.75
	Process and refine for sell	34	85.00	23	57.50	57	71.25
10.	Crop residue management						
	Both surface mulch & in situ incorporation of residues in soil	0	0.00	26	65.00	26	65.00
	Both crop residue as feed and plant nutrients	40	100	14	35.00	54	67.50

Table 4.2.3.3 presented the farm management under rice-based farming system (RBFS) of Churachandpur district and it was reported that majority (65.00%) farmers practiced ‘manual’ land preparation in rice-mustard farming (RMFS) and 75.00 per cent farmers practiced ‘manual’ land preparation in rice-vegetable farming system (RVFS). In the selection of variety, majority (52.50%) used ‘local variety’ in RMFS and 47.50 per cent used ‘only HYV’ in RVFS. In nutrient management, majority (55.00%) farmers used ‘organic fertilizers’ in RMFS and 62.50 per cent farmers used ‘organic fertilizers’ in RVFS. In water management, majority (85.00%) used ‘rainfed irrigation’ in RMFS and 55.00 per cent used ‘rainfed irrigation’ in RVFS. In weed management, majority (70.00%) farmers used ‘cultural control’ in RMFS and 55.00 per cent farmers practiced ‘manual’ in RVFS. In pest management, majority (37.50%) practiced ‘cultural control’ in RMFS and 30.00 per cent ‘biological control’ and ‘cultural control’ in RVFS. In diseases management, majority (57.50%) farmers used ‘cultural control’ in RMFS and 37.50 per cent farmers practiced ‘cultural control’ in RVFS. In harvesting, majority (87.50%) farmers practiced ‘manual’ harvesting in RMFS and 70.00 per cent farmers practiced ‘manual’ harvesting in RVFS. In post-harvest management, majority (75.00%) farmers practiced ‘processing and refinement for sell’ in RMFS and 52.50 per cent practiced ‘not process for sell’ in RVFS. In crop residue management, (55.00%) farmers practiced ‘surface mulch & in situ incorporation of residues in soil’ in RMFS and 60.00 per cent farmers used ‘crop residue as feed and plant nutrients’ in RVFS. In overall category of respondents in RBFS, majority (70.00%) farmers practiced ‘manual’ land preparation practices, in selection of variety 36.25 per cent farmers selected ‘HYV’, in nutrient management 58.75 per cent farmers used ‘organic fertilizers’, in water management 70.00 per cent farmers practiced ‘rainfed irrigation’, in weed management 55.00 per cent farmers practiced ‘cultural control’, in pest management 33.75 per cent farmers used ‘cultural control’, in diseases management 47.50 per cent farmers practiced ‘cultural control’, in harvesting 78.75 per cent farmers practiced ‘manual’ harvesting, in post-harvest management 61.25 per cent farmers followed ‘processing and refinement for sell’ and in crop residue management 52.50 per cent farmers practiced ‘crop residue as feed and plant nutrients’.

Table 4.2.3.4. Distribution of respondents based on the farm management practices under rice-based farming system (RBFS) of Senapati district

S/N	District	Senapati district				Overall (n=80)	
	Particulars	RFFS (n=40)		RVFS (n=40)			
		f	%	f	%	f	%
1.	Land preparation						
	Only manual	40	100	40	100	80	100
	Both (Machine & manual)	0	0.00	0	0.00	0	0.00
2.	Variety of crop						
	Only local indigenous	14	35.00	7	17.50	21	26.25
	Only HYV	7	17.50	2	5.00	9	11.25
	Both (local & HYV)	19	47.50	31	77.50	50	62.50
3.	Nutrient Management						
	Only Organic	40	100	31	77.50	71	88.75
	Both (Chemical & organic)	0.00	0.00	9	22.50	9	22.50
4.	Water management						
	Rainfed	36	90.00	32	80.00	68	85.00
	Both (rainfed & irrigated)	4	10.00	8	20.00	12	15.00
5.	Weed management						
	Manual	16	40.00	35	87.50	51	63.75
	Chemical control	0	0.00	0	0.00	0	0.00
	Cultural control	24	60.00	5	12.50	29	36.25
6.	Pest management						
	Chemical control	0	0.00	0	0.00	0	0.00
	Biological control	2	5.00	6	15.00	8	10.00
	Physical control	10	25.00	9	22.50	19	23.75
	Cultural control	28	70.00	25	62.50	53	66.25
7.	Diseases management						
	Chemical control	0	0.00	4	10.00	4	5.00
	Biological control	2	5.00	2	5.00	4	5.00
	Physical control	12	30.00	15	37.50	27	33.75
	Cultural control	26	65.00	19	42.50	45	56.25
8.	Harvesting						
	Manual	40	100	40	100	80	100
	Machine	0	0.00	0	0.00	0	0.00
	Both (manual & machine)	0	0.00	0	0.00	0	0.00
9.	Post-harvest management						
	Not process for sell	6	15.00	17	42.50	23	28.75
	Process and refine for sel	34	85.00	23	57.50	57	71.25
10.	Crop residue management						
	Both surface mulch & in situ incorporation of residues in soil	0	0.00	26	65.00	26	65.00
	Both crop residue as feed and plant nutrients	40	100	14	35.00	54	67.50

Table 4.2.3.4 presented the farm management under rice-based farming system (RBFS) of Senapati district and it was reported that 100 per cent farmers practiced ‘manual’ land preparation in rice-fish farming system (RFFS) and rice-

vegetable farming (RVFS). In the selection of variety, majority (47.50%) cultivate both 'local and HYV variety' in RFFS and 77.50 per cent farmers cultivate both 'local and HYV variety' in RVFS. In nutrient management, majority (100%) farmers used 'organic fertilizers' in RFFS and (77.50%) farmers used 'organic fertilizers' in RVFS. In water management, majority (90.00%) farmers cultivated with 'rainfed irrigation' in RFFS and 80.00 per cent farmers cultivate with 'rainfed irrigation' in RVFS. In weed management, majority (60.00%) farmers practiced 'cultural control' in RFFS and 87.50 per cent farmers practiced 'manual' in RVFS. In pest management, majority (70.00%) farmers practiced 'cultural control' in RFFS and 62.50 per cent farmers practiced 'cultural control' in RVFS. In diseases management, majority (65.00%) farmers practiced 'cultural control' in RFFS and 42.50 per cent farmers practiced 'cultural control' in RVFS. In harvesting, 100 per cent farmers practiced 'manual' harvesting in RFFS and 100 per cent farmers practiced 'manual' harvesting in RVFS. In post-harvest management, majority (85.00%) farmers followed 'processing and refinement for sell' in RFFS and 57.50 per cent farmers 'do not follow processing for sell' in RVFS. In crop residue management, 100 per cent farmers 'practiced crop residue as feed and plant nutrients' in RFFS and 65.00 per cent farmers practiced 'surface mulch & in situ incorporation of residues in soil' in RVFS.

In the overall category of respondents, majority (100%) of the farmers practiced 'manual' land preparation practices, 62.50 per cent cultivate 'both local and HYV', 88.75 per cent used 'organic fertilizers' in nutrient management, 85.00 per cent farmers cultivate practiced 'rainfed irrigation' in water management, 66.25 per cent practiced 'cultural control' in pest management, 56.25 per cent practiced 'cultural control' in diseases management, in harvesting 100 per cent farmers practiced 'manual' and in post-harvest management 67.50 per cent farmers practiced 'crop residue as feed and plant nutrients' in RBFS.

4.2.4 Farm resource management

4.2.4.1 Farm resource management for Farming System I: Rice-Fish Farming System (RFFS)



Plate 1: Field structure for rice-fish farming system in Imphal East and Thoubal district

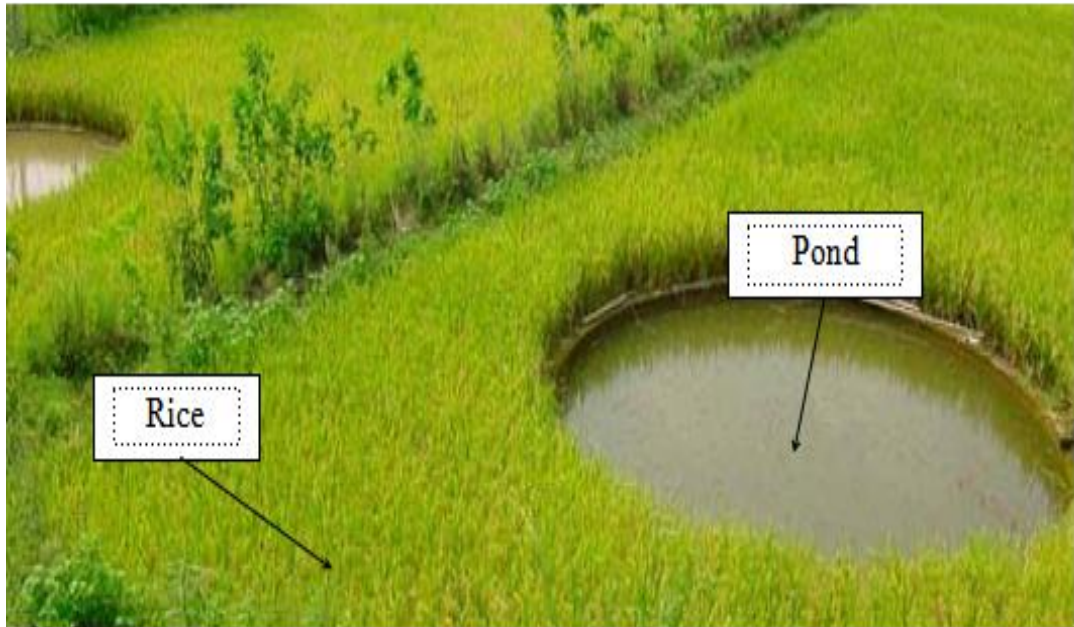


Plate 2: Field structure for rice-fish farming system in Senapati district

1. Field preparation for RFFS

For the cultivation of RFFS, traditional rice fields need to be modified for better fish shelter and harvesting. Rice fields require to construct trenches, dykes, and ponds that provide a suitable area for fish.

1.2 Construction of a pond and trench in a rice field

The construction of trenches in RFFS significantly increases the water storage capacity. It provides a better environment for the fish; it helps to raise and stabilize the yield of both rice and fish. Trench helps fish to find food in the passway, and it is extremely helpful when the water level is low. Trenches and ponds are an easy way to collect fish when the rice field is drained. And these trench and ponds makes a better refuge for the fish. It also helps during fertilization, which prevents fish from any kind of injury from the chemicals.

It was observed that the trenches and ponds in the valley area, i.e., Imphal East district and Thoubal district, was construction in an integrated form where the trenches and ponds were dug from all sides of the field, or from one side, or at one corner of the field. The size of the trench varied from one farmer to another farmer; in Imphal East district and Thoubal district, it was observed that the majority of farmers constructed the trench with a depth of about 1.5 to 3.5 feet and a width of 2.5 to 3.5 feet. And the length of the trench was usually from 27 feet to 33 feet, whereas for farmers cultivated in large areas, the length of the trench was about 20 to 60 feet.

In the hilly area, i.e., Senapati district, pond system was commonly observed, and trenches were constructed separately at the edge of a rice plot. In Senapati district, it was observed that a pond was constructed with a size of about 1 to 2.5 sq. m. at the center of the rice field or at the corner or on one side of the field to collect the fish, and a trench was constructed at the edge of a rice plot of about 1.5 to 2.5 feet in width after the completion of bund construction and dug a small pit.

1.3 Dyke construction

Dyke prevents leakage of water; it helps to retain water up to the desired depth and also guards the escape of cultivated fish during floods. Dyke construction is needed to create water retention and keep the fish alive throughout the aquaculture process. Dyke was constructed around the rice plot with a height of 1.5 to 3.5 feet, depending on the topography of the plot and the tidal amplitude in the area.

2. Farm resource management under rice-fish farming

2.1 Selection of rice and fish varieties

In Thoubal district, the major cultivated rice varieties reported by the farmers were Dharum, Sanaphou, Loyalakpa, Thangjing, Brojen, Tolen, Koubru Phou, Thoibi, and Phouren, while in High Yield Variety, CAU-R1, Seva 307, Seva 314, RCM-9, and RCM-13 were reported by farmers.

In Imphal East district, the major cultivated rice varieties reported by the farmers were Dharum, Brojen, Moirang Phou, Tolen, Koubru Phou, Kakcheng, and Leibung, while in High Yield Variety (RCM-13, RCM-12), Seva-1, Seva-2, Seva-3, Hybrid 807, and Seva 314 were reported by farmers. It was also reported that the Dharum variety is the most suitable rice variety in RFFS as it has a thick stalk and is tolerant of standing against water submerged for a long duration as compared to other varieties.

In Senapati district, the major cultivated rice varieties reported by the farmers were the local varieties: Rommitei, Rureka, Rureta, Thukka, Thuktei, Kithuk, Ngaiha, Louru, Desha, Dharum, and red rice, while in high-yield varieties, RCM-9, Barjamani, KD-13, and KD-14 were reported by farmers.

Major fishes reported by the farmers from Thoubal, Imphal East and Senapati district were Common Carp (*Cyrus carpio*), Rohu (*Labeo rohita*), Mrigal Carp (*Cirrhinus cirrhosus*), Silver Carp (*Hypophthalmichthys molitrix*), Catla (*Labeo*

catla), Climbing Fish (*Anabas testudineus*), Tilapia (*Oreochromis niloticus*), Grass Carp (*Ctenopharyngodon idella*) etc were commonly cultivated in RFFS.

2.2 Cultivation practices of the Rice-Fish Farming System (RFFS)

From the study, it was observed that in Thoubal district and Imphal East district, RFFS was practiced in two crop cycles, i.e., the first crop cycle (Kharif season) and the second crop cycle (Pre-Kharif season). In the cultivation practices of RFFS, two methods of rice-fish cultivation were found in the study area, i.e., the simultaneous method (growing fish along with the rice at the same time) and the rotational method (growing rice and fish at different times). In Thoubal district and Imphal East district, both concurrent and rotational methods were observed, whereas in Senapati district, the majority of farmers cultivated the first crop cycle (Kharif season) i.e., rotational method of RFFS.

2.2.1 Method of farming in first crop cycle (Kharif season):

In the first crop cycle (Kharif season) from June-July to November, i.e., 150 days. RFFS were practiced in the Kharif season in the three districts i.e., Thoubal district, Imphal East district, and Senapati district. In this crop cycle, rice and fish were cultivated simultaneously. This method is also known as the concurrent method. In this method, rice and fish are cultivated in integrated form. Rice seeds are sown in the first week of June, and seedlings are transplanted into the main field after sowing for 30–40 days. As per the farmer reports, transplantation is more beneficial as it can maintain plant spacing for fish movements. The spacing of plants maintained by farmers was usually 10–30 inches (plant to plant). After 15 to 20 days of rice transplantation, fish were released into the rice field by collecting fish from the fish stocking ponds. During this time, the water level of the rice field was maintained at 1.5 feet for around 40 days. For weeding, it was done manually before 45 days from the day of the transplantation of the rice crop. For weeding, the rice field was drained, and fish took refuge in the trenches. Then the rice field is refilled again after being weeded by maintaining a water level of about 2–2.5 feet. However, the majority of farmers avoid manual weeding and instead farmers cultivate grass carp for weed

control. Thus, the labor required for weeding was eliminated, which reduced the labor cost. Weedicides were also avoided by all the farmers in the RFFS as they may cause pollution in ponds or cause fish death. Trench maintenance in the corner of the field allows for fish refuge, makes weeding and fertilizer management easier, and also helps prevent damage caused by sunlight. To harvest the rice grain, farmers drained out water in the trenches or ponds, leaving up to 3–4 inches of water level. Then rice grain was harvested in the first week of November by cutting $\frac{1}{4}$ length of the rice stalk. Fish were also harvested during the month of November, around the 3rd week, on the occasion of one of the biggest festivals, 'Ningol Chakhouba' in Manipur. And some farmers continue to stock the fish by refilling the water in the rice field up to 3 feet to harvesting around the 1st week of January, in the 'Emoinu' festival. The harvested fish ranges from 0.800 to 3 kg per fish. After harvesting was done, the rice field was cleaned and made free from rice crop stubbles. It was let dry for around 3–4 weeks (February-March) and then flooded (April) with around 1-2 inches of water. In May first plough was done and then the field was ready for next-season rice cultivation after two or three plough.

In Senapati district, it was observed that rice cultivation was a little earlier than in Imphal East district and Thoubal district. In this district, most of the farmers cultivated RFFS using the rotational method. Rice seeds were sown in the first week of May, and after sowing for 35–45 days, rice seedlings were transplanted into the main field. The spacing of plants maintained by farmers was usually 10–25" inches (plant to plant). After about 20 days of rice transplantation, fish were released into the rice field by collecting fish from the fish stocking ponds or readily available from the market. During this time, the water level was maintained at 1.5 feet for around 40 days. Weeding was done either manually before 45 days from the day of the transplantation of the rice crop or by releasing grass carp in the rice field to control the weeds. So, the labor required for weeding was eliminated, which reduced the labor cost. Weedicides were avoided by all the farmers in the rice-fish farming system as they may cause pollution in ponds or cause fish death. To harvest the rice grain, farmers drained out water into the trenches or ponds, leaving up to 3–4 inches of water level. Then rice grain is harvested in the first week of October by cutting $\frac{1}{4}$

length of the rice stalk. After harvesting the rice crop, the field is turned into a pond by fully flooding and refilling the water with a drainpipe. Then the fingerlings from the stocked pond or trench were released into the rice field directly. The released fingerlings fed on the rice stubble or cut off stock, then the fish is ready to be harvested in February-March. In April, land preparation started with once or twice plowing, and the field was ready for next-season rice cultivation.

2.2.2 Method of farming in second crop cycle (pre-Kharif season):

Pre-Kharif season practices of RFFS are found only in two districts, i.e., Imphal East district and Thoubal district. Second crop (pre-Kharif season): the duration of the crop cycle was about 90 days from February-March to May; this crop cycle emphasized on fish. In the second crop cycle, rice seeds are sown during the first week of February, and after 25–30 days of sowing, seedlings are transplanted into the main field. When the rice attains the early stem elongation stage (41–50 days after transplanting), the rice stock becomes stronger and sturdier, and the first batch of fingerlings are harvested from the stock pond or readily available from the market and released into the rice field. Only Rohu, Mrigal, and Common Carp fingerlings of small size (20–30 cm) were released in the rice field. A grass carp of smaller size, 40–50 cm long, was also released during the second batch. This prevents them from feeding onto the rice crop as the stock of rice becomes hard and sturdy, and they only feed on the leaves grooving downward. Grass carp control the weed growth in the rice field. And the water level was maintained at about 2–2.5 feet until the rice was ready for harvest. When the rice grain was ready to harvest, farmers drained out water into the trenches or ponds. Then rice grain was harvested in the 3rd week of May by cutting $\frac{1}{4}$ length of the rice stalk. After harvesting the rice crop, the field was turned into a pond by fully flooding and refilling the water with a drainpipe. Then the fingerlings from the stocked pond or trench were released into the rice field directly. The released fingerlings fed on the rice stubble or cut off stock. Supplementary feeds were also given twice a day if necessary but mostly fed on grasses.

2.2.3 Nutrient management and farm component interaction in RFFS

From the study, it was observed that farmers practiced RFFS primarily using organic fertilizers. The majority of farmers avoided using higher doses of chemical fertilizers and instead used organic manure (poultry droppings, pig excreta, cow dung, and plant waste) and nutrient fixation plants like Azolla. In monocrop rice cultivation, application of fertilizers is normally required about three times in one crop cycle; however, in RFFS, farmers apply fertilizer (15–20 kg of nitrogen and potash mix per 0.25 hectare) once during the entire crop cycle if needed. And the majority of farmers grow Azolla in rice fields throughout the cropping period, which helps in providing rice nutrients.



Plate 3: Field of rice-fish farming system and its component

Azolla microphylla is an aquatic fern and an inexpensive feed for fish. Azolla served as an in-situ fresh food for the macro-phytophagous fish, which improved the fish food and gradually increased fish production. Azolla is used as a feed for fish as well as a bio-fertilizer by fixing N_2 from the air. The interaction among the components of rice-fish cultivation improved soil nutrients and increased production of rice as well as fish. Fish culture in rice fields loosens the soil as a result of their swimming, thus aerating the soil, enhancing the decomposition of organic

matter, and promoting the release of nutrients from the soil. The excreta of fish directly fertilize the water in rice fields, leading to an increase in the utilizable source of nitrogen for the rice crop. Integration of allied components like azolla and fish with rice farming could provide a wider scope for bio-resource recycling. Apart from this, highly fertile zooplankton, phytoplankton, and a large number of filamentous algae were developed in the rice field. Fish consume zooplankton, phytoplankton, algae, and weeds that compete with rice; hence, fish play an important role in the soil and nutrient stability of the rice crop. Pesticides and other chemicals were eliminated in the management practices; farmers usually managed with biological or physical control and cultural practices of pest and disease management. Most of the farmers reported that in RFFS, fish can minimize diseases and pest outbreaks, thereby reducing the application of pesticides that can pollute soil and fish. Rice crop residue, like rice stalks or cut-off stalks of rice, was also fed by fish.

3. Benefits of RFFS as perceived by respondents

1. There is no need to keep fish supplementary food because fish food is already available at the rice field.
2. Pesticides and chemicals are free in the field.
3. Rice crop residue is the best food for fish.
4. Reduce farm inputs such as labor costs, fertilizer requirements, and weeding costs.
5. Profit is more than 50% from the investment, a good source of income generation from farm activity.

4. Challenges faced by farmers in RFFS

1. Difficulty harvesting rice crops.
2. Need to protect birds in the pre-kharif season crop cycle.
3. Climate change and changes in rainfall patterns make farming difficult.
4. It is difficult to grow rice seedlings due to the low temperature during the pre-kharif season.
5. If the water level increases in a rice field, it causes fish death.

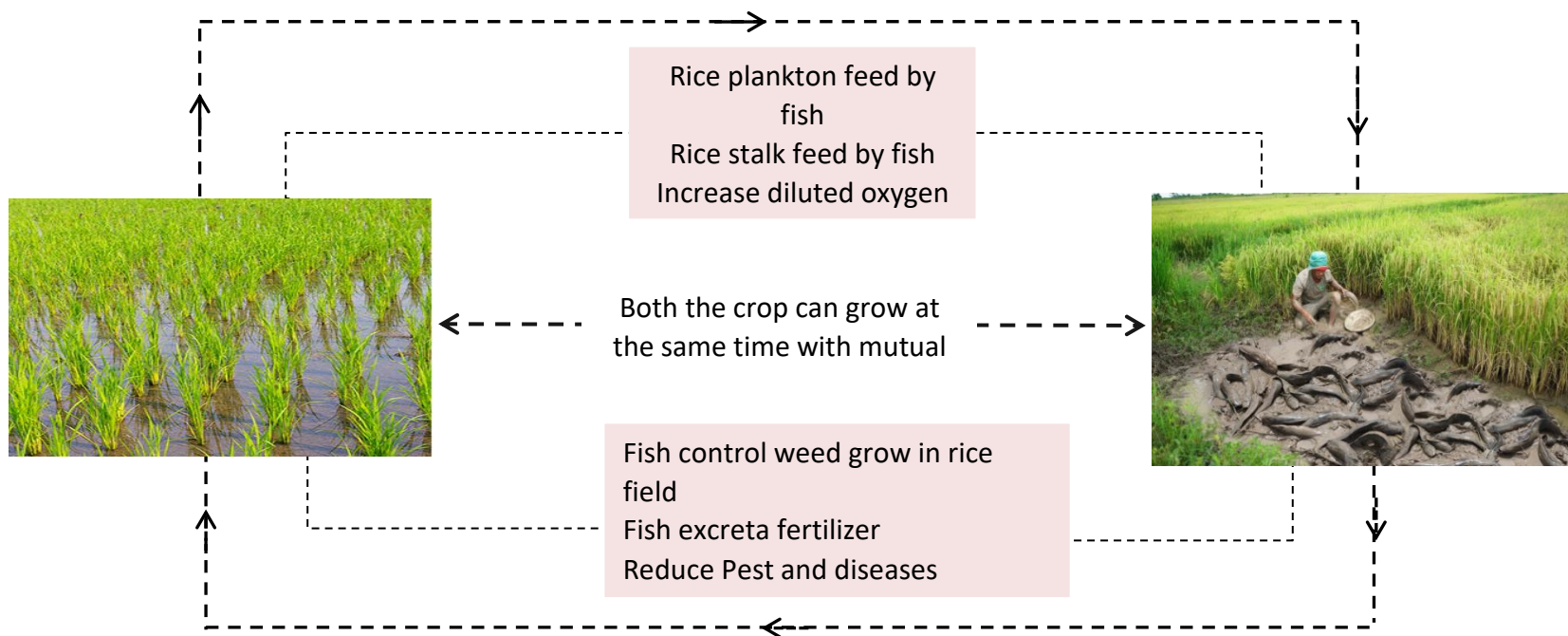


Fig 4.2.4.1: Interaction of farm resources components in rice-fish farming system

4.2.4.2 Farming system II: Rice-Mustard farming system (RMFS)



Plate 4: Field of a rice-mustard farming system at hill region

In the study, it was found that rice-mustard farming system (RMFS) was predominantly cultivated in three districts, i.e., Imphal East district, Thoubal district, and Churachandpur district. It was observed that zero-tillage mustard or rapeseed was cultivated in Rabi season after harvesting rice crop, which was cultivated in Kharif season. Mustard was cultivated after harvesting the rice crop, which helped in utilizing the residual moisture in the rice field. Mustard and rapeseed were the predominant crops grown in the rainfed area during the rabi season after the harvested rice crop. Normally, no irrigation is required in the rapeseed-mustard as it is sown on residual soil moisture and receives one or two showers during the October and November months. RMFS reduced the cost of cultivation and improved the soil condition with the addition of organic matter over time. The duration of practicing zero-tillage RMFS in the selected study area was from November 2nd week to March 1st week.

1. Land preparation:

From the study, it was reported that rice crop was grown in the Kharif season, i.e., May/June to October/November. Land preparation for growing mustard started from October (last week) to November (1st week) followed by rice cultivation. In the land preparation, the majority of farmers threshed out rice straws and thinly scattered them over the entire rice field to serve as mulch for conserving soil moisture and providing nutrients. However, some farmers burned the straw to kill weed plants and diseases that remain in the soil. After 7–10 days, the field was ready for sowing the seeds.

2. Varieties commonly grown in the study area:

In Thoubal district, the major cultivated rice varieties reported by the farmers were Dharum, Sanaphou, Loyalakpa, Thangjing, Brojen, Tolen, Koubru Phou, Thoibi, and Phouren, while in High Yield Variety, CAU-R1, Seva 307, Seva 314, RCM-9, and RCM-13 were reported by farmers.

In Imphal East district, the major cultivated rice varieties reported by the farmers were Dharum, Brojen, Moirang Phou, Tolen, Koubru Phou, Kakcheng, and Leibung, while in High Yield Variety (RCM-13, RCM-12), Seva-1, Seva-2, Seva-3, Hybrid 807, and Seva 314 were reported by farmers.

In Churachandpur district, the major rice varieties cultivated were Rommitei, Rureka, Rureta, Thukka, Thuktei, Kithuk, Ngaiha, Louru, Desha, Dharum, Kd, Barjamani, KD-13 and KD-14.

The mustard varieties commonly cultivated by the farmers in the Thoubal, Imphal East and Churachandpur district were local (Yella, Andang, Amubi) and HYV (NRCHB-101, TS-36, TS-38, Toria-38, M-27, Ragini).

3. Seed rate and sowing time:

In the study it was found that the seed rate of mustard usually used by farmers was about 3–6 kg per hectare of land. Most of the farmers sown mustard from October (last week) to November (3rd week), while some farmers sown very late (1st week of December). Late sowing caused moisture stress and higher pest infestation.

4. Water and weeding management:

It was reported that in cases of moisture stress, farmers irrigated mustard crop once at the flowering stage to obtain a good yield. However, most of the farmers follow rainfed irrigation. In case of weed management in mustard crop farmers followed cultural practices (thinning operations or burning fields to reduce the weed effect) in zero-tillage RMFS that help the growth and development of crop plants.

5. Pest and disease management:

Farmers reported that the major insect pests of mustard include aphids (*Lipaphis erysimi*) and painted bugs (*Bagrada hilaris*), which threaten the crop right from sowing until the end of the crop season. White rust (*Albugo candida*), Sclerotinia rot (*Sclerotinia sclerotiorum*), Alternaria blight (*Alternaria brassicae*), and powdery mildew (*Erysiphe cruciferum*) were the major diseases that reduced the yield potential of rapeseed mustard substantially. To control pests and diseases, farmers' practices included cultural control and physical control methods like irrigation of crops at the seeding stage to protect against painted bugs, maintenance of weed-free crops by clean cultivation, regular monitoring of crops, and destruction of pest-infested or infected plants. As per the farmers reports, early sowing helped to recede the mustard crop from damages caused by white rust and aphids.

6. Harvesting

As per the farmer report, mustard was harvested as soon as the pods turn yellowish-brown and normally that farmers harvest after 90–105 days of sowing from

February to March. Harvesting and threshing of mustard was done manually. The crop was harvested with the help of sickles. The harvested crop was stacked on the threshing floor for 5–6 days before threshing. Then threshing was done very easily with the help of sticks. The threshed grain was separated from the husk with the help of a slow-moving natural air current. The cleaned seed was dried in the sun for 4-5 days, and then the seeds were ready for making mustard oil.

7.Crop residue management and farm component interaction in RMFS

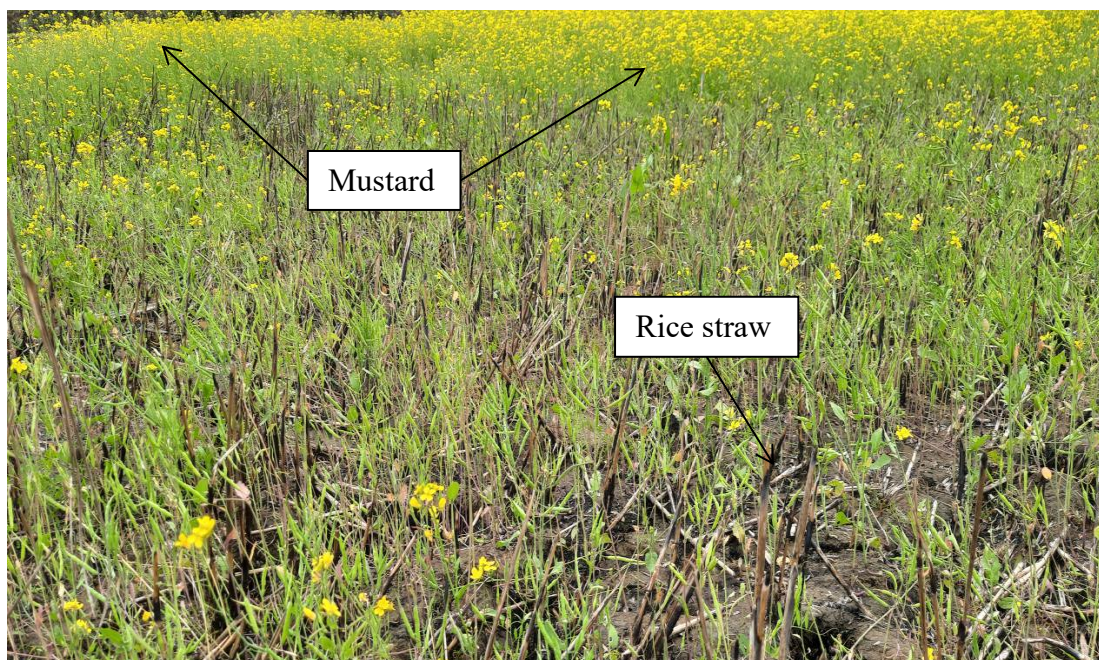


Plate 5: Field of a rice-mustard farming system in valley region

In the study, it was observed that in the rice field, sufficient residual moisture was available, as it holds enough moisture from the last-season crop (rice crop). Farmers sown mustard with zero or minimum tillage to avoid soil moisture loss. The crop residues of rice cultivation include rice stalks, stubble's, leaves, and seed pods, which help prevent soil moisture loss and provide nutrients to the mustard plant. The residue from the previous harvest was scattered and spread over the rice field to protect the soil from being damaged by the sun or frost. And this crop residual allows for an even breakdown of nutrients and other organic matter. The residue of the rice crop acts as fertilizer and eliminates the need to add extra chemical fertilizers, and mulching with rice straw resulted in a significant increase in mustard yield. It also

helped in conserving soil moisture, reducing weed problems, and maintaining soil temperature.

Farmers reported that the standing rice stubbles retained up to 30 cm for better conservation of soil moisture and does not necessarily need watering. As the residue spreads on the field, it protects the water in the soil from evaporating, allowing the field to absorb more water and reducing the amount of runoff, which helps increase the stability of water absorption. The crop residues of rice help form additional soil components increased in soil microbes that lead to a healthier network of food production and support a wide variety of soil microorganisms and insects to grow. As per the farmer reports, weeds continue to grow on no-till farms and require the use of herbicides to be eliminated. Otherwise, the field residues of rice cultivation can increase the efficiency of irrigation and control soil erosion, which has a beneficial effect on soil fertility and productivity.

8. Benefits of RMFS as perceived by respondents

1. Reduced cost of cultivation.
2. Increased cropping intensity.
3. Earned an additional income with less effort.
4. Conserves soil moisture, requires less water, and saves tillage costs and time.
5. Soil is protected from erosion.

9. Challenges faced by farmers in RMFS

1. Low moisture content in the uplands after Kharif rice
2. The fast decline in water table during the winter season in uplands areas has adverse effects on the productivity of the crops.
3. Increased pest incidence in late sowing

Rice cultivated in Kharif season (June-Nov)

Rice harvested before mid-November



Mustard cultivated in Rabi season (Nov-Mar)

Mustard sow after mid-November

Zero Tillage method



Rice field preserve
enough moisture
to grow mustard

Rice stalk residue -
prevent moisture
loss

Stalk residue and
straw give
compost and
nutrients

Reduce pest and diseases infestation

Improve soil quality and soil microorganism

Fig 4.2.4.2: Interaction of farm resources components in rice-mustard farming system

4.2.4.3 Farming System III: Rice-Vegetable Farming System (RVFS)

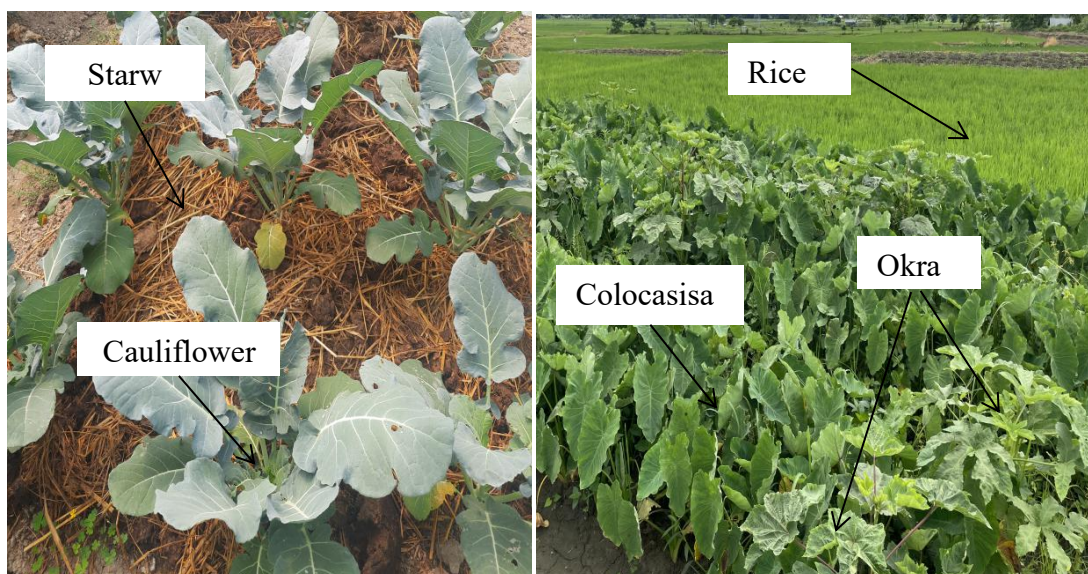


Plate 6 Field of a rice-vegetables farming system

Rice-vegetable farming system (RVFS) is majorly cultivated in Senapati district and Churachandpur district. In this farming practice, rice was cultivated in the Kharif season (May–October) whereas vegetables were cultivated in the Rabi season (November–March–April) followed by rice cultivation.

From the study, it was observed that mustard was cultivated, followed by rice crop. Land preparation in RVFS started for rice crop was started in April and vegetables in October (last week) to November (1st week). Farmers ploughed 2-3 times after harvesting the rice crop and the crop residue was incorporated while plowing. In Churachandpur district, plowing was done with both machines and manuals, whereas in Senapati district, plowing was done manually by using a spade and other small implements. Major rice varieties cultivated were Rommitei, Rureka, Rureta, Thukka, Thuktei, Kithuk, Ngaiha, Louru, Desha, Dharum, Kd, Barjamani, KD-13 and KD-14.

And major vegetable crop grown in the RVFS were colocasia, ginger, turmeric, cabbage, cauliflowers, maize, potatoes, pumpkins, and guards. Farmer from Churachandpur district and Senapati district reported that rice crop sown in May and

vegetable crops were sown in the November followed by rice cultivation. And weeding for vegetables crop was done manually 2-3 times in Churachandpur district and Senapati district. For fertilizer management, framers used both organic and chemical fertilizers in both districts and majority of farmers were followed rainfed cultivation. The harvesting of rice crop was done in October and for vegetables in late February–March.

2. Crop residue management and farm component interaction in RVFS



Plate 7 Rice-vegetables cultivated field in Senapati district

In the upland area, RVFS was a common practice, especially under Jhum cultivation and terrace-cultivated areas. Two methods of cultivation under rice-vegetable farming were observed, i.e., rice and vegetables cultivated simultaneously (cultivating rice and vegetables in an integrated manner) and rationally (cultivating vegetables crop followed by rice crop). In the simultaneous cultivation of rice and vegetables, over 60% of the field is occupied by the rice crop and the remaining area is allotted for the plantation of different varieties of seasonal vegetables. In the case of rotational cultivation, rice crops are planted during the Kharif season (May–Oct) and vegetables crops are planted during the Rabi season (Nov–Feb).

In RVFS, rice residues were the most important component, and the recycling of its residue played a major role in providing plant nutrients. Rice bran, rice husk straw, and rice stalk residue were fully utilized, and these components were interconnected with the vegetable's cultivation. Traditionally, farmers burned straw in the field as a quick and easy method of disposal, while some farmers incorporated straw into the soil as a common management practice that helped improve fertility. Recycling materials and energy through re-connecting crop and livestock production also becomes indispensable in RVFS.

Rice bran and straw are used as food for animals like cows and pigs, and the waste of animals in return provides nutrients to the plants. The stalk and the stubble remain in the field, preserving soil moisture and providing nutrients. Farmers commonly use straw for mulching vegetable crops to prevent soil moisture loss. In the nutrient cycle, rice straw returns to the soil; the stubbles usually retained in situ and either incorporated burned ash or incorporated fresh rice residue into the soil during land preparation. This process is associated with the benefits of improving soil quality and recycling nutrients. All the components in the production system of RVFS were interconnected with mutual benefits. As per the farmers report, continued mono-cropping exerted pressure on the weed community, favoring weed species with phenotypes and phenologies that are similar to rice, such as weedy rice and *Echinochloa spp.*, known as Urichak in the local language.

Moreover, the intensive use of chemical herbicides and pesticides may increase the resistant species of weeds, diseases, and pests. Crop rotation in RVFS strategies may not eradicate troublesome species, but it can limit the potential threats to the crops. Cultivation of vegetables in Rabi season, followed by rice crop, improved weed control. In the integrated rice-vegetable farming system, plantations of cover crops improve nutrient dynamics, soil organic matter content, microbial activity, water retention, and prevent nitrate leaching. Returning rice crops such as straws improved overall soil conditions, reduced the requirement for N fertilizers, and supported sustainable rice productivity. Rice plants provide straw and bran for cattle

as feed, and cattle produce manure, which is used as organic fertilizer for rice crops. It can increase the production and productivity of rice crops and increase farmers' income. There is a reciprocal relationship in all the components of the RVFS.

3. Benefits of RMFS as perceived by respondents

1. Increase family income
2. Provide food for the family and reduce family expenditures.
3. Reduces diseases, pests, and weed infestations.

4. Challenges faced by farmers in RMFS

1. Difficult to used technology like seeds driller and tractor in terrace and jump cultivated area.
2. Lack of a water reservoir tank
3. Difficult for transportation and high labour cost
4. Low productivity of rice as compared with the valley area
5. Lack of availability of farm inputs

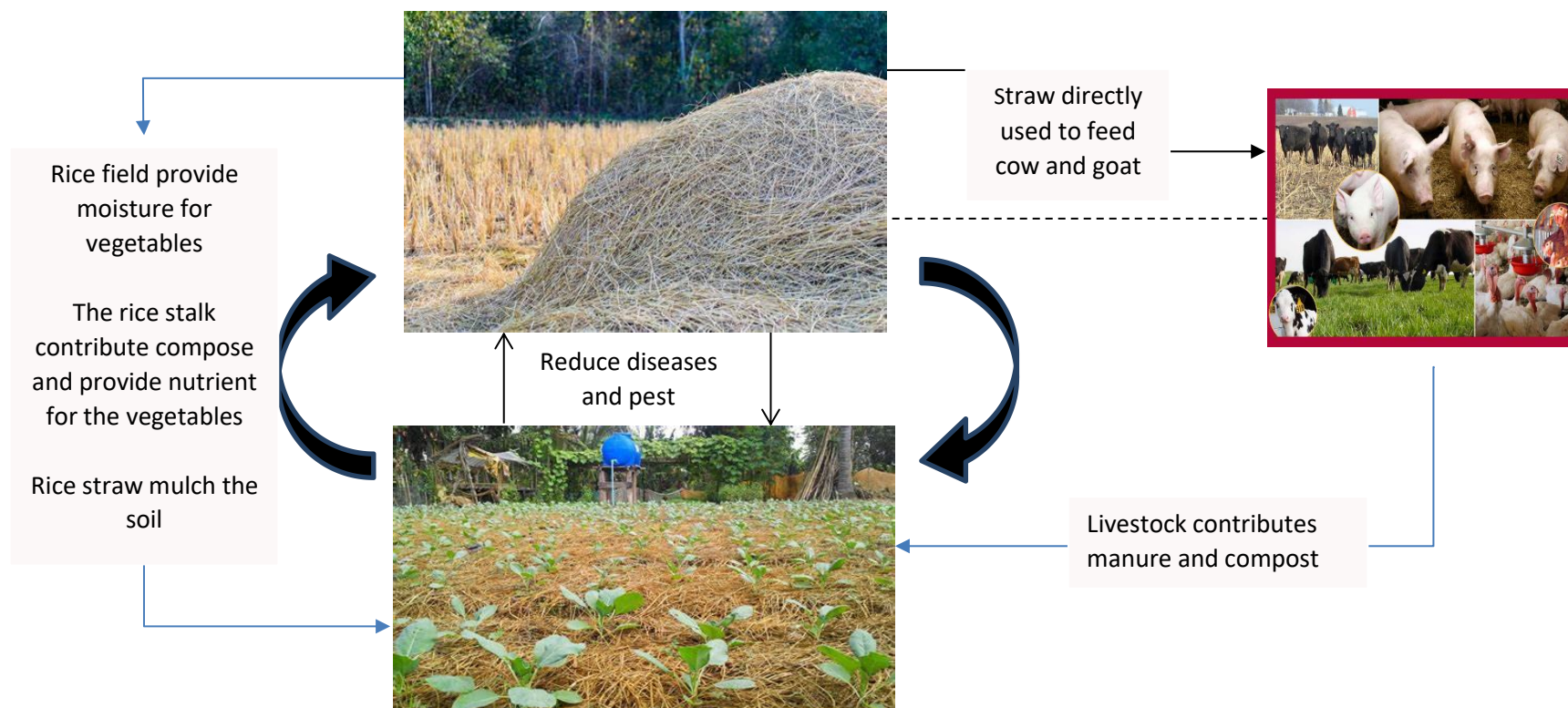


Fig 4.2.4.3: Interaction of farm resources components in rice-vegetables farming system

4.3 Attitude and extent of adoption of sustainable agriculture practices under rice-based farming system

4.3.1 Attitude

Table 4.3.1.1 Distribution of respondents based on their attitude towards the adoption of sustainable agricultural practices

Districts	Level of attitude	f	%	Mean	SD	Attitude Index
Thoubal n₁=80	Less favourable (<39.24)	6	7.50	45.00	5.76	64.29
	Favourable (39.24-50.76)	59	73.75			
	Highly favourable (>50.76)	15	18.75			
Imphal East n₂=80	Less favourable (<40.89)	5	6.25	47.89	7.00	68.41
	Favourable (40.89-54.98)	54	67.50			
	Highly favourable (>54.89)	21	26.25			
Churachandpur n₃=80	Less favourable (<40.02)	4	5.00	46.20	6.18	66.00
	Favourable (40.02-52.38)	60	75.00			
	Highly favourable (>52.38)	16	20.00			
Senapati n₄=80	Less favourable (<38.63)	10	12.50	44.04	5.41	62.91
	Favourable (38.63-49.45)	59	73.75			
	Highly favourable (> 49.45)	11	13.75			
Overall n=320	Less favourable (<39.28)	25	7.81	45.37	6.09	65.40
	Favourable (39.28-51.46)	232	72.50			
	Highly favourable (> 51.46)	63	19.69			

f:Frequency; %:Percentage

Table 4.3.1.1 and Fig 4.3.1.1 depicts the level of attitude of farmers from the selected districts of Manipur towards adoption of sustainable agricultural practices. It was revealed that majority (73.75%) of the respondents had favourable attitude towards

the adoption of sustainable agricultural practices followed by 18.75 per cent of the respondents had highly favourable attitude and 7.50 per cent of the respondents had less favourable attitude in Thoubal district with 64.29 attitude index. In Imphal East district, majority (67.50%) of the respondents had favourable attitude followed by 26.25 per cent of the respondents had highly favourable attitude and 6.25 of the respondents had less favourable attitude towards the adoption of sustainable agricultural practices with 68.41 attitude index. In Churachandpur district, majority (75.00%) of the respondents had favourable attitude followed by 20.00 per cent of the respondents had highly favourable attitude and 5.00 per cent of the respondents had less favourable attitude towards the adoption of sustainable agricultural practices with 66.00 attitude index. In Senapati district, majority (73.75%) of the respondents had favourable attitude followed by 13.75 per cent of the respondents had highly favourable attitude and 12.50 per cent of the respondents had less favourable attitude towards the adoption of sustainable agricultural practices with 62.91 attitude index.

Comprising all the selected districts it was found that majority (72.50%) of the respondents had favourable attitude followed by 19.69 per cent of the respondents had highly favourable attitude and 7.81 per cent of the respondents had less favourable attitude towards the adoption of sustainable agricultural practices with 65.40 attitude index. Similar findings were found in the (Nataraju *et al.*, 2019; Pawar and Channaveer 2021; Liao *et al.*, 2022; and Londhe and Kadam 2022) that majority of the respondents obtained a medium attitude score. In comparison of the attitude index of all the selected districts Imphal East had the highest (68.41) attitude index in the adoption of sustainable agriculture practices. It can be inferred that respondents of Imphal East district had more favourable attitude towards adoption of sustainable agriculture practices as compare with Thoubal district, Senapati and Churachandpur district.

Table 4.3.1.2 Comparative account on attitude towards adoption of sustainable agricultural practices

S/N	Districts	Attitude towards sustainable (μ)	Z Value	P value
1.	Thoubal	45.00	-2.90**	< 0.01
2.	Imphal East	47.89		
3.	churachandpur	46.20	2.30**	< 0.01
4.	Senapati	44.04		
5.	Imphal East	47.89	3.84**	< 0.01
6.	Senapati	44.04		
7.	Imphal East	47.89	1.59**	< 0.01
8.	churachandpur	46.20		
9.	Thoubal	45.00	1.03 ^{NS}	> 0.05
10.	Senapati	44.04		
11.	Thoubal	45.00	-1.32 ^{NS}	> 0.05
12.	Churachandpur	46.20		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.3.1.2 it was evident that the attitude towards adoption of sustainable agricultural practices of all the selected districts were statistically significant at 1% and 5% level of significance except Thoubal district vs Churachandpur district and Thoubal vs Senapati district (p-value >0.05).

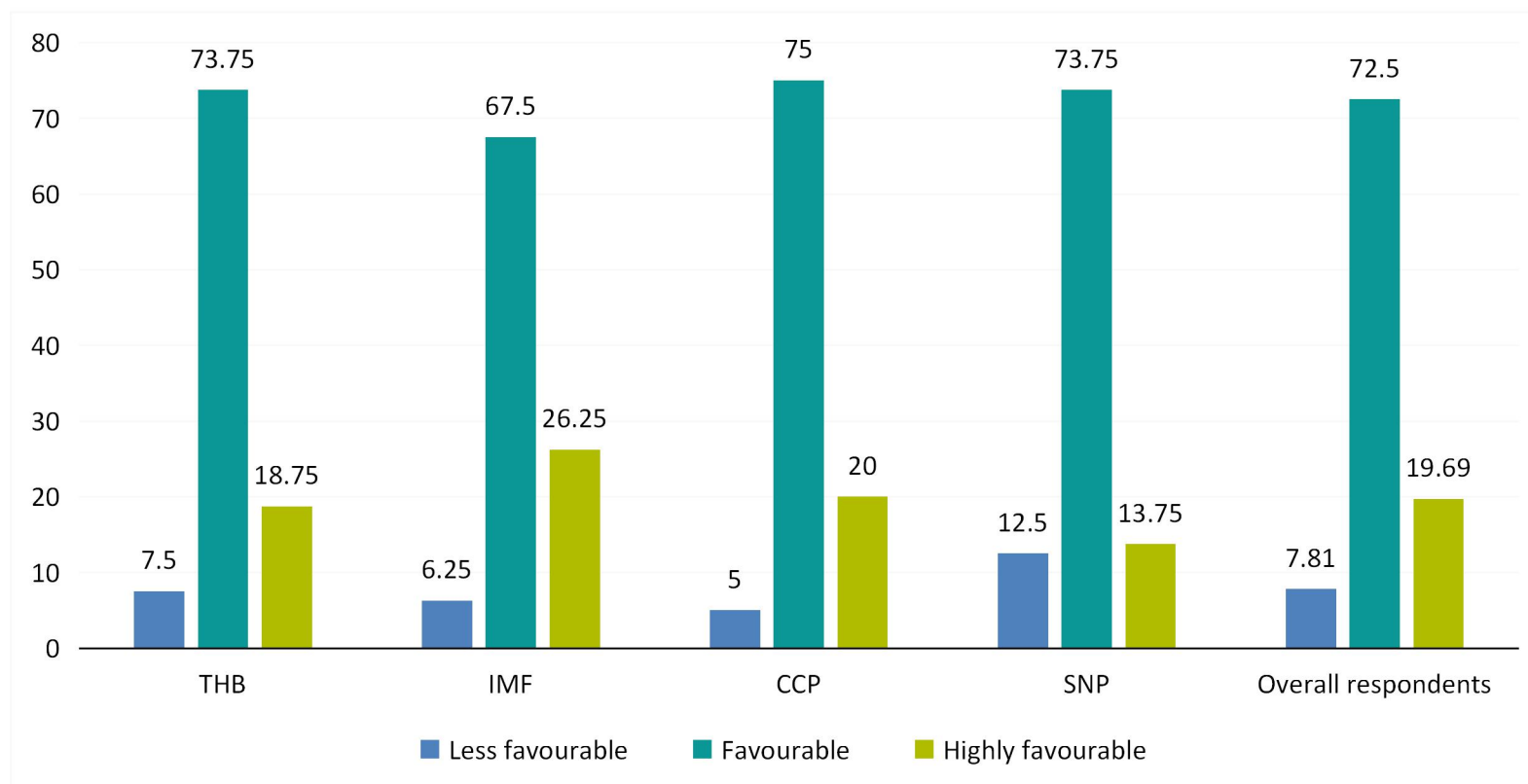


Fig 4.3.1.1 Distribution of respondents based on their attitude towards the adoption of sustainable agricultural practices

Table 4.3.1.3: Correlation of socio-economic and personal variables with attitude towards the adoption of sustainable agricultural practices

Coefficient of correlation was computed in order to explore the relationships between the socio-economic and personal characteristics of the farmers and their attitude towards adoption of sustainable agricultural practices. Relationships between the selected characteristics of the farmers and their attitude towards adoption of sustainable agricultural practices have been presented in Table 4.3.1.3.

S/N	Independent's variables	Correlation coefficient (r)	P value
1.	Age	0.057	0.306
2.	Education	-0.088	0.116
3.	Family size	0.203**	0.001
5.	Experienced in rice-based farming	0.133*	0.018
6.	Training exposure	0.094	0.093
7.	Extension contacts	0.148**	0.008
8.	Formal information sources	0.044	0.436
9.	Informal information sources	0.082	0.143
10.	Mass media information sources	0.117*	0.036
11.	Social media information sources	0.169**	0.002
12.	Perception towards climate change	0.119*	0.034
13.	Market orientation	0.041	0.460
14.	Production orientation	0.129*	0.021
15.	Risk orientation	-0.075	0.180
16.	Innovativeness	0.137*	0.014

Table 4.3.1.3 revealed that the variables family size had positive and significant association ($r=0.203^{**}$) with dependent variable with attitude towards adoption of sustainable agricultural practices at 1% level of significance. It indicates that with increase in family size might be helpful in improving the attitude of farmers towards adoption of sustainable agricultural practices. Study made by (Ghosh and Hasan, 2020) had the similar findings that there was a positive and significant association with family size with attitude towards sustainable agricultural practices. The variables extension contacts ($r=0.148^{**}$), mass media information sources utilization ($r=0.117^{**}$) and social media information sources utilization ($r=0.169^{**}$) had positive and significant association with attitude towards adoption of sustainable practices at 1% level of significance. It means higher the level of extension contacts

of respondents increases the favourable attitude towards adoption of sustainable agricultural practice. An exposure to different information sources viz., social media information sources and mass media information sources also increase adoption of sustainable agricultural practice. Similar finding was found by (Gosh *et al.*, 2019). And the variables experience ($r=0.133^*$), perception towards climate change ($r=0.119^*$), production orientation ($r=0.129^*$) and innovativeness ($r=0.137^*$) had positive and significant association with attitude towards adoption of sustainable agricultural practices at 5% level of significance. It means higher the level of these variables, respondents had higher level of favourable attitude towards adoption of sustainable agricultural practices.

Variable's age, education, training exposure, formal information sources, informal information sources, market orientation and risk orientation had non-significant association with attitude towards **'adoption of sustainable agricultural practices'**. Based upon the findings, the null hypothesis (**H₀2a**) was rejected:

H₀2a: There is no association between the variables family size, experience in rice-based farming, extension contacts, mass media information sources utilization, social media information sources utilization, experienced in rice-based, perception towards climate change, production orientation and innovativeness with attitude towards **'adoption of sustainable agricultural practices'** was rejected.

The variables age, education, training exposure, formal information sources, informal information sources, market orientation and risk orientation had non-significant association with the attitude towards **'adoption of sustainable agricultural practices'**. Therefore, the following null hypothesis **H₀2b** was accepted:

H₀2b: There is no association between variables age, education, training exposure, formal information sources, informal information sources, market orientation and risk orientation with attitude towards **'adoption of sustainable agricultural practices'** was accepted.

4.3.2 Adoption

Table 4.3.2.1 Distribution of respondents based on the extent of adoption of sustainable agricultural practices in valley districts

S/N	Dimensions of sustainable practices	Thoubal district (n ₃ =80)				Mean	Overall mean	AI	Imphal East district (n ₄ =80)				Mean	Overall mean	AI	
		Ad	%	Nd	%				Ad	%	Nd	%				
Nutrient management																
1	Animal manure	39	48.75	41	51.25	0.49	0.69	52.12	36	45.00	44	55.00	0.45	0.59	53.75	
2	Compost/crop residue	60	75.00	20	25.00	0.75			61	76.25	19	23.75	0.76			
3	Nitrogen fixing crop	66	82.50	14	17.50	0.83			45	56.25	35	43.75	0.56			
Soil conservation																
4	Cover crop plantation	43	28.75	57	71.25	0.29	0.32		51	63.75	29	36.25	0.64	0.40		
5	No-till farming	40	50.00	40	50.00	0.50			49	61.25	31	38.75	0.61			
6	Contour farming	0	0.00	80	100	0.00			0	0.00	80	100	0.00			
7	Terrace farming	0	0.00	80	100	0.00			0	0.00	80	100	0.00			
8	Crop rotation	63	78.75	17	21.25	0.79			60	75.00	20	25.00	0.75			
Water conservation																
9	Mulching	54	67.50	26	32.50	0.67	0.56		58	72.50	22	27.50	0.73	0.65		
10	Drought tolerant crop	19	23.75	61	76.25	0.24			34	42.50	46	57.50	0.43			

11	Rain water harvesting	55	68.75	25	31.25	0.69		50	62.50	30	37.50	0.63		
12	Recycle water	50	62.50	30	37.50	0.63		65	81.25	15	18.75	0.81		
Plant protection														
13	Selection of diseases free seeds	55	68.75	25	31.25	0.69	0.46	45	56.25	35	43.75	0.56	0.47	
14	Biological control	28	35.00	52	65.00	0.35		35	43.75	45	56.25	0.44		
15	Timely plantation	65	81.25	15	18.75	0.81		58	72.50	22	27.50	0.73		
16	Resistant varieties	21	26.25	59	73.75	0.26		30	37.50	50	62.50	0.38		
17	Physical control	46	57.50	34	42.50	0.58		52	65.00	28	35.00	0.65		
18	Maintain crop diversity	29	36.25	51	63.75	0.36		38	47.50	42	52.50	0.48		
Weed management														0.76
19	Manual weeding	75	93.75	5	6.25	0.94	0.74	71	88.75	9	11.25	0.89		
20	Weeding by harrow or trowel	35	43.75	45	56.25	0.44		40	50.00	40	50.00	0.50		
21	Ploughing before seeding	68	85.00	12	15.00	0.85		72	90.00	8	10.00	0.90		
Restoration and rehabilitation														0.25
22	Reforestation	25	31.25	55	68.75	0.31	0.30	13	16.25	67	83.75	0.16		
23	Regeneration planting	23	28.75	57	71.25	0.29		26	32.50	54	67.50	0.33		

Ad: Adopter; **Nd:** Non-Adopter and **AI:** Adoption Index

Table 4.3.2.1 presents the adoption of different dimensions of sustainable agricultural practices in Thoubal district. It was revealed that with respect to adoption of nutrient management majority (82.50%) of the respondents adopted 'nitrogen fixing crop' and 51.25 per cent of the respondents didn't adopt 'animal manure'. In soil conservation, majority (78.75%) of the respondents adopted 'crop rotation' and 71.25 per cent of the respondents didn't adopt 'cover crop plantation'. In water conservation, majority (76.25%) of the respondents didn't adopt 'drought tolerant crop' and 68.75 per cent of the respondents were adopted 'rain water harvesting'. In plant protection, majority (81.25%) of the respondents adopted 'timely plantation' and 73.75 per cent of the respondents adopted 'resistant varieties. In weed management, majority (93.75%) of the respondents adopted 'manual weeding' and 56.25 per cent of the respondents adopted 'weeding by harrow or trowel'. In restoration and rehabilitation, majority (71.25%) of the respondents didn't adopt 'regeneration planting' and 31.25 per cent of the respondent's adopted 'reforestation'.

Overall mean of sustainable agricultural practices in Thoubal district was 52.12. Productivity and sustainability will increase when more sustainable agricultural practices are adopted. Therefore, it's critical to assist the farmers in overcoming the operational obstacles so that they can maintain farm sustainability and productivity with less effort.

Table 4.3.2.1 presented the adoption of different dimensions of sustainable agricultural practices in Imphal East district. It was revealed that with respect to adoption of nutrient management majority (76.25%) of the respondents adopted 'compost/crop residue' and 55.00 per cent of the respondents didn't adopt 'animal manure'. In soil conservation, majority (75.00%) of the respondents adopted 'crop rotation' and 38.75 per cent of the respondents didn't adopt 'no tillage farming'. In water conservation, majority (81.25%) of the respondents adopted 'recycled water' and 57.50 per cent of the respondents adopted 'drought tolerant crop'. In plant protection, majority (72.50%) of the respondents adopted 'timely plantation' and 62.50 per cent of the respondents adopted 'resistant varieties. In weed management, majority (90.00%) of the respondents adopted 'ploughing to get rid weed before

seeding’ and 50.00 per cent of the respondents didn’t adopt ‘weeding by harrow or trowel’. In restoration and rehabilitation, majority (83.75%) of the respondents didn’t adopt ‘reforestation’ and 32.50 per cent of the respondents adopted ‘regeneration planting’.

Overall mean of sustainable agricultural practices in Thoubal district was 53.75. Compared to Thoubal districts, farmers in Imphal East district adopted sustainable agriculture techniques at a higher rate. This could be because Imphal East district farmers possess greater skills in sustainable practices, and adoption can also be influenced by experience and income. To enhance adoption in both districts, it is necessary to provide relevant and accurate information, accelerate innovation of sustainable technology. Training on appropriate methods to use tools and making them aware of the latest information on innovation technology might help them in increasing the adoption of sustainable practices.

Table 4.3.2.2 Distribution of respondents based on the extent of adoption of sustainable agriculture practices in hill districts

S/N	Dimensions of sustainable practices	Churachandpur district (n ₁ =80)				Mean	Overall mean	AI	Senapati district (n ₂ =80)				Mean	Overall mean	AI
		Ad	%	Nd	%				Ad	%	Nd	%			
Nutrient management							0.48	41.48						0.66	46.90
1	Animal manure	38	47.50	42	52.50	0.48			43	53.75	37	46.25	0.54		
2	Compost/crop residue	56	70.00	24	30.00	0.70			47	58.75	33	41.25	0.59		
3	Nitrogen fixing crop	20	25.00	60	75.00	0.25	68		85.00	12	15.00	0.85			
Soil conservation												0.60			
4	Cover crop plantation	30	37.50	50	62.50	0.38	38		47.50	42	52.50		0.48		
5	No-till farming	29	36.25	51	63.75	0.36	46		57.50	34	42.50		0.58		
6	Contour farming	36	45.00	44	55.00	0.45	31		38.75	49	61.25		0.39		
7	Terrace farming	80	100	0	0.00	1.00	80		100	0	0.00		1.00		
8	Crop rotation	58	72.50	22	27.50	0.73	57		71.25	23	28.75		0.71		
Water conservation												0.38			
9	Mulching	42	52.50	38	47.50	0.53	28		35.00	52	65.00		0.35		
10	Drought tolerant crop	25	31.25	55	68.75	0.31	30		37.50	50	62.50		0.38		
11	Rain water harvesting	18	22.50	62	77.50	0.23	35		43.75	45	56.25		0.44		
12	Recycle water	14	17.50	66	82.50	0.18	27		33.75	53	66.25		0.34		
Plant protection												0.45			
13	Diseases free seeds	46	57.50	34	42.50	0.58	56		70.00	24	30.00		0.70		
14	Biological control	10	12.50	70	87.50	0.13	5		6.25	75	93.75		0.06		
15	Timely plantation	40	50.00	40	50.00	0.50	60		75.00	20	25.00	0.75			

16	Resistant varieties	16	20.00	64	80.00	0.20			9	11.25	71	88.75	0.11		
17	Physical control	38	47.50	42	52.50	0.48			35	43.75	45	56.25	0.44		
18	Maintain crop diversity	39	48.75	41	51.25	0.49			49	61.25	31	36.75	0.61		
Weed management															
19	Manual weeding	80	100	0	0.00	1.00	0.40		80	100	0	0.00	1.00	0.33	
20	Weeding by harrow or trowel	15	18.75	65	81.25	0.19			0	0.00	80	100	0.00		
21	Ploughing before seeding	0	0.00	80	100	0.00			0	0.00	80	100	0.00		
Restoration and rehabilitation															
22	Reforestation	12	15.00	68	85.00	0.15	0.18		21	26.25	59	73.75	0.26	0.23	
23	Regeneration planting	21	26.25	59	73.75	0.26			18	22.50	62	77.50	0.23		

Ad: Adopter; **Nd:** Non-Adopter and **AI:** Adoption Index

Table 4.3.2.2 presented the adoption of different dimensions of sustainable agricultural practices in Churachandpur district. It was revealed that with respect to adoption of nutrient management majority (75.00%) of the respondents didn't adopt 'nitrogen fixing crop' and 70.00 per cent of the respondents adopted 'compost/crop residue'. In soil conservation, majority (72.50%) of the respondents adopted 'crop rotation' and 63.75 per cent of the respondents didn't adopt 'no till-farming'. In water conservation, majority (82.50%) of the respondents didn't adopt 'recycle water' and 52.50 per cent of the respondents adopted 'mulching'. In plant protection, majority (87.50%) of the respondents didn't adopt 'biological control' and 57.50 per cent of the respondents didn't adopt 'disease free seed. In weed management, majority (100%) of the respondents adopted 'manual weeding' and 100 per cent of the respondents didn't adopt 'ploughing to get rid weeds before seeding'. In restoration and rehabilitation, majority (85.00%) of the respondents didn't adopt 'reforestation' and 26.25 per cent of the respondents adopted 'regeneration planting'. Overall mean of sustainable agricultural practices of Churachandpur district was 41.48.

Table 4.3.2.2 presented the adoption of different dimensions of sustainable agricultural practices in Senapati district. It was revealed that with respect to adoption of nutrient management majority (85.00%) of the respondents adopted 'nitrogen fixing crop' and 46.25 per cent of the respondents didn't adopt 'animal manure'. In soil conservation, majority (100%) of the respondents adopted 'terrace farming' and 61.25 per cent of the respondents didn't adopt 'contour farming'. In water conservation, majority (66.25%) of the respondents didn't adopt 'recycled water' and 43.75 per cent of the respondents adopted 'rain water harvesting'. In plant protection, majority (93.75%) of the respondents didn't adopt biological control and 75.00 per cent of the respondents adopted 'timely plantation'. In weed management, majority (100%) of the respondents adopted 'manual weeding' and 100 per cent of the respondents didn't adopt 'ploughing to get rid weeds before seeding' and 'weeding by harrow or trowel'. In restoration and rehabilitation, majority (77.50%) of the respondents didn't adopt

‘regeneration planting’ and 26.25 per cent of the respondent’s adopted ‘reforestation’. Overall mean of sustainable agricultural practices of Senapati district was 46.90.

The above results showed that adoption level for farmers were low (below average) in Churachandpur district (41.48%) and Senapati district (46.90%)—even lower than in Imphal East and Thoubal district. It could be the result of poor communication, inadequate farmer education, complex technology, a lack of support for farmers implementing sustainable practices, or farmers who are reluctant to use technology due to the lack of the necessary technical know-how. Another major reason for low adoption of sustainable practices could be institutional and structure barrier in hilly area. Analysing the factors that contributed to farmers' low adoption of technology and persuading them that sustainable technologies are superior than the existing farming practices can help to improve the adoption of sustainable agricultural practices.

Table 4.3.2.3 Distribution of overall respondents based on the adoption of sustainable agricultural practices

n=320

S/N	Dimensions of sustainable practices	Ad	%	Nd	%	Mean	AI
1	Animal manure	156	48.75	164	51.25	0.49	48.56
2	Compost/crop residue	224	70.00	96	30.00	0.70	
3	Nitrogen fixing crop	199	62.19	121	37.81	0.63	
4	Cover crop plantation	162	50.63	158	49.38	0.51	
5	No-till farming	164	51.25	156	48.75	0.51	
6	Contour farming	67	20.94	253	79.06	0.21	
7	Terrace farming	160	50.00	160	50.00	0.50	
8	Crop rotation	238	74.38	82	25.63	0.74	
9	Mulching	182	56.88	138	43.13	0.57	
10	Drought tolerant crop	108	33.75	212	66.25	0.34	
11	Rain water harvesting	158	49.38	162	50.63	0.49	
12	Recycle water	156	48.75	164	51.25	0.49	
13	Diseases free seeds	202	63.13	118	36.88	0.63	
14	Biological control	78	24.38	242	75.63	0.24	
15	Timely plantation	223	69.69	97	30.31	0.70	
16	Resistant varieties	76	23.75	244	76.25	0.24	
17	Physical control	171	53.44	149	46.56	0.53	
18	Maintain crop diversity	155	48.44	165	51.56	0.48	
19	Manual weeding	306	95.63	14	4.38	0.96	
20	Weeding by harrow or trowel	90	28.13	230	71.88	0.28	
21	Ploughing to get ride weed before seeding	140	43.75	180	56.25	0.44	
22	Reforestation	71	22.19	249	77.81	0.22	
23	Regeneration planting	88	27.50	232	72.50	0.27	

Ad: Adopted; **Nd:** Non-Adopted and **AI:** Adoption Index

From Table 4.3.2.3 it was revealed that 95.63 per cent of the respondents adopted ‘manual weeding’ and 4.38 per cent of the respondents didn’t adopt, 79.06 per cent of the respondents didn’t adopt ‘contour farming’ and 20.94 per

cent of the respondents adopted, 77.81 per cent of the respondents didn't adopt 'reforestation' and 22.19 per cent of the respondents adopted, 76.25 per cent of the respondents didn't adopt 'resistant varieties' and 23.75 per cent of the respondents adopted, 75.63 per cent of the respondents didn't adopt 'biological control' and 24.38 per cent of the respondents adopted, 74.38 per cent of the respondents 'adopted crop rotation' and 25.63 per cent of the respondents didn't adopt, 72.50 per cent of the respondents didn't adopt 'regeneration planting' and 27.50 per cent of the respondents adopted, 70.00 per cent of the respondents adopted 'compost/crop residue' and 30.00 per cent of the respondents didn't adopt adopted, 71.88 per cent of the respondents didn't adopt 'weeding by harrow or trowel' and 28.13 per cent of the respondents adopted, 69.69 per cent of the respondents adopted 'timely plantation' and 30.31 per cent of the respondents 'adopted timely plantation', 66.25 per cent of the respondents didn't adopt 'drought tolerant crop' and 33.75 per cent of the respondents adopted, 63.13 per cent of the respondents adopted 'diseases free seeds' and 36.88 per cent of the respondents didn't adopt, 62.19 per cent of the respondents 'adopted nitrogen fixing crop' and 37.81 per cent of the respondents didn't adopt, 56.88 per cent of the respondents adopted 'mulching' and 43.13 per cent of the respondents didn't adopt, 56.25 per cent of the respondents didn't adopt 'ploughing to get ride weed before seeding' and 43.75 per cent of the respondents adopted, 53.44 per cent of the respondents adopted 'physical control' and 46.56 per cent of the respondents didn't adopt, 51.56 per cent of the respondents didn't adopt 'maintain crop biodiversity' and 48.44 per cent of the respondents adopted, 51.25 per cent of the respondents didn't adopt 'animal manure' 'no-tillage farming' 'recycle water' and 48.75 per cent of the respondents adopted, 50.63 per cent of the respondents adopted 'cover crop plantation' and 49.38 per cent of the respondents didn't adopt, 50.63 per cent of the respondents didn't adopt 'rain water harvesting' and 49.38 per cent of the respondents adopted, 50.00 per cent of the respondents adopted 'Terrace farming' and 50.00 per cent of the respondents didn't adopt. Adoption index of the overall respondents based on the adoption of sustainable agricultural practices was 48.56. It indicates that farmers had low adoption on sustainable agricultural practices therefore it is important to enhance the linkage among

research, extension and farmers to facilitate sustainable innovation practices to the farmers.

Table 4.3.2.4 Ranking of adoption on sustainable agricultural practices based on mean score

S/N	Dimensions of sustainable practices	Mean	Ranking
1.	Manual weeding	0.96	I
2.	Crop rotation	0.74	II
3.	Compost/crop residue	0.70	III
4.	Timely plantation	0.70	III
5.	Nitrogen fixing crop	0.63	IV
6.	Diseases free seeds	0.63	IV
7.	Mulching	0.57	V
8.	Physical control	0.53	VI
9.	Cover crop plantation	0.51	VII
10.	No-till farming	0.51	VII
11.	Terrace farming	0.50	VIII
12.	Cow/animal manure	0.49	IX
13.	Rain water harvesting	0.49	IX
14.	Recycle water	0.49	IX
15.	Maintain crop diversity	0.48	X
16.	Ploughing to get ride weed before seeding	0.44	XI
17.	Drought tolerant crop	0.34	XII
18.	Weeding by harrow or trowel	0.28	XIII
19.	Regeneration planting	0.27	XIV
20.	Biological control	0.24	XV
21.	Resistant varieties	0.24	XV
22.	Reforestation	0.22	XVI
23.	Contour farming	0.21	XVII

Table 4.3.2.4 and Fig 4.3.2.4 presented the mean score and ranking of adoption under the dimensions of sustainable agricultural practices in the selected districts. It was revealed that ‘manual weeding’ was ranked I in adoption of sustainable agricultural practices with a mean score of 0.96 followed by ‘crop rotation’ was ranked II with a mean score of 0.74, ‘compost/crop residue’ and ‘timely plantation’ was ranked III with a mean score of 0.70, ‘nitrogen fixing crop’ and ‘selection of diseases free seeds’ was ranked IV with a mean score of 0.63, ‘mulching’ was ranked V with a mean score of 0.57, physical control was ranked VI with a mean score of 0.53, ‘cover crop plantation’ and ‘no tillage farming’ was ranked VII with a mean score of 0.51, ‘terrace framing’ was ranked VIII with a mean score of 0.50, ‘animal manure’, ‘rain water harvesting’ and ‘recycle water’ was ranked IX with a mean score of 0.49, ‘maintain crop diversity’ was ranked X with a mean score of 0.48, ‘ploughing to get rid weeds before seeding’ was ranked XI with a mean score of 0.44, ‘drought tolerant crop’ was ranked XII with a mean score of 0.34, weeding by ‘harrow or trowel’ was ranked XIII with a mean score of 0.28 average mean, ‘regeneration planting’ was ranked XIV with a mean score of 0.27, ‘biological control’ and ‘resistant varieties’ was ranked XV with a mean score of 0.24, ‘reforestation’ was ranked XVI with a mean score of 0.22 and ‘contour farming’ was ranked XVII with a mean score of 0.21.

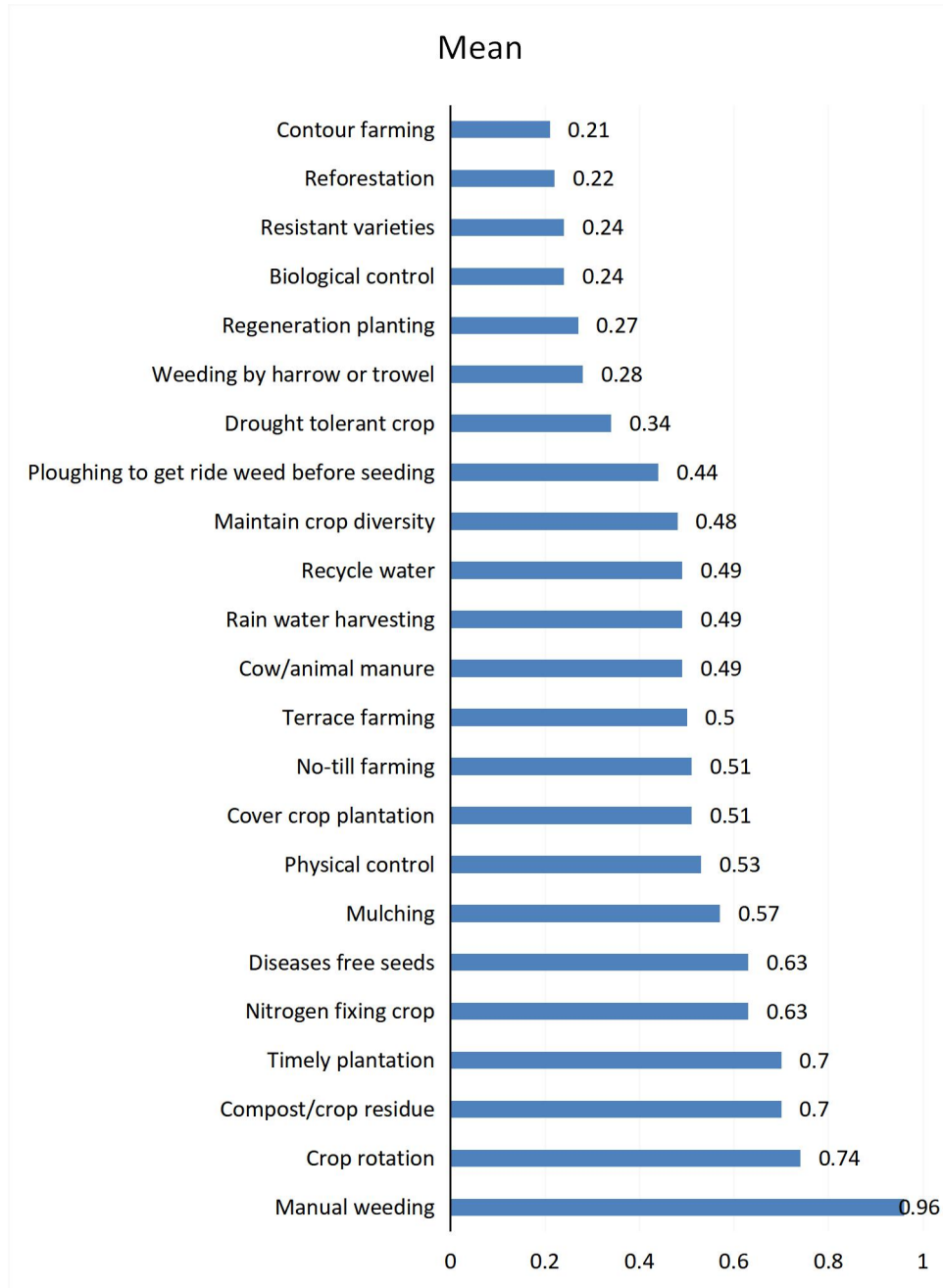


Fig 4.3.2.4 Ranking of adoption of sustainable agricultural practices based on mean score

Table 4.3.2.5 Distribution of overall respondents based on the adoption level of sustainable agricultural practices

Districts	Level of adoption	f	%	Mean	SD	AI
Thoubal n₁=80	Low (<5.39)	13	16.25	8.28	2.89	52.12
	Medium (5.39-11.17)	45	56.25			
	High (>11.17)	22	27.50			
Imphal East n₂=80	Low (<5.79)	8	10.00	8.79	3.00	53.75
	Medium (5.79-11.79)	63	78.75			
	High (>11.79)	9	11.25			
Churachandpu r n₃=80	Low (<4.75)	16	20.00	6.12	1.37	41.48
	Medium (4.75-7.49)	43	53.75			
	High (>7.49)	21	26.25			
Senapati n₄=80	Low (<5.46)	14	17.50	7.59	2.13	46.90
	Medium (5.46-9.72)	55	68.75			
	High (>9.72)	11	13.75			
Overall n=320	Low (<5.60)	51	15.94	7.70	2.10	48.56
	Medium (5.60-9.80)	206	64.38			
	High (>9.80)	63	19.69			

f:Frequency; %:Percentage

From Table 4.3.2.5 it was revealed that in Imphal East district majority (78.75%) of the respondents had medium level of adoption followed by 11.25 per cent of the respondents having high level of adoption and 10.00 per cent of the respondents having low level of adoption of sustainable agricultural practices with an adoption index of 53.75. In Senapati district, majority (68.75%) of the respondents had medium level of adoption followed by 17.50 per cent of the respondents having low level of adoption and 13.75 per cent of the respondents having high level of adoption of sustainable agricultural practices with an adoption index 46.90. In Thoubal district, majority (56.25%) of the respondents had medium level of adoption followed by 27.50 per cent of the respondents having high level of adoption and 16.25 per cent of the respondents having low level of adoption of sustainable agricultural practices with an adoption index

52.12. In Churachandpur district, majority (53.75%) of the respondents had medium level of adoption followed by 26.25 per cent of the respondents having high level of adoption and 20.00 per cent of the respondents having low level of adoption of sustainable agricultural practices with an adoption index 41.48.

Overall, it was found that majority (64.38%) of the respondents had medium level of adoption followed by 10.69 per cent of the respondents having high level of adoption and 15.94 per cent of them had low level of adoption with 48.56 adoption index. These findings are in the line of similar findings with the study by Podikunju and Arathy (2022) who found that that majority of the respondents (48.30%) had medium level of adoption of safe handling of pesticides.

Table 4.3.2.6 Comparative account on response of adoption on the sustainable agricultural practices

S/N	Districts	Adoption level (μ)	Z Value	P value
1.	Thoubal	8.28	-0.89 ^{NS}	> 0.05
2.	Imphal East	8.79		
3.	churachandpur	6.12	-4.64**	< 0.01
4.	Senapati	7.59		
5.	Imphal East	8.79	2.99**	< 0.01
6.	Senapati	7.59		
7.	Imphal East	8.79	7.92**	< 0.01
8.	churachandpur	6.12		
9.	Thoubal	8.28	2.00*	< 0.05
10.	Senapati	7.59		
11.	Thoubal	8.28	6.67**	< 0.01
12.	Churachandpur	6.12		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.3.2.6, it was evident that farmers from all the four district were found significantly different at 1% and 5% level of significance except 'Thoubal district vs Imphal East district' was found non significant (p-value >0.05).

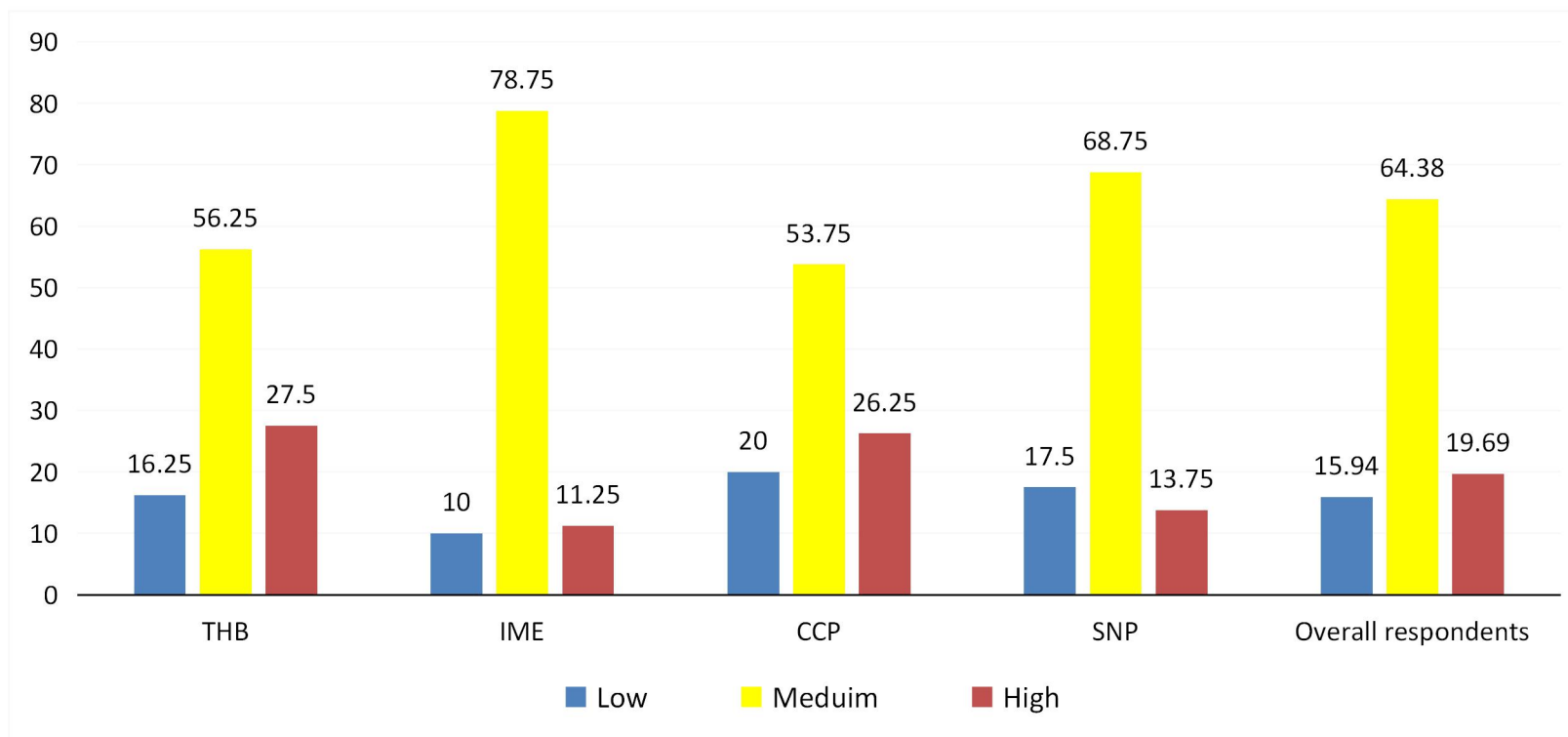


Fig 4.3.2.5 Distribution of respondents based on the adoption level of sustainable agricultural practices

4.3.2.2 Extent of adoption on rice-based farming system

Table 4.3.2.2.1 Distribution of respondents based on the extent of adoption of sustainable practices under rice-fish farming system in Thoubal district

S/N	Dimensions of sustainable practices	Thoubal district Extent of Adoption (n ₁ =40)						Mean	Overall mean	AI
		FA	%	PA	%	NA	%			
1.	Dyke construction	40	100	0	0.00	0	0.00	2.00	1.58	69.00
2.	Farm site selection	20	50.00	20	50.00	0	0.00	1.50		
3.	Field design	14	35.00	26	65.00	0	0.00	1.35		
4.	Land preparation	17	42.50	23	57.50	0	0.00	1.43		
5.	Selection of fish species	30	75.00	10	25.00	0	0.00	1.75		
6.	Flooding and weeding of rice	10	25.00	30	75.00	0	0.00	1.75		
7.	Fertilization of rice	15	37.50	25	62.50	0	0.00	1.38		
8.	Stocking of fish seeds	8	20.00	32	80.00	0	0.00	1.83		
9.	Water quality monitoring	0	0.00	6	15.00	34	85.00	0.15		
10.	Harvesting time	32	80.00	8	0.00	0	0.00	1.80		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nill adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

From Table 4.3.2.2.1 it was evident that majority (100%) of the respondents from Thoubal district had full level of adoption of the recommended practices of 'dyke construction' followed by 85.00 per cent of the respondents having nil level of adoption of the recommended practices of 'water quality monitoring' and 80.00 per cent of the respondents having partial level of adoption of the recommended practices of 'stocking of fingerlings. Recommended practices of rice-fish farming system had an adoption index of 69.00.

Table 4.3.2.2.1 presented the mean score of the recommended practices of rice-fish farming system in Thoubal district and it was evident that the highest mean score (2.00) was observed in the recommended practices of 'rotation and concurrent system' followed by the recommended practices 'stocking of fingerlings' mean score (1.83), the recommended practices 'harvesting time' had mean score (1.80), the recommended practices of 'flooding and weeding' had mean score (1.75), the recommended practices of 'selection of fish species' had mean score (1.75), the recommended practices of 'farm site selection' had mean score (1.50), the recommended practices of 'land preparation' had mean score (1.43), the recommended practices of 'fertilization of rice' had mean score (1.38), the the recommended practices of 'field design' had mean score (1.35) and the recommended practices of 'water quality monitoring' had mean score (0.15). Mean of all the recommended practices of rice-fish farming system in Thoubal district was 1.58.

The above findings indicates that Thoubal district had high adoption level i.e., 69.00 adoption index in rice-fish farming system. It may be due to availability, affordability and profitability of the technology. Technology adoption can be further improved in rice-fish farming system for maximum yield and income. Therefore, policy makers should encourage farmers to see the benefits of rice-fish farming system and farmers needs training to understand the important on continue adoption of rice-fish farming system.

Table 4.3.2.2.2 Distribution of respondents based on the extent of adoption of sustainable practices under rice-fish farming system in Imphal East district

S/N	Dimensions of sustainable practices	Imphal East district Adoption level (n ₂ =40)						Mean	Overall mean	AI
		FA	%	PA	%	NA	%			
1.	Dyke construction	40	100	0	0.00	0	0.00	2.00	1.50	67.75
2.	Farm site selection	13	32.50	27	67.50	0	0.00	1.33		
3.	Field design	16	40.00	24	60.00	0	0.00	1.40		
4.	Land preparation	18	45.00	22	55.00	0	0.00	1.43		
5.	Selection of fish species	19	47.50	20	50.00	0	0.00	1.48		
6.	Flooding and weeding of rice	20	50.00	20	50.00	0	0.00	1.50		
7.	Rice fertilization	10	25.00	30	75.00	0	0.00	1.70		
8.	Stocking of fingerlings	17	42.50	23	57.50	0	0.00	1.43		
9.	Water quality monitoring	0	0.00	8	20.00	32	80.00	0.20		
10.	Harvesting time	22	55.00	18	45.00	0	0.00	1.55		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nill adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

From Table 4.3.2.2.2 it was revealed that in Imphal East district majority (100%) of the respondents had full level of adoption on the recommended practices of 'dyke construction' followed by 80.00 per cent of the respondents having nil level adoption of recommended practices of 'water quality monitoring' and 75.00 per cent of the respondents having partial level adoption of recommended practices of 'rice fertilization'. Recommended practices of rice-fish farming system had 67.75 adoption index.

Table 4.3.2.2.2 presented the mean score of the recommended practices of rice-fish farming system in Imphal East district and it was evident that the highest mean score (2.00) was observed in the recommended practices of 'dyke construction' followed by the recommended practices 'rice fertilization' mean score (1.70), the recommended practices 'harvesting time' mean score (1.55), the recommended practices 'flooding and weeding' mean score (1.50), the recommended practices 'selection of fish species' mean score (1.48), the recommended practices 'land preparation and stocking of fingerlings' mean score (1.43), the recommended practices 'field design' mean score (1.40), the recommended practices 'farm site selection' mean score (1.33) and recommended practices 'water quality monitoring' mean score (0.20). Overall mean of the recommended practices of rice-fish farming system in Imphal East district was 1.50.

The result indicates that adoption of recommended practices of rice-fish farming system in Imphal district is high (67.75 adoption index) however it is lesser than Thoubal district (69.00 adoption index). So, adoption status of Imphal East district can be improved through facilitation of a communication channel that provide an accurate and timely information between to the farmers.

Table 4.3.2.2.3 Distribution of respondents based on the extent of adoption of sustainable practices under rice-fish farming system in Senapati district

S/N	Dimensions of sustainable practices	Senapati district (n ₃ =40)						Mean	Overall mean	AI
		FA	%	PA	%	NA	%			
1.	Dyke construction	32	80.00	8	20.00	0	0.00	1.80	1.07	53.50
2.	Farm site selection	10	25.00	30	75.00	0	0.00	1.25		
3.	Field design	5	12.50	25	62.50	10	25.00	0.88		
4.	Land preparation	10	25.00	30	75.00	0	0.00	1.25		
5.	Selection of fish species	20	50.00	20	50.00	0	0.00	1.49		
6.	Flooding and weeding of rice	9	22.50	18	45.00	13	32.50	1.00		
7.	Rice fertilization	0	0.00	21	52.50	19	47.50	0.53		
8.	Stocking of fingerlings	10	25.00	24	60.00	6	15.00	1.13		
9.	Water quality monitoring	0	0.00	0	0.00	40	100	0.00		
10.	Harvesting time	20	50.00	20	50.00	0	0.00	1.40		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nill adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

From Table 4.3.2.2.3 it was revealed that in Senapati district majority (100%) of the respondents had nil level of adoption on the recommended practices of ‘water quality monitoring’ followed by 80.00 per cent of the respondents having full level of adoption of recommended practices of ‘dyke construction’ and 75.00 per cent of the respondents having partial level of adoption of recommended practices of ‘farm site selection’ and 75.00 per cent of the respondents having recommended practices of ‘land preparation’. Recommended practices of rice-fish farming system had 53.50 adoption index.

Table 4.3.2.2.3 presented the mean score of the recommended practices of rice-fish farming system in Senapati district and it was evident that the highest mean score (1.80) was observed in the recommended practices of ‘dyke construction’ followed by the recommended practices of ‘selection of fish species’ mean score (1.49), the recommended practices of ‘harvesting time’ mean score (1.40), the recommended practices of ‘farm site selection’ and ‘land preparation’ mean score (1.25), the recommended practices of ‘stocking of fingerlings’ mean score (1.13), the recommended practices of ‘flooding and weeding’ mean score (1.00), the recommended practices of ‘field design’ mean score (0.88), the recommended practices of ‘rice fertilization’ mean score (0.53) and the recommended practices of ‘water quality monitoring’ mean score (0.00). Overall mean of the recommended practices of rice-fish farming system in Senapati district was 1.07. The above results indicates that adoption of recommended practices of rice-fish farming system in Senapati district had 53.50 adoption index which is lower than the Thoubal district (69.00 adoption index) and Imphal East district (67.75 adoption index). It may be due poor communication and lack of networking between the extension system and farmers of Senapati district as a result there is lack of technical skills and knowledge on using the recommended technology. Therefore, it is suggested that sustainable technologies generation, technology dissemination and adoption interventions need be strengthened. Moreover, the linkage among the research, extension and farmers needs to be enhance through facilitation a multi-stakeholders innovation platform.

4.3.2.2.4 Distribution of overall respondents based on the extent of adoption of sustainable practices under rice-fish farming system

S/N	Dimensions of sustainable practices	Overall adoption level (n=120)						Mean Score	Overall mean	AI
		FA	%	PA	%	NA	%			
1	Dyke construction	112	93.33	8	6.67	0	0.00	1.93	1.14	63.42
2	Farm site selection	43	35.83	77	64.17	0	0.00	1.36		
3	Field design	35	29.17	75	62.50	10	8.33	1.21		
4	Land preparation	45	37.50	75	62.50	0	0.00	1.37		
5	Selection of fish species	69	57.50	50	41.67	1	0.83	1.57		
6	Flooding and weeding of rice	39	32.50	68	56.67	13	10.83	1.47		
7	Rice fertilization	25	20.83	76	63.33	19	15.83	1.20		
8	Stocking of fingerlings	35	29.17	79	65.83	6	5.00	1.46		
9	Water quality monitoring	0	0.00	14	11.67	106	88.33	0.12		
10	Harvesting	74	61.67	46	38.33	0	0.00	1.58		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nill adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

Table 4.3.2.2.4 presented the overall extent of adoption of rice-fish farming system of Thoubal district, Imphal East district and Senapati district. It was evident that majority (93.33%) of the respondents had full level adoption of recommended practices of 'dyke construction' followed by 88.00 per cent of the respondents having nil level of adoption of 'water quality monitoring' and 65.00 per cent of the respondents having partial level of adoption of 'stocking fingerlings'. Recommended practices of rice-fish farming system had 63.42 adoption index.

Table 4.3.2.2.4 presented the overall mean score of the recommended practices of rice-fish farming system in Thoubal district, Imphal East district and Senapati district and it was evident that the highest mean score (1.93) was observed in the recommended practices of 'dyke construction' followed by the recommended practices of 'harvesting time' mean score (1.58), the recommended practices of 'selection of fish species' mean score (1.57), the recommended practices of 'flooding and weeding' mean score (1.47), the recommended practices 'stocking of fingerlings' mean score (1.46), the recommended practices of 'land preparation' mean score (1.37), the recommended practices of 'farm site selection' mean score (1.36), the recommended practices of 'field design' mean score (1.21), the recommended practices of 'rice fertilization' mean score (1.20) and the recommended practices of 'water quality monitoring' mean score (0.12). Overall mean of the recommended practices of rice-fish farming system was 1.14.

The above results indicates that recommended rice-fish farming system had 63.42 adoption index and low adoption of the recommended practices were found in water quality monitoring of rice-fish farming system. Therefore, it is necessary to take effective measures to overcome the problem to the adoption of the technologies and pay more attention to the use of the particular practice to improve sustainability and production efficiency.

Table 4.3.2.2.5 Distribution of overall respondents based on the level of adoption of rice-fish farming system

Districts	Level of adoption	Frequency	Percentage	Mean	SD	AI
Thoubal n₁=40	Low (<13.38)	6	15.00	14.85	1.47	69.00
	Medium (13.38-16.34)	18	45.00			
	High (>16.34)	16	40.00			
Imphal East n₂=40	Low (<12.60)	8	20.00	13.94	1.34	67.75
	Medium (12.60-15.28)	17	42.50			
	High (>15.28)	15	37.50			
Senapati n₃=40	Low (<8.85)	3	7.50	10.55	1.70	53.50
	Medium (8.85-12.25)	30	75.00			
	High (>12.25)	7	17.50			
Overall n=120	Low (<11.47)	17	14.17	12.97	1.50	63.42
	Medium (11.47-14.48)	65	54.17			
	High (>14.48)	38	31.67			

From Table 4.3.2.2.5 and Fig 4.3.2.2.5 it was revealed that in Senapati district majority (75.00%) of the respondents had medium level of adoption followed by 17.50 per cent of the respondents having high level of adoption and 7.50 per cent of the respondents having low level of adoption of the recommended practices of rice-fish farming system with an adoption index of 53.50. In Thoubal district, majority (45.00%) of the respondents had medium level of adoption followed by 40.00 per cent of the respondents having high level of adoption and 15.00 per cent of the respondents having low level of adoption of the recommended practices of rice-fish farming system with an adoption index of 69.00. In Imphal East district, majority (42.50%) of the respondents had medium level of adoption followed by 37.50 per cent of the respondents having high level of adoption and 20.00 per cent of the respondents having low level of adoption of the recommended practices of rice-fish farming system with an adoption index of 67.75.

Overall, it was found that majority (54.17%) of the respondents had medium level of adoption followed by 31.67 per cent of the respondents having high

level of adoption and 14.17 per cent of them had low level of adoption of the recommended practices of rice-fish farming system with an adoption index of 63.42. It indicates that respondents had high adoption of the recommended practices of rice-fish farming system. Using an appropriate agricultural technology is the most effective way to achieve sustainable agriculture. Adoption level can be further improved by motivating farmers to perform better and providing reliable advice about an appropriate technology solution specific to the farmers situation.

Table 4.3.2.2.6 Comparative account on adoption of sustainable practices under rice-fish farming system

S/N	Districts	Adoption level (μ)	Z Value	P value
1.	Thoubal	14.85	9.72**	< 0.01
2.	Imphal East	13.94		
3.	Imphal East	13.94	2.94**	< 0.01
4.	Senapati	10.55		
5.	Thoubal	14.85	11.95**	< 0.01
6.	Senapati	10.55		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.3.2.2.6 evident that the adoption of rice-fish farming system of all the selected districts were statistically significant at 1% level of significance.

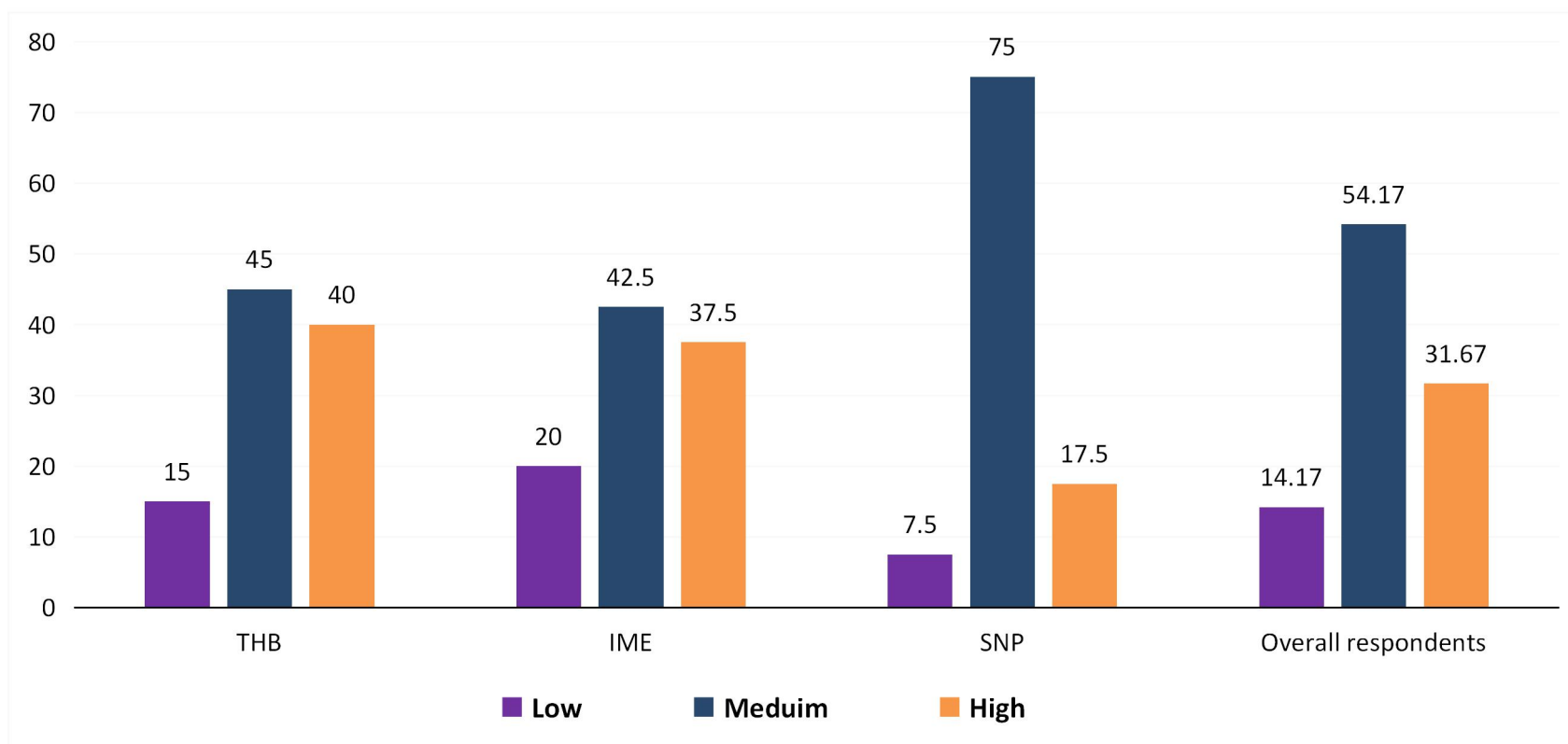


Fig 4.3.2.2.5 Distribution of respondents based on the level of adoption of rice-fish farming system

4.3.2.3. Extent of adoption of rice-mustard farming system

Table 4.3.2.3.1 Distribution of respondents based on the extent of adoption of rice-mustard farming system in Thoubal district

S/N	Recommended practices	Thoubal district Extent of Adoption (n ₁ =40)						Mean Score	Overall mean	AI
		FA	%	PA	%	NA	%			
1.	Selection of varieties	19	47.50	20	50.00	1	2.50	1.43	1.34	68.25
2.	Seed rate	17	42.50	20	50.00	3	7.50	1.20		
3.	Land preparation	15	37.50	20	50.00	5	12.50	1.23		
4.	Sowing time	30	75.00	10	25.00	0	0.00	1.73		
5.	Fertilizer management	16	40.00	20	50.00	4	10.00	1.28		
6.	Diseases management	8	20.00	23	57.50	9	22.50	0.98		
7.	Pest management	14	35.00	24	60.00	2	5.00	1.38		
8.	Weed management	13	32.50	25	62.50	2	5.00	1.23		
9.	Water management	19	47.50	17	42.50	4	10.00	1.35		
10.	Harvesting time	25	62.50	15	37.50	0	0.00	1.55		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nill adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

From Table 4.3.2.3.1 it was revealed that in Thoubal district majority (75.00%) of the respondents had full level of adoption of the recommended practices of 'sowing time' followed by 62.50 per cent of respondents having partial level of adoption of the recommended practices of 'weed management' and 22.50 per cent of them had nil adoption of the recommended practices of 'diseases management' under rice-mustard farming system. Recommended practices of rice-mustard farming system had 68.25 adoption index.

Table 4.3.2.3.1 presented the mean score of the recommended practices of rice-mustard farming system in Thoubal district and it was evident that the highest mean score (1.73) was observed in the recommended practices of 'sowing time' followed by the recommended practices of 'harvesting time' mean score (1.55), the recommended practices of 'selection of varieties' mean score (1.43), the recommended practices of 'pest management' mean score (1.38), the recommended practices of 'water management' mean score (1.35), the recommended practices of 'fertilizer management' mean score (1.28), the recommended practices of 'weed management' mean score (1.23), the recommended practices of 'land preparation' mean score (1.23), the recommended practices of 'seeds rate' mean score (1.20) and the recommended practices of 'diseases management' mean score (0.98). Overall mean of the recommended practices of rice-mustard farming system was 1.34.

The above results indicates that the rice-mustard farming system in Thoubal district had high adoption i.e., 68.25 adoption index however there is low adoption in disease management. Majority farmers reported that they were faced problem of diseases like Alternaria blight, concentric spot, circular to linear lesions, dark brown lesions developed on the stems of the plant. So, it is suggested for early sowing and irrigation to avoid the diseases infestation. Strengthened the extension delivery channel to promote technology adoption of rice mustard farming system may improve the adoption level of Thoubal district.

Table 4.3.2.3.2 Distribution of respondents based on the extent of adoption of rice-mustard farming system in Imphal East district

S/N	Recommended practices	Imphal East district Extent of adoption (n ₂ =40)						Mean	Overall mean	AI
		FA	%	PA	%	NA	%			
1.	Selection of varieties	32	80.00	8	20.00	0	0.00	1.75	1.46	74.88
2.	Seed rate	19	47.50	17	42.50	4	10.00	1.38		
3.	Land preparation	30	75.00	10	25.00	0	0.00	1.60		
4.	Sowing time	20	50.00	20	50.00	0	0.00	1.75		
5.	Fertilizer management	25	62.50	13	32.50	2	5.00	1.48		
6.	Diseases management	12	30.00	23	57.50	5	12.50	1.20		
7.	Pest management	17	42.50	18	45.00	5	12.50	1.28		
8.	Weed management	21	52.50	19	47.50	0	0.00	1.50		
9.	Water management	15	37.50	21	52.50	4	10.00	1.23		
10.	Harvesting time	28	70.00	12	30.00	0	0.00	1.48		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nil adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

From Table 4.3.2.3.2 it was revealed that in Imphal East district majority (80.00%) of the respondents had full level of adoption of the recommended practices of 'selection of varieties' followed by 57.50 per cent of respondents having partial level of adoption of the recommended practices of 'diseases management' and 12.50 per cent of them had nil level of adoption of the recommended practices of 'pest management and diseases management' under rice-mustard farming system. Recommended practices of rice-mustard farming system had 68.25 adoption index.

Table 4.3.2.3.2 presented the mean score of the recommended practices of rice-mustard farming system in Imphal East district and it was evident that the highest mean score (1.75) was observed in the recommended practices of 'selection of varieties' and 'sowing time' followed by the recommended practices of 'land preparation' mean score (1.60), the recommended practices of 'weed management' mean score (1.50), the recommended practices of 'fertilizer management' and 'sowing time' mean score (1.48), the recommended practices of 'seeds rate' mean score (1.38), the recommended practices of 'pest management' mean score (1.28), the recommended practices of 'water management' mean score (1.23) and the recommended practices of 'diseases management' mean score (1.20). Overall mean of the recommended practices of rice-mustard farming system was 1.46.

The above results indicates that the rice-mustard farming system in Imphal district had high adoption level i.e., 74.88 adoption index however majority farmers reported that oil content in mustard seeds was low. Therefore, it is suggested to cultivate high yield variety and intervention of better crop management technique.

Table 4.3.2.3.3 Distribution of respondents based on the extent of adoption of sustainable practices under rice-mustard farming system in Churachandpur district

S/N	Recommended practices	Churachandpur district Extent of adoption (n ₃ =40)						Mean	Overall mean	AI
		FA	%	PA	%	NA	%			
1.	Selection of varieties	11	27.50	16	40.00	13	32.50	0.90	0.90	47.63
2.	Seed rate	10	25.00	15	37.50	15	37.50	0.88		
3.	Land preparation	10	25.00	18	45.00	12	30.00	0.90		
4.	Sowing time	17	42.50	20	50.00	3	7.50	1.33		
5.	Fertilizer management	9	22.50	15	37.50	16	40.00	0.88		
6.	Diseases management	6	15.00	12	30.00	22	55.00	0.40		
7.	Pest management	8	20.00	14	35.00	18	45.00	0.75		
8.	Weed management	14	35.00	18	45.00	8	20.00	1.13		
9.	Water management	7	17.50	19	47.50	14	35.00	0.58		
10.	Harvesting time	10	25.00	30	75.00	0	0.00	1.28		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nill adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

From Table 4.3.2.3.3 it was revealed that in Churachandpur district majority (75.00%) of the respondents had partial level of adoption of the recommended practices of 'harvesting time' followed by 55.00 per cent of the respondents having nil level of adoption of the recommended practices of 'diseases management' and 42.50 per cent of them had full adoption of the recommended practices of 'sowing time' under rice-mustard farming system. Recommended practices of rice-mustard farming system had 47.63 adoption index.

Table 4.3.2.3.3 presented the mean score of the recommended practices of rice-mustard farming system in Churachandpur district and it was evident that the highest mean score (1.28) was observed in the recommended practices of 'harvesting time' followed by the recommended practices 'sowing time' mean score (1.33), the recommended practices 'weed management' mean score (1.13), the recommended practices 'selection of varieties' and 'land preparation' mean score (0.90), the recommended practices 'seed rate' and 'fertilizer management' mean score (0.88), the recommended practices 'water management' mean score (0.58) and the recommended practices 'diseases management' mean score (0.40). Overall mean of the recommended practices of rice-mustard farming system was 0.90. The above results indicates that the rice-mustard farming system in Churachandpur district had low adoption *i.e.* 47.63 adoption index which is lower than Imphal East district (74.88 adoption index) and Thoubal district (68.25 adoption index). And low technology adoption was observed in the recommended fertilizer management, 'water management', and 'diseases management'. It may be due to lack of awareness and effective extension mechanism about the rice-mustard farming system. Based on the findings an effort aimed at addressing these particular practices should be put to improve the farmers skills through training and education. It is suggested that programs or strategies may be framed to lead to higher level level of adoption of technologies in Churachandpur district to achieved the maximum attainable farm production and income.

Table 4.3.2.3.4 Distribution of overall respondents based on the extent of adoption of sustainable practices under rice-mustard farming system

S/N	Recommended practices	Overall adoption level (N=120)						Mean	Overall mean	AI
		FA	%	PA	%	NA	%			
1.	Selection of varieties	62	51.67	44	36.67	14	11.67	1.36	1.23	3.59
2.	Seed rate	46	38.33	52	43.33	22	18.33	1.15		
3.	Land preparation	55	45.83	48	40.00	17	14.17	1.24		
4.	Sowing time	67	55.83	50	41.67	3	2.50	1.60		
5.	Fertilizer management	50	41.67	48	40.00	22	18.33	1.21		
6.	Diseases management	26	21.67	58	48.33	36	30.00	0.86		
7.	Pest management	39	32.50	56	46.67	25	20.83	1.14		
8.	Weed management	48	40.00	62	51.67	10	8.33	1.29		
9.	Water management	41	34.17	57	47.50	22	18.33	1.05		
10.	Harvesting time	63	52.50	57	47.50	0	0.00	1.44		

FA: Full adoption; **PA:** Partial adoption; **NA:** Nil adoption; **AI:** Adoption Index; **%:** Percentage and **f:** Frequency

Table 4.3.2.3.4 presented the overall extent of adoption of the recommended sustainable practices under rice-mustard farming system of Thoubal district, Imphal East district and Churachandpur district. It was revealed that majority (55.83%) of the respondents had full level of adoption of the recommended practices of 'sowing time' followed by 51.67 per cent of the respondents having partial level of adoption of the recommended practices of 'weed management' and 30.00 per cent of them had nil level of adoption of the recommended practices of 'disease management'. Recommended practices of rice-mustard farming system had 63.59 adoption index.

Table 4.3.2.3.4 presented the mean score of the recommended practices of rice-mustard farming system of Thoubal district, Imphal East district and Churachandpur district. It was evident that the highest mean score (1.60) was observed in the recommended practices of 'sowing time' followed by the recommended practices of 'harvesting time' mean score (1.44), the recommended practices 'selection of varieties' mean score (1.36), the recommended practices 'weed management' mean score (1.29), the recommended practices 'land preparation' mean score (1.24), the recommended practices 'fertilizer management' mean score (1.21), the recommended practices of 'seed rate' mean score (1.15), the recommended practices of 'pest management' mean score (1.14), the recommended practices of 'water management' mean score (1.05) and the recommended practices of 'diseases management' mean score (0.86). Overall mean of the recommended practices of rice-mustard farming system was 1.23.

From the above findings indicates that farmers possess higher adoption in the recommended rice-mustard farming system it may be due to rice-mustard farming system was one of the most widely cultivated, less labour requirement and low-cost rice-based farming system practiced. And most the farmers had experienced and familiar with the recommended the technology result in higher adoption of rice-mustard farming system. However, recommended practiced like

diseases management and water management found as low adoption therefore technology adoption need to be improved in this particular area. To improve the adoption status it is suggested to enhance the agricultural inputs supply chains, training to improved skill on the particulars and extension services.

Table 4.3.2.3.5 Distribution of overall respondents based on the level of adoption under rice-mustard farming system

Districts	Level of adoption	f	%	Mean	SD	AI
Thoubal n₁=40	Low (<11.20)	5	12.50	13.41	2.32	68.25
	Medium (11.20-15.62)	24	60.00			
	High (>15.62)	11	27.50			
Imphal East n₂=40	Low (<12.62)	3	7.50	14.81	2.18	74.88
	Medium (12.69-16.99)	23	57.50			
	High (>16.99)	14	35.00			
Churachandpur n₃=40	Low (<5.76)	3	7.50	8.70	2.93	47.63
	Medium (5.65-11.63)	27	67.50			
	High (>11.63)	8	20.00			
Overall n=120	Low (<8.19)	11	9.17	12.02	3.45	63.59
	Medium (8.19-14.80)	74	61.67			
	High (>14.80)	31	25.83			

From Table 4.3.2.3.4 and Fig 4.3.2.3.4 it was revealed that in Churachandpur district majority (67.50%) of the respondents had medium level of adoption followed by 20.00 per cent of the respondents having high level of adoption and 7.50 per cent of them had low level of adoption of the recommended practices of rice-mustard farming system with an adoption index of 47.63. In Thoubal district, majority (60.00%) of the respondents had medium level of adoption followed by 27.50 per cent of the respondents having high level of adoption and 12.50 per cent of them had low level of adoption of the recommended practices of rice-mustard farming system with an adoption index of

47.63. In Imphal East district, majority (57.50%) of the respondents had medium level of adoption followed by 35.00 per cent of the respondents having high level of adoption and 7.50 per cent of them had low level of adoption of the recommended practices of rice-mustard farming system with an adoption index of 74.88. Overall, it was found that majority (61.67%) of the respondents had medium level of adoption followed by 25.83 per cent of the respondents having high level of adoption and 9.17 per cent of them had low level of adoption of the recommended practices of rice-mustard farming system with an adoption index of 63.69. The above findings were similar to the findings of Brunda *et al.* (2019); Shasani *et al.* (2020) and Rufaida and Singh, (2022) that majority farmers belonged to medium level of adoption of the recommended cultivation technologies. Therefore, it was necessary to intensify the extension efforts to increase the knowledge level and adoption of recommended rice-mustard farming system technologies which would help in increasing crop yield and income.

Table 4.3.2.3.6 Comparative account on response of adoption of rice-mustard farming system

S/N	Districts	Adoption level (μ)	Z Value	P value
1.	Thoubal	13.41	-2.66*	< 0.05
2.	Imphal East	14.81		
3.	Imphal East	14.81	-10.32**	< 0.01
4.	churachandpur	8.70		
5.	Thoubal	13.41	1.01 ^{NS}	> 0.05
6.	Churachandpur	8.70		

** significant at 1% level of probability, * significant at 5% level of probability

From the Table 4.3.2.3.6, it was evident that adoption of rice-mustard farming system of all the selected districts were statistically significant at 1% and 5% level of significance except Thoubal district vs Churachandpur district (p-value >0.05).

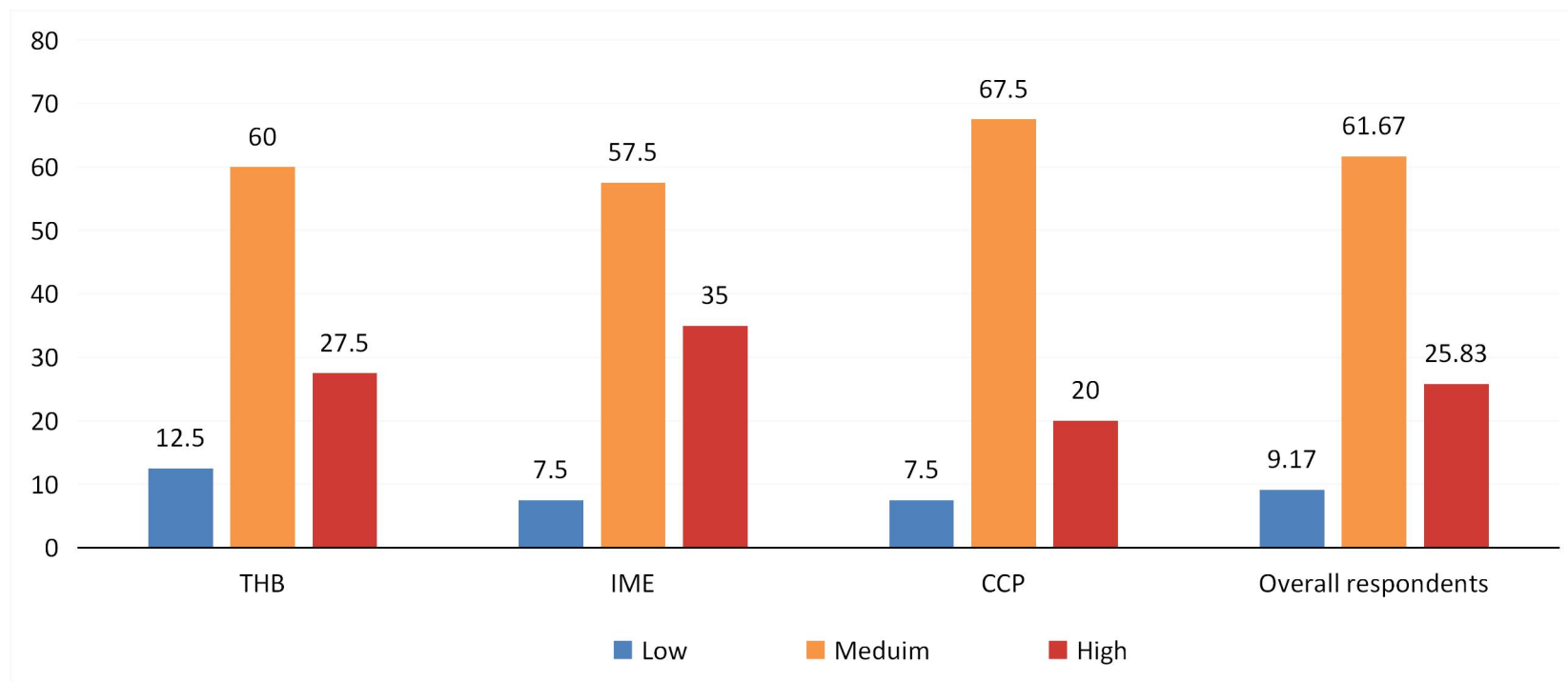


Fig 4.3.2.3.5 Distribution of respondents based on the level of adoption of rice-mustard farming system

4.3.2.4 Extent of adoption of rice-vegetables farming system

Table 4.3.2.4.1 Distribution of respondents based on the extent of adoption of rice-vegetables farming system

Recommended practices	Churachandpur district (n ₁ =40)						Mean	Overall Mean	AI
	FA	%	PA	%	NA	%			
Selection of varieties	13	32.50	15	37.50	12	30.00	1.03	1.09	54.38
Seed rate	10	25.00	17	42.50	13	32.50	0.95		
Land preparation	11	27.50	22	55.00	7	17.50	1.10		
Sowing time	17	42.50	20	50.00	3	7.50	1.35		
Fertilizer management	12	30.00	19	47.50	9	22.50	1.08		
Diseases management	9	22.50	16	40.00	15	37.50	0.85		
Pest management	10	25.00	16	40.00	14	35.00	0.93		
Weed management	12	30.00	21	52.50	7	17.50	1.13		
Water management	13	32.50	18	45.00	9	22.50	1.08		
Harvesting time	17	42.50	23	57.50	0	0.00	1.43		
Recommended practices	Senapati district (n ₂ =40)						Mean		
	FA	%	PA	%	NA	%			
Selection of varieties	15	37.50	18	45.00	7	17.50	1.20	1.24	62.25
Seed rate	16	40.00	17	42.50	7	17.50	1.18		
Land preparation	15	37.50	23	57.50	2	5.00	1.33		
Sowing time	20	50.00	20	50.00	0	0.00	1.53		
Fertilizer management	17	42.50	20	50.00	3	7.50	1.35		
Diseases management	12	30.00	18	45.00	10	25.00	1.00		
Pest management	11	27.50	16	40.00	13	32.50	0.95		
Weed management	14	35.00	23	57.50	3	7.50	1.28		
Water management	12	30.00	20	50.00	8	20.00	1.15		
Harvesting time	19	47.50	21	52.50	0	0.00	1.45		

AI:Adoption Index

From Table 4.3.2.4.1 it was revealed that in Churachandpur district majority (57.50%) of the respondents had partial level of adoption of recommended practices of 'weed management' followed by 42.50 per cent of the respondents having full level of adoption of recommended practices of 'harvesting time' and 'sowing time' and 37.50 per cent of the respondents having nil level of adoption of recommended practices of 'pest management' under rice-vegetable farming system. Recommended practices of rice-vegetable farming system had 54.38 adoption index.

Table 4.3.2.4.1 presented the mean score of the recommended practices of rice-vegetable farming system in Churachandpur district and it was evident that the highest mean score (1.43) was observed in the recommended practices of 'harvesting time' followed by the recommended practices of 'sowing time' mean score (1.35), the recommended practices of 'weed management' mean score (1.13), the recommended practices of 'land preparation' mean score (1.10), the recommended practices of 'water management' and 'fertilizer management' mean score (1.08), the recommended practices of 'selection of varieties' mean score (1.03), the recommended practices of 'pest management' mean score (0.93) and recommended practices of 'diseases management' mean score (0.85) 0.85 mean. Overall mean score of the recommended rice-vegetable farming system was 1.09.

The above results indicates that Churachandpur district had 54.38 adoption index in rice-vegetable farming system and low adoption on pest and diseases management. Moreover, churachandpur district had lower adoption index than Senapati district (62.25 adoption index) under rice-vegetable farming system. It may be due to lack of technical knowledge and skills of farmers on the recommended practices. Lack of awareness and connectivity with extension workers or limited access to the technology could also be the main reason of slow adoption in Churachandpur district.

From Table 4.3.2.4.1 it was revealed that in Senapati district majority (57.50%) of the respondents had partial level of adoption of recommended practices of 'land preparation' and 'weed management' followed by 50.00 per cent of the respondents having full level of adoption of recommended practices of 'sowing

time’ and 32.50 per cent of the respondents having nil level of adoption of recommended practices of ‘pest management’ under rice-vegetables farming system. Recommended practices of rice-vegetable farming system had 62.25 adoption index.

Table 4.3.2.4.1 presented the mean score of rice-vegetables farming system in Senapati district and it was evident that the highest mean score (1.53) was observed in the recommended practices of ‘sowing time’ followed by the recommended practices of ‘harvesting time’ mean score (1.45), the recommended practices of ‘fertilizer management’ mean score (1.35), the recommended practices of ‘land preparation’ mean score (1.33), the recommended practices of ‘weed management’ mean score (1.28), the recommended practices of ‘selection of varieties’ mean score (1.20), the recommended practices of ‘water management’ mean score (1.15), the recommended practices of ‘diseases management’ mean score (1.00) and the recommended practices of ‘pest management’ mean score (0.95). Overall mean of rice-vegetable farming system was 1.24.

The above results indicates that Senapati district had 62.25 adoption index in rice-vegetable farming system which is higher than Churachandpur district however low adoption of pest management was observed in the recommended of rice-vegetable farming system. To improve the adoption status it is suggested to provide training and regular contact with extension workers for timely and relevant information about the rice-vegetable farming system.

Table 4.3.2.4.2 Distribution of overall respondents based on the extent of adoption under rice-vegetables farming system

S/N	Recommended practices	Overall (n=80)						Mean
		FA	%	PA	%	NA	%	
1.	Selection of varieties	28	35.00	33	41.25	19	23.75	1.11
2.	Seed rate	26	32.50	34	42.50	20	25.00	1.06
3.	Land preparation	26	32.50	45	56.25	9	11.25	1.21
4.	Sowing time	37	46.25	40	50.00	3	3.75	1.44
5.	Fertilizer management	29	36.25	39	48.75	12	15.00	1.21
6.	Diseases management	21	26.25	34	42.50	25	31.25	0.93
7.	Pest management	21	26.25	32	40.00	27	33.75	0.94
8.	Weed management	26	32.50	44	55.00	10	12.50	1.20
9.	Water management	25	31.25	38	47.50	17	21.25	1.11
10.	Harvesting time	36	45.00	44	55.00	0	0.00	1.44
11.	Average	1.17						
12.	AI	58.31						

FA: Full adoption; PA: Partial adoption; NA: Nil adoption; AI: Adoption Index; %: Percentage and f: Frequency

Table 4.3.2.4.2 presented the overall extent of adoption of rice-vegetable farming system of Churachandpur district and Senapati district. It was revealed that majority (56.25%) of the respondents had partial level of adoption of the recommended practices of 'land preparation' followed by 45.00 per cent of the respondents having full level of adoption of the recommended practices of 'harvesting time' and 33.75 per cent of the respondents having nil level of adoption of the recommended practices of 'pest management'. Recommended practices of rice-vegetable farming system had 58.31 adoption index.

Table 4.3.2.4.2 presented the mean score of overall respondents under rice-vegetable farming system and it was evident that the highest mean score (1.44) was observed in the recommended practices of 'sowing time' and 'harvesting time' followed by the recommended practices of 'land preparation' and 'fertilizers

management’ mean score (1.21), the recommended practices of ‘weed management’ mean score (1.20), the recommended practices of ‘water management’ and ‘selection of varieties’ mean score (1.11), the recommended practices of ‘seed rate’ mean score (1.06), the recommended practices of ‘pest management’ mean score (0.94) and recommended practices of ‘diseases management’ mean score (0.93). Overall, mean score of the recommended practices of rice-vegetable farming system was 1.17.

From the above findings it was indicated that farmers possess medium adoption (58.31 adoption index) on rice-vegetable farming system. And the recommended practiced like diseases management and pest management were found as low adoption therefore technology adoption need to be improved in this particular area. Enhancing the extension contact with farmers emphasizing on the pest and diseases management and help farmers to get easy access of agricultural information to achieved maximum benefit of the adoption. Analyzing the factors that contributed to farmers' low adoption of technology can help to improve the adoption of pest and diseases management practices.

Table 4.3.2.4.3 Distribution of overall respondents based on the level of adoption under rice-vegetable farming system

Districts	Level of adoption	f	%	Mean	SD	AI
Churachandpur n₃=40	Low (<8.15)	3	7.50	10.60	2.45	54.38
	Medium (8.15-13.04)	34	85.00			
	High (>13.04)	5	12.50			
Senapati n₄=40	Low (<10.63)	2	5.00	12.29	1.66	62.25
	Medium (10.63-13.95)	31	77.50			
	High (>13.95)	7	17.50			
Overall n=160	Low (<9.39)	5	6.25	11.44	2.05	58.31
	Medium (9.39-13.50)	65	81.25			
	High (>13.50)	12	15.00			

?: Percentage and f: Frequency

From Table 4.3.2.4.3 and Fig 4.3.2.4.3 it was revealed that in Churachandpur district majority (85.00%) of the respondents had medium level of adoption of rice-vegetable farming system followed by 12.50 per cent of the respondents having high level of adoption and 7.50 per cent of the respondents having nil level of adoption of recommended practices of rice-vegetable farming system. In Senapati district, majority (97.50%) of the respondents had medium level of adoption followed by 17.50 per cent of the respondents having high level of adoption and 5.00 per cent of the respondents having low level of adoption of recommended practices of rice-vegetables farming system.

Overall, it was found that majority (81.25%) of the respondents had medium level of adoption of recommended practices of rice-vegetables framing system followed by 15.00 per cent of the respondents having high level of adoption and 6.25 per cent of the respondents having low level of adoption of the recommended practices of rice-vegetable farming system with an adoption index of 58.31. These findings were found similar with Mhoja *et al.*, (2021) that majority farmers had medium level of adoption in adoption of rice management technology.

Table 4.3.2.4.4 Comparative account of adoption under rice-vegetable farming system

S/N	Districts	Adoption level (μ)	Z Value	P value
1.	Churachandpur	10.60	-3.21**	< 0.01
2.	Senapati	12.29		

** significant at 1% level of probability, * significant at 5% level of probability

From Table 4.3.1.2 it was evident that the farmers adopting rice-vegetable farming system from all the selected districts were statistically significant at 1%.

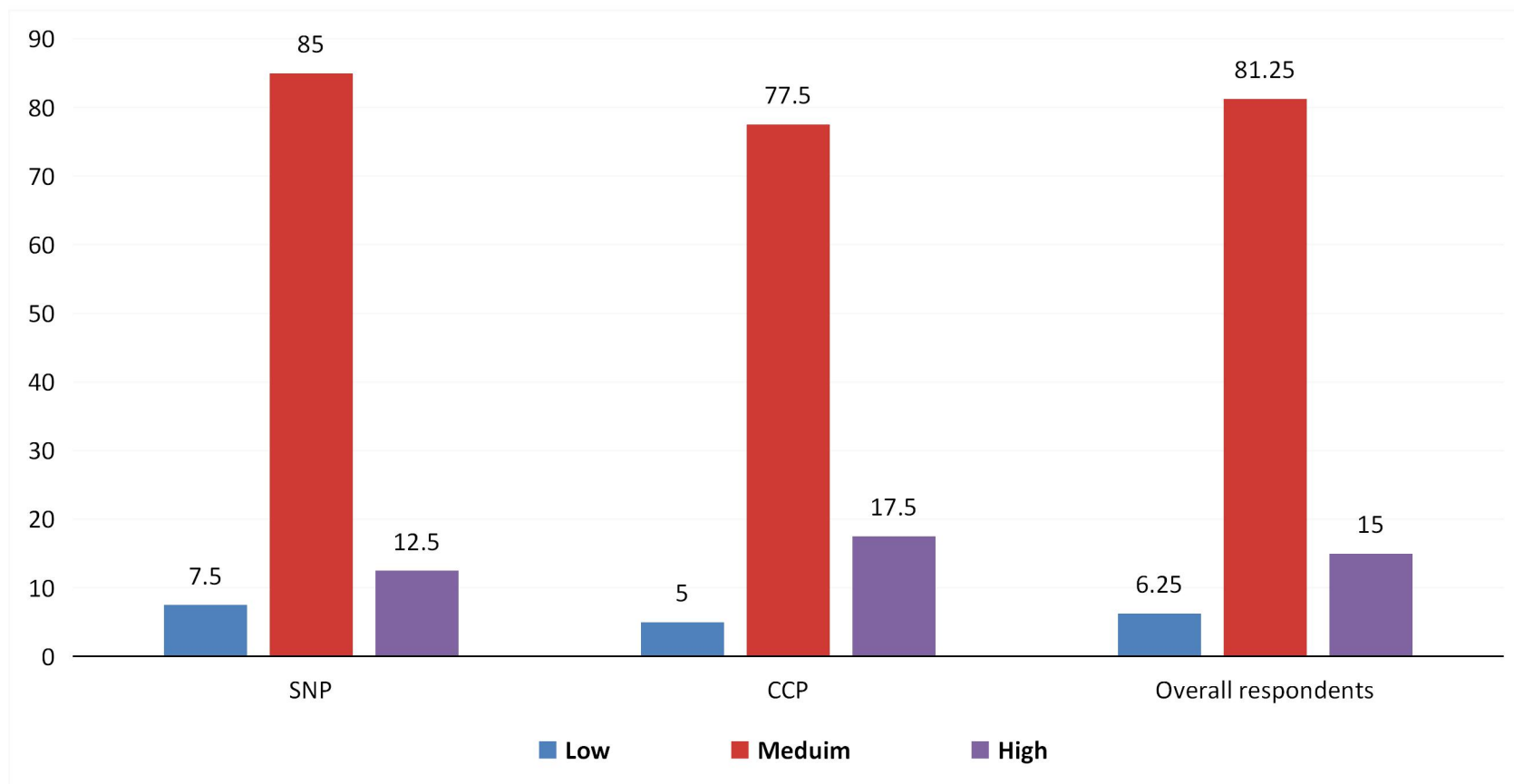


Fig 4.3.2.4.3 Distribution of overall respondents based on the level of adoption under rice-vegetable farming system

Table 4.3.3: Correlation of socio-economic and personal characteristics of farmers with their adoption of rice-based farming system

Coefficient of correlation was computed in order to explore the relationships between the socio-economic and personal characteristics of the farmers and adoption of rice-based farming system. Relationships between the selected characteristics of the farmers and adoption of rice-based farming system have been presented in Table 4.3.3.

S/N	Independent's variables	Correlation coefficient (r)	P value
1.	Age	0.152**	0.006
2.	Education	0.042	0.458
3.	Experienced in rice-based farming	0.154**	0.006
4.	Total size of landholding	0.008	0.893
5.	Size of land under riced-based	0.132*	0.018
6.	Annual income	0.300**	0.00
7.	Income from rice-based	0.308**	0.00
8.	Training exposure	0.122*	0.029
9.	Extension contacts	0.066	0.239
10.	Formal information sources utilization	0.035	0.536
11.	Informal information sources utilization	0.029	0.611
12.	Mass media information sources utilization	0.159**	0.004
13.	Social media information sources utilization	0.099	0.078
14.	Perception towards climate change	0.318**	0.00
15.	Market orientation	0.225**	0.00
16.	Production orientation	0.103	0.065
17.	Risk orientation	0.080	0.155
18.	Innovativeness	0.173**	0.002

** significant at the 0.01 level (2-tailed), * significant at the 0.05 level (2-tailed)

Table 4.3.3 revealed that the variables age ($r=0.152^{**}$), annual income ($r=0.300^{**}$), income from rice-based farming ($r=0.308^{**}$), mass media information sources utilization ($r=0.159^{**}$), perception towards climate change ($r=0.318^{**}$), market orientation ($r=0.225^{**}$) and innovativeness ($r=0.173^{**}$) had positive and significant association with dependent variable adoption of rice-based farming

system at 1% level of significance. And the variables size of land under rice-based farming ($r=0.132^*$) and training exposure ($r=0.122^*$) had positive and significant association with dependent adoption of rice-based farming system at 5% level of significance. These findings were similar to the findings of Iheke *et al.* (2021) and Checco *et al.* (2023).

Variable's education, total size of landholding, extension contact, formal information sources utilization, informal information sources utilization, social media information sources utilization, production orientation and risk orientation had non-significant association with '**adoption of rice-based farming system**'. Based upon the findings, the null hypothesis (**H_{03a}**) was rejected:

H_{03a}: There is no association between the variables age, annual income, income from rice-based farming, mass media information sources utilization, perception towards climate change, market orientation and innovativeness, size of land under rice-based farming, training exposure with '**adoption of rice-based farming system**' was rejected.

The variables education, total size of landholding, extension contact, formal information sources utilization, informal information sources utilization, social media information sources utilization, production orientation and risk orientation were found non-significant association with '**adoption of rice-based farming system**'. Therefore, the following null hypothesis **H_{03b}** was accepted:

H_{03b}: There is no association between variables education, total size of landholding, extension contact, formal information sources utilization, informal information sources utilization, social media information sources utilization, production orientation and risk orientation with '**adoption of rice-based farming system**' was accepted.

Table 4.3.4: Path coefficients of selected variables with respect to adoption of rice-based farming system

S/N.	Variables	Direct effect	Three largest variables through which indirect effect are channelized	Total indirect effect	Total effect
X ₁	Age	0.076 11 th	0.118 (X ₂) 0.022(X ₆) 0.019(X ₅)	- 0.076 9 th	0.000 13 th
X ₂	Experience in agriculture	0.138 2 nd	0.065(X ₁) 0.020(X ₆) 0.015(X ₇)	0.050 11 th	0.188 2 nd
X ₃	Experience in rice-based farming system	-0.118 5 th	0.074(X ₂) 0.040(X ₁) 0.012(X ₈)	-0.272 1 st	-0.39 10 th
X ₄	Size of land under rice-based farming system	-0.083 10 th	0.076(X ₅) 0.032(X ₆) 0.026(X ₂)	-0.091 8 th	-0.174 3 rd
X ₅	Total landholding size	0.096 7 th	0.054(X ₆) 0.019(X ₂) 0.015(X ₁)	-0.036 13 th	0.060 6 th
X ₆	Annual income	0.128 4 th	0.041(X ₅) 0.031(X ₇) 0.027(X ₁)	0.172 4 th	0.044 8 th
X ₇	Income from rice-based farming system	0.164 1 st	0.026(X ₁₁) 0.024(X ₆) 0.024(X ₁₀)	-0.144 7 th	0.020 12 th
X ₈	Training exposure	-0.095 8 th	0.015(X ₃) 0.014(X ₁₀) 0.012(X ₉)	-0.217 2 nd	-0.312 1 st
X ₉	Mass media information utilization	0.093 9 th	0.031(X ₆) 0.023(X ₁₁) 0.020(X ₁₀)	-0.066 10 th	0.027 11 th
X ₁₀	Risk orientation	0.114 6 th	0.050(X ₁₁) 0.034(X ₇) 0.022(X ₁₃)	-0.168 5 th	-0.054 7 th
X ₁₁	Perception	0.138 2 nd	0.042(X ₁₀) 0.031(X ₇) 0.026(X ₆)	-0.180 3 rd	-0.042 9 th
X ₁₂	Market orientation	0.074 12 th	0.039(X ₁₁) 0.025(X ₁₀) 0.021(X ₆)	-0.151 6 th	-0.077 5 th
X ₁₃	Innovativeness	0.130 3 rd	0.020(X ₁₀) 0.018(X ₇) 0.170(X ₃)	-0.043 12 th	0.087 4 th

Path analysis was attempted to determine the direct, indirect effects and total effects between the numbers of variables and thus help to quantitatively interpret the interrelationships within a known or assumed casual system that existed in some specific populations. The Table 4.3.4 shows the direct, indirect effects and total effect among the interrelated independent variables with the adoption of rice-based farming system.

Total effect

It was observed from Table 4.3.4 that among the socio-economic and personnel characteristics of rice based cultivated farmers the highest total effect on adoption of rice-based farming system was exerted by training exposure (-0.312) having 1st position followed by experience in agriculture (0.188) having 2nd position, size of land under rice-based farming system (-0.174) having 3rd position, innovativeness (0.087) having 4th position, market orientation (-0.077) having 5th position, total landholding size (0.060) having 6th position, risk orientation (-0.054) having 7th position, annual income (0.044) 8th position, perception (-0.042) 9th position, experience in rice based farming system (-0.39) 10th position, mass media information utilization (0.027) 11th position, income from rice-based farming system (0.020) 12th position and age (0.000) 13th position.

Direct effect

It was observed from Table 4.3.4 that among the socio-economic and personnel characteristics of rice based cultivated farmers the highest direct effect on adoption of rice-based farming system was exerted by income from rice-based farming system (0.164) 1st position followed by experience in agriculture and perception (0.138) 2nd position, innovativeness (0.130) 3rd position, annual income (0.128) 4th position, experience in rice based farming system (-0.118) 5th position, risk orientation (0.114) 6th position, total landholding size (0.096) 7th position, training exposure (-0.095) 8th position, mass media information utilization (0.093) 9th position, size of land under rice-based farming system (-0.083) 10th position, age (0.076) 11th position, market orientation (0.074) 12th position.

Total indirect effect and three largest variables through which indirect effect are channelized

It was observed from Table 4.3.4 that among the socio-economic and personnel characteristics of rice based cultivated farmers the first substantial indirect effect on adoption of rice-based farming system was exerted by experience in rice-based farming system (-0.272) through experience in agriculture (0.074) followed by age (0.040) and training exposure (0.012). In 2nd position exerted by training exposure (-0.217) through experience in rice-based farming system (0.015) followed by risk orientation (0.014) and mass media information utilization (0.012). In 3rd position exerted by perception (-0.180) through risk orientation (0.042) followed by income from rice-based farming system (0.031) and annual income (0.026). In 4th position exerted by annual income (0.172) through total landholding size (0.041) followed by income from rice-based farming system (0.031) and age (0.027). In 5th position exerted by risk orientation (-0.168) through perception (0.039) followed by risk orientation (0.025) and annual income (0.021). In 6th position exerted by market orientation (-0.151) through total landholding size (0.041) followed by income from rice-based farming system (0.031) and age (0.027). In 7th position exerted by income from rice-based farming system (-0.144) through perception (0.026) followed by annual income (0.024) and risk orientation (0.024). In 8th position exerted by size of land under rice-based farming system through total landholding size (0.076) followed by annual income (0.032) and experience in agriculture (0.026). In 9th position exerted by age (-0.076) through experience in agriculture (0.118) followed by annual income (0.022) and total landholding size (0.019). In 10th position exerted by mass media information utilization (-0.066) through annual income (0.031) followed by perception (0.023) and risk orientation (0.020). In 11th position exerted by experience in agriculture (0.050) through age (0.065) followed by annual income (0.020) and income from rice-based farming system (0.015). In 12th position exerted by innovativeness (-0.043) through risk orientation (0.020) followed by income from rice-based farming system (0.018) and experience in rice-based farming system (0.170).

Thus, it was revealed that experience in agriculture, experience in rice-based farming system, risk orientation, annual income, market orientation, income from rice-based farming system, size of land under rice-based farming system were the important variables in absence of which, independent variables are not able to influence the adoption of rice-based farming system.

Table 4.3.5: Socio-economic and personnel factors explaining variance towards adoption of sustainable rice-based farming

Factors	Variables	Factors loading	% of variance explained	Cumulative % explained	Factors Renamed
F-1	Age	.810	15.133	15.133	Personal information
	Experience in agriculture	.758			
	Experience in rice-based farming	.680			
	Social media information sources utilization	.490			
	Total land holding size	.487			
	Family size	.439			
	Family type	.416			
F--2	Annual income	.669	10.859	25.992	Communication and economic attributes
	Size of land under rice-based	.593			
	Perception towards climate change	.506			
	Mass media information sources utilization	.503			
	Total landholding size	.437			
	Sex	.386			
F--3	Total landholding size	-.508	8.461	34.453	Economic attributes
	Size of land under rice-based	-.451			
	Family size	-.430			
	Production orientation	.428			
	Experience in agriculture	.417			
	Market orientation	.394			

Factors	Variables	Factors loading	% of variance explained	Cumulative % explained	Factors Renamed
F-4	Extension contacts	.670	8.330	42.783	Informativeness
	Formal information sources utilization	.594			
	Innovativeness	-.506			
	Informal information sources utilization	.421			
	Training exposure	.397			
	Mass media information sources utilization	.342			
F-5	Family type	.695	7.044	49.827	Household members
	Family size	.627			
F-6	Risk orientation	.702	5.590	55.417	Entrepreneurial attributes
	Product orientation	-.535			
F-7	Formal information sources utilization	.531	5.116	60.533	Information access
	Informal information sources utilization	-.531			
F-8	Income from rice-based farming system	-.486	4.603	65.136	Innovative farmers
	Sex	.473			
	Innovativeness	-.413			
F-9	Training exposure	-.460	4.451	69.587	Production training
	Sex	.389			
	Production orientation	-.333			

The data furnished in Table 4.3.5 studied the factors that influence in adoption of sustainable rice-based farming system. This was performed to pool and simplify a number of variables into lesser. A total of 21 independent variables were conglomerated and thus, nine factors were elicited and renamed. The nine factors accounted for 69.59 per cent variation in the study.

Factor 1

This factor accounted for 15.13 per cent of the total variation embedded with adoption of sustainable rice-based farming system. It could be seen from the

Table 4.3.5 that this factor was a conglomeration of variables namely age, experience in agriculture, experience in rice-based farming system, social media information sources utilization, total land holding size, family size and family type. This factor was renamed as “Personal information”. According to (Roy *et al.*, 2020) found that reported that family type, landholding size has positive association with adoption level of farmers. This finding inferred that the adoption of sustainable rice-based farming system was found influenced by a combination of experience, total landholding size, family type and their association effects.

Factor 2

The second factor consisted of the variables, annual income, size of land under rice-based farming system, perception towards climate change, mass media information sources utilization, total landholding size and sex contributed 10.86 per cent to the total variance and renamed the factor as “Communication and economic attributes” factor. These variables under a single factor drive the farmers to adopt the sustainable rice-based farming system. This factor helped the farmers in receiving farm information to the farmers, income and important of cultivating land. According to (Makate *et al.*, 2018) found that farm size was associated with the adoption. The intensity of technology adoption tends to be higher among the farmers with higher off-farm income.

Factor 3

The third factor was renamed as ‘Economic attributes’ factor. The variables total landholding size, size of land under rice-based farming system, family size, product orientation, experience in agriculture and market orientation comprised of this factor and a total of 8.461 per cent was contributed to the total variance of the study. According to (Wu, 2022) found that adoption of new agricultural technologies has a positive and significant impact on family farms’ income. It means the farmers having annual income had higher potential of adopting sustainable technology than the farmers with low income. And (Gajanand *et al.*, 2017) reported that there is positive and significant relationship found between

market orientation and adoption of farm innovations in trained farmers. The farmers having more experience in agriculture tend to be more market and production orientation. This factor helps the farmers in developing an entrepreneurial mindset like market orientation and production orientations which contributed to adoption of sustainable rice-based farming system.

Factor 4

The fourth factor renamed as “Informativeness” consisted of variables viz., extension contacts, formal information sources utilization, innovativeness, informal information sources utilization, training exposure and mass media information sources utilization explained 8.33 per cent of the total variance. This inferred that the farmers with more information sources utilization, more frequency of extension contact and training exposure were found to adopt sustainable rice-based farming system. Oyingbo *et al.* (2019) observed that the availability of extension services played a positive effect on the adoption of sustainable technologies. Paramasivam *et al.* (2021) observed that rate of adoption was influenced by the training undergone in organic farming and extension contact. Farmers who have access extension contact are more likely to adopt sustainable agriculture practices (Priya and Singh, 2022).

Factor 5

The fifth factor was renamed as “Household members” factor. The variables family size, family type, comprised of this factor and a total of 7.04 per cent was contributed to the total variance of the study. It inferred that family members play an important role in adoption of sustainable rice-based farming system.

Factor 6

The six factor was renamed as “Entrepreneurial attributes” factor. The variables risk orientation and production orientation comprised of this factor and a total of 5.59 per cent was contributed to the total variance of the study. According

(Gajanand *et al.*, 2017) to there is positive and significant relationship found between market orientation, production orientation and adoption of farm innovations in trained farmers. This means higher risk orientation and production orientation higher the adoption of sustainable rice-based farming system. So, this factor help in developing the entrepreneurial behaviour of the farmers that contributes towards the adoption of sustainable rice-based farming system.

Factor 7

The seventh factor renamed as “Information access” consisted of variables viz., informal information sources utilization and formal information sources utilization explained 5.12 per cent of the total variance of the study. This inferred that the farmers with more information sources utilization tend to have higher rate of adoption of sustainable technology.

Factor 8

The eight factors accounted for 4.60 per cent of the total variation embedded with adoption of sustainable rice-based farming system. This factor was a conglomeration of variables income from rice-based farming system, sex and innovativeness. This factor was renamed as “Innovative farmers” factor. It inferred that the innovative farmers possessed higher income that contribute in adoption of sustainable rice-based farming system.

Factor 9

The ninth factor was renamed as “Production training” factor. The variables production orientation, sex and training exposure had contributed a total of 4.451 per cent towards the total variance of the study. It inferred that the farmers who attended training tend to have more production orientation which contribute in the adoption of sustainable rice-based farming system

4.4 Factors determining the sustainability of rice-based farming system

Table 4.4.1 Sustainable index of rice-based farming systems in the selected districts of Manipur

Region	Districts	Dimensions of sustainability			Overall Sustainability index N=320	Rank
		Environmental Sustainability Index	Social Sustainability Index	Economic Sustainability Index		
Valley area	Thoubal n ₁ =80	65.03	67.38	63.92	65.44	I
	Imphal East n ₂ =80	59.57	64.26	62.34	62.05	III
	Average score	62.30	65.82	63.13	63.75	
Hill area	Churachandpur n ₃ =80	60.59	59.07	55.75	58.47	IV
	Senapati n ₄ =80	68.07	57.38	56.08	60.34	III
	Average score	64.33	58.23	55.92	59.41	
Overall n=320		61.58				

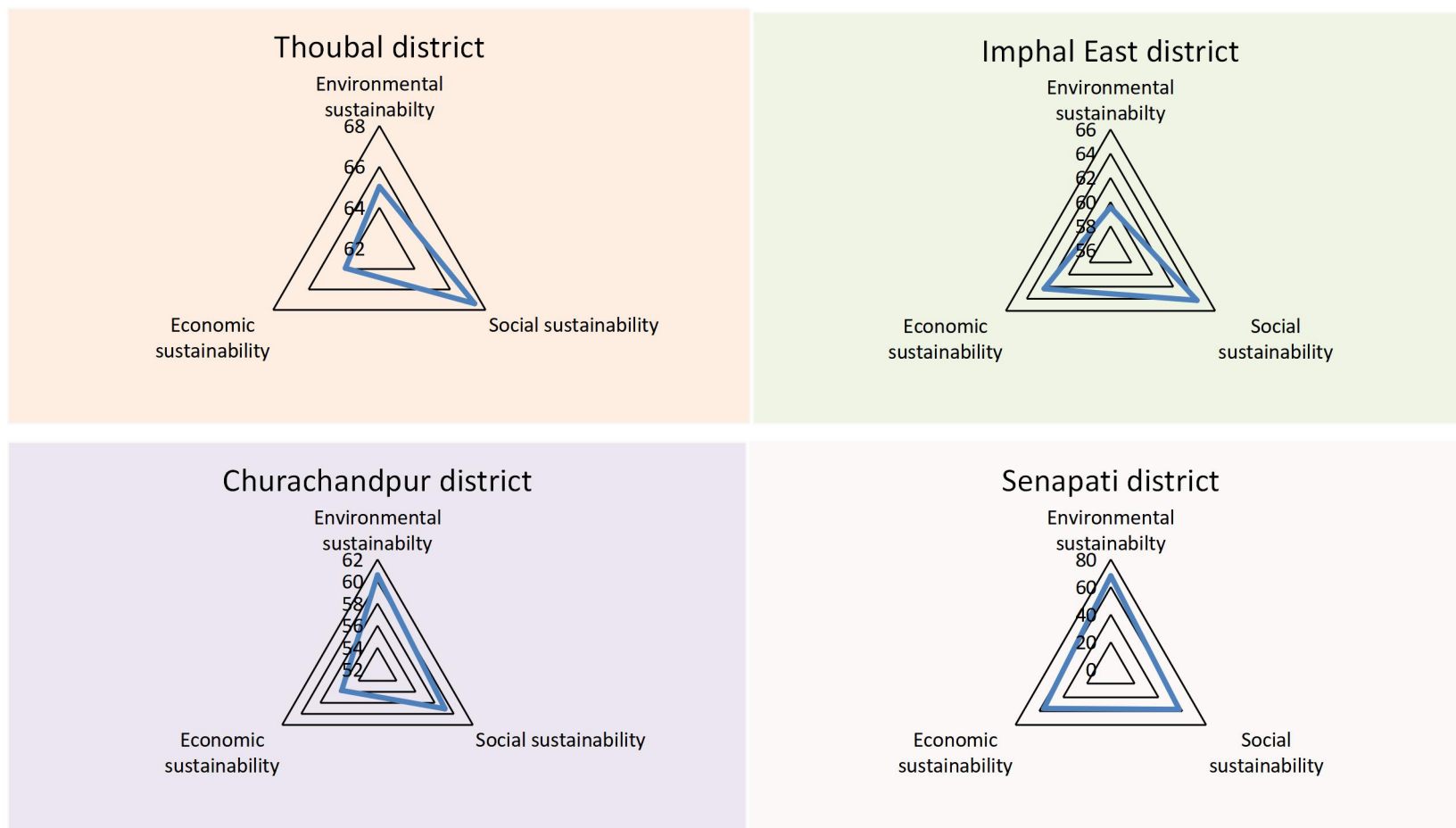


Fig 4.4.1.1 Sustainable index of rice-based farming systems in the selected districts of Manipur

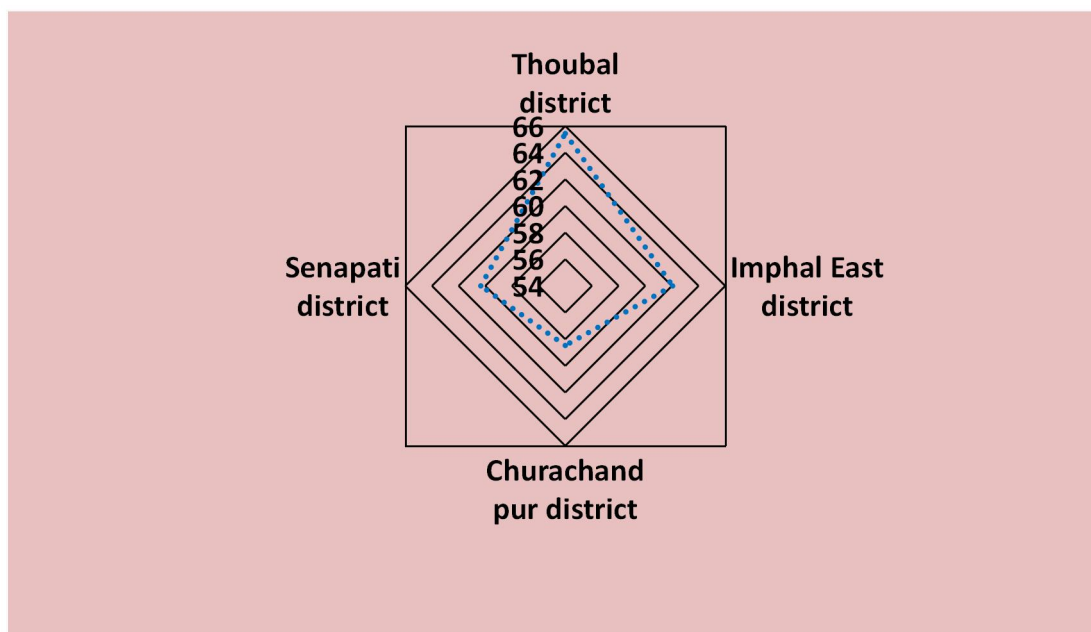


Fig 4.4.1.2 Overall sustainable index of rice-based farming systems in the selected districts of Manipur

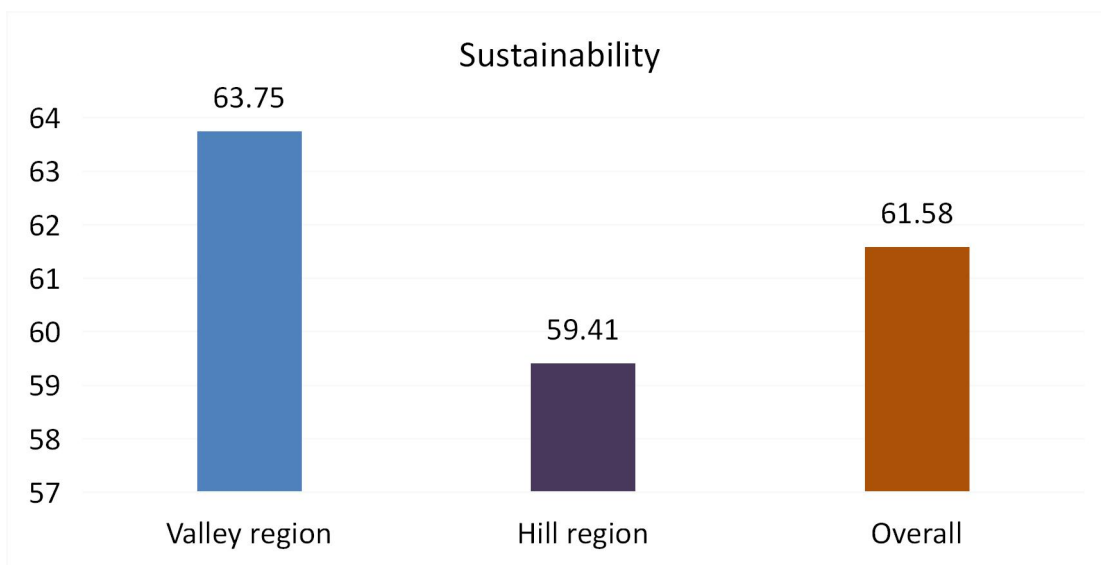


Fig 4.4.1.3 Sustainable index of valley region and hill region of rice-based farming systems

Table 4.4.1 depicts the sustainability index of rice-based farming systems in the selected districts of Manipur comprising all the three dimensions namely economic sustainability, social sustainability, environmental sustainability. It was observed that in Thoubal district, social sustainability had the highest (67.38) sustainability index followed by environmental sustainability index (65.03) and economic sustainability index (63.92). In Imphal East district, social sustainability had the highest (64.26) sustainability index followed by economic sustainability index (62.34) and environmental sustainability index (59.57). Further revealed that Thoubal district and Imphal East district representing valley region had the higher (63.75) sustainability index contributed by social sustainability (65.82) sustainability score followed by economic sustainability (63.13) sustainability score and environmental sustainability (62.30) sustainability score. Overall sustainability score of valley region was (63.75).

In Churachandpur district, environmental sustainability had the highest (60.59) sustainability index followed by social sustainability index (59.07) and economic sustainability index (55.75). In Senapati district, environmental sustainability had the highest (68.07) sustainable index followed by social sustainability index (57.38) and economic sustainability index (56.08). Overall, it was revealed that among all the selected districts, environmental sustainability had the highest (63.32) sustainability index followed by social sustainability index (60.51) and economic sustainability index (59.52) under rice-based farming systems in Manipur. Further revealed Churachandpur district and Senapati district, representing hill region had the highest (63.75) sustainability index contributed by environmental sustainability (64.33) sustainability score followed by social sustainability (58.23) sustainability score and economic sustainability (55.92) sustainability score. Overall sustainability score of hill region was (59.41).

Table 4.4.2 Sustainable index of the selected rice-based farming system in Manipur

S/N	Dimension of sustainability	Sustainable Index			Overall sustainability
		Environmental sustainability	Social Sustainability	Economic Sustainability	
1.	RFFS- Rice-fish framing system	67.33	65.38	63.78	65.49
2.	REFS-Rice-mustard farming system	58.53	61.92	56.72	59.06
3.	RVFS-Rice-vegetable farming system	64.47	57.13	55.08	58.89

Table 4.4.1 depicts the overall sustainability index comprising all the three dimensions namely environmental sustainability, social sustainability and economic sustainability. It was observed that rice-based farming systems in Thoubal districts ranked first having the highest sustainable index (65.44), followed by Imphal East district which ranked II with sustainability index of 62.05, Senapati district ranked III having sustainability index of 60.34 and Churachandpur district ranked IV having sustainability index of 58.47. Overall sustainability index of rice-based farming system was (61.58).

From the above findings it may be inferred that valley region was found to be higher sustainable than hill region in terms of rice- based farming system. Low sustainability in hill region may be due to fragile ecology, inaccessibility of technology, lack of natural conservation, prone to natural hazards. Based on district, Thoubal districts was found as the highest sustainable district followed by Imphal East district, Senapati district and Churachandpur district. The overall sustainability index of rice-based farming system was found to be moderate.

Table 4.4.2 depicts the sustainability index of rice-fish farming systems (RFFS), rice-mustard farming systems (RMFS) and rice-vegetable farming system (RVFS) in the three dimensions namely economic sustainability, social sustainability, environmental sustainability. It was observed that in RFFS environmental sustainability had the highest (67.38) sustainability index followed by social sustainable index (65.38) and economic sustainable index (63.78). In RMFS, social sustainability had the highest (61.92) sustainability index followed by environmental sustainability (58.53) and economic sustainable index (56.72). In RVFS, environmental sustainability had the highest (64.47) sustainable index followed by social sustainable index (57.13) and economic sustainable index (55.08).

Overall sustainability index comprising all the three dimensions namely environmental sustainability, social sustainability and economic sustainability. It was observed that rice-fish farming systems had the highest (65.49) sustainable index followed by rice-mustard farming (59.06) sustainable index and rice-vegetables farming (58.89) sustainable index.

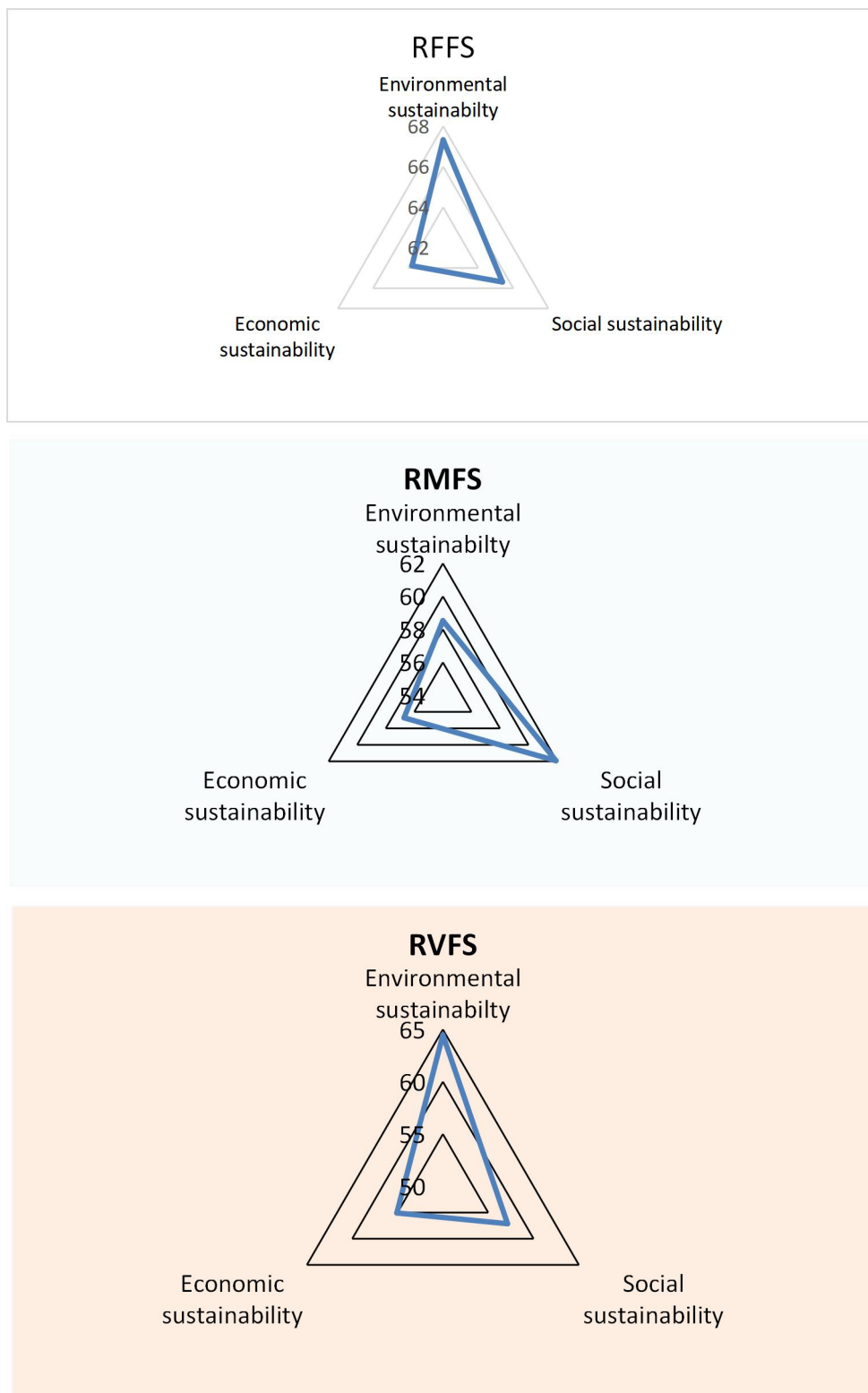


Fig 4.4.2: Sustainable index of the selected rice-based farming system in Manipur

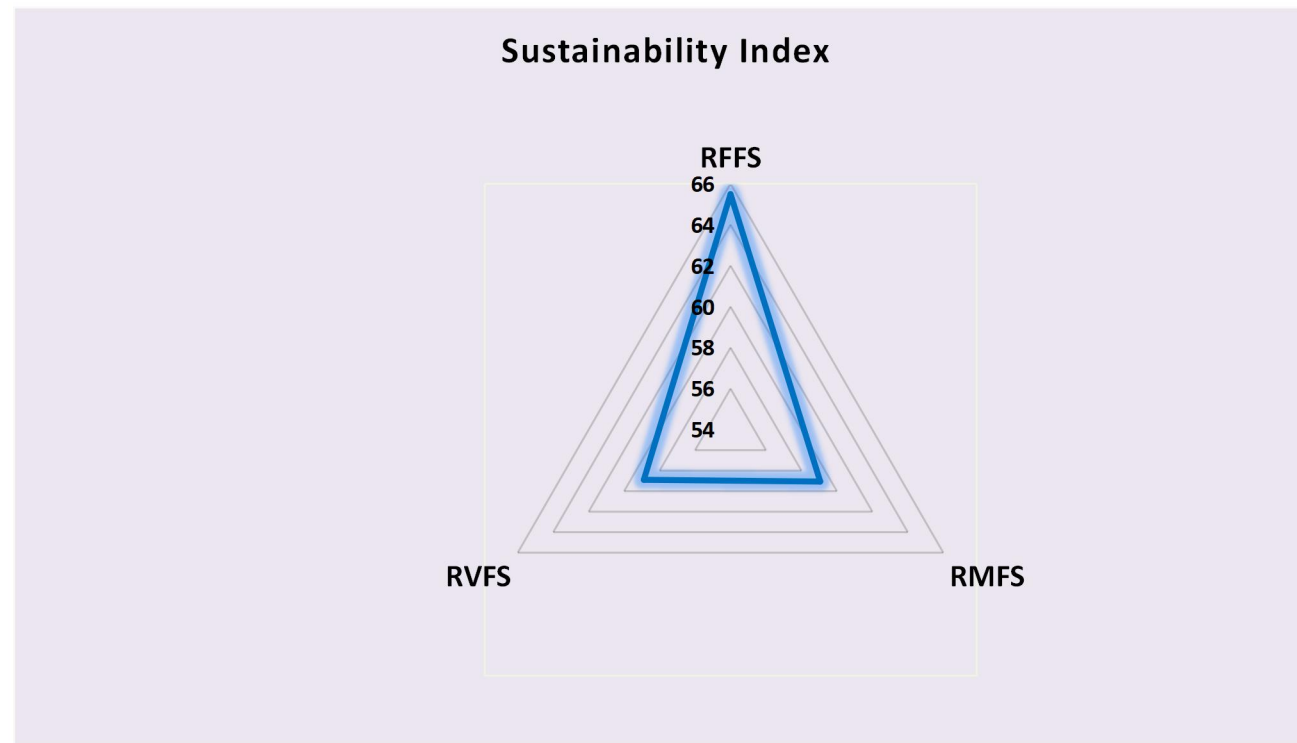


Fig 4.4.2: Overall sustainable index of the selected rice-based farming system in Manipur

Table 4.4.3: Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Thoubal district

n₁=80

S/N	Dimension of sustainability	Level of sustainable	f	%	Mean	SD
1.	Environment sustainability	Low (<12.25)	8	10.00	14.89	2.63
		Medium (12.25-17.52)	59	73.75		
		High (Above 17.52)	13	16.25		
2.	Social sustainability	Low (< 11.91)	5	6.25	15.45	3.54
		Medium (11.91-18.99)	60	75.00		
		High (> 18.99)	15	18.75		
3.	Economic Sustainability	Low (< 7.66)	15	18.75	9.64	1.98
		Medium (7.66 -11.62)	55	68.75		
		High (>11.62)	10	12.50		

f: Frequency & %: Percentage

Table 4.4.3 and Fig 4.4.3 presented the distribution of respondents based on the sustainability of rice-based farming system in Thoubal district. It was observed that majority (75.00%) of the respondents had medium level of social sustainability followed by 18.75 per cent of them having high level of social sustainability and 6.25 per cent of them having low level of social sustainability. In context of environmental sustainability, majority (73.75%) of the respondents had medium level of sustainability followed by 16.25 per cent of them having high level of sustainability and 10.00 per cent of them having low level of sustainability. Further in context of economic sustainability, majority (68.75%) of the respondents had medium level of sustainability followed by 18.75 per cent of them having low level of sustainability and 12.50 per cent of them having high level of sustainability.

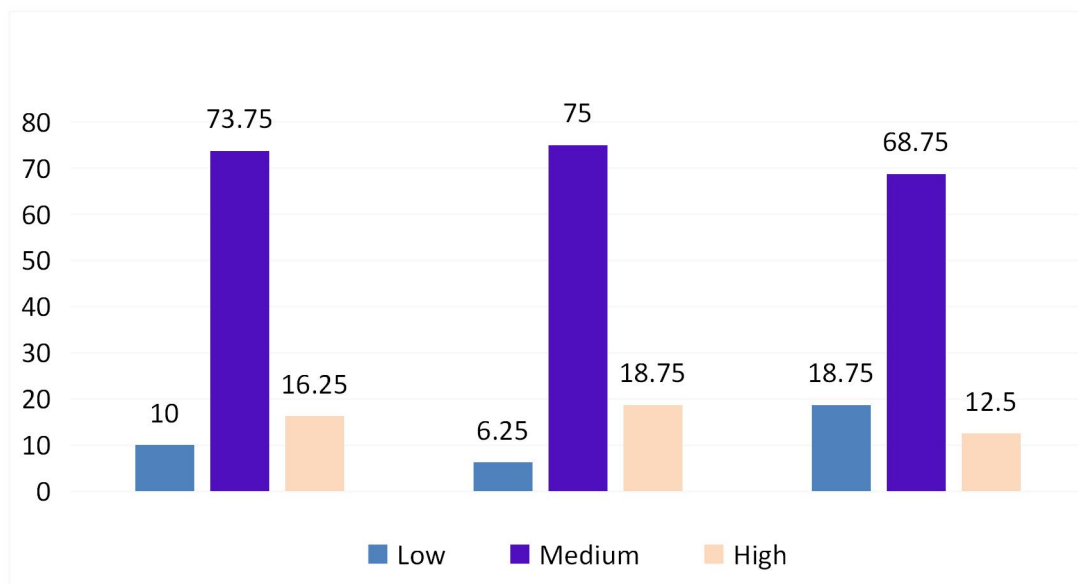


Fig 4.4.3: Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Thoubal district

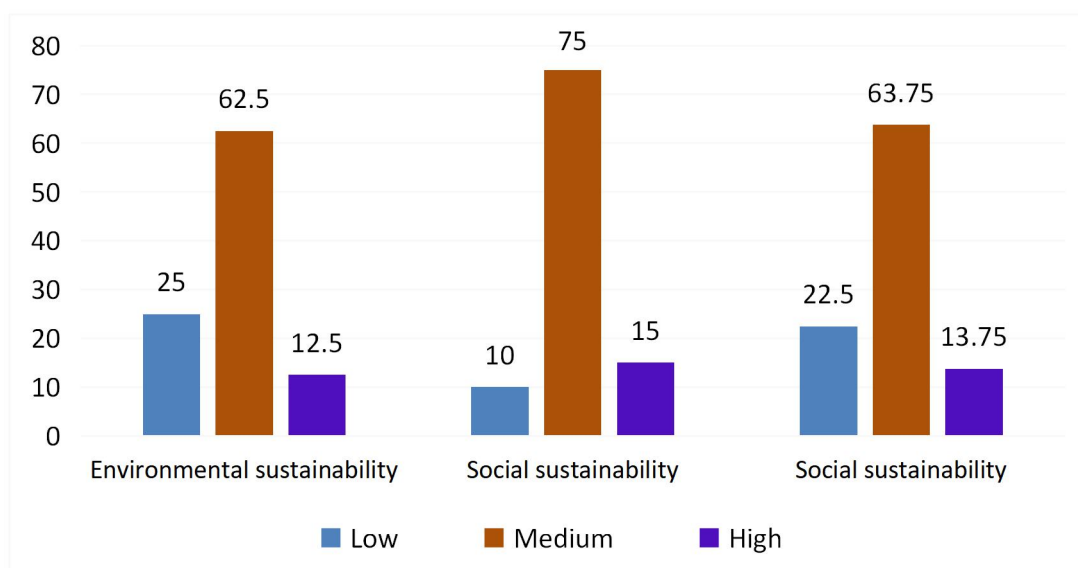


Fig 4.4.4: Distribution of respondents based on the sustainability of rice-based farming system practiced by the farmers of Imphal East district

Table 4.4.4: Distribution of respondents based on the sustainability of rice-based farming system practiced by the farmers of Imphal East district

n₂=80

S/N	Dimension of sustainability	Level of sustainability	f	%	Mean	SD
1.	Environment sustainability	Low (< 10.74)	20	25.00	12.98	2.24
		Medium (10.74-15.22)	50	62.50		
		High (>15.22)	10	12.50		
2.	Social sustainability	Low (< 8.99)	8	10.00	13.80	4.81
		Medium (8.99-18.61)	60	75.00		
		High (>18.61)	12	15.00		
3.	Economic Sustainability	Low (< 6.80)	18	22.50	9.19	2.39
		Medium (6.80 -11.58)	51	63.75		
		High (> 11.58)	11	13.75		

f: Frequency & %: Percentage

Table 4.4.4 and Fig 4.4.4 presented the distribution of respondents based on the sustainability of rice-based farming system in Imphal East district. It was observed that majority (75.00%) of the respondents had medium level of sustainability of social sustainability followed by 15.00 per cent of the respondents having high level of sustainability and 10.00 per cent of them having low level of sustainability. In context of economic sustainability, majority (63.75%) of the respondents had medium level of sustainability followed by 22.50 per cent of them having low level of sustainability and 13.75 per cent of them having high level of sustainability. Further in context of environmental sustainability, majority (62.50%) of the respondents had medium level of sustainability followed by 25.00 per cent of them having low level of sustainability and 12.50 per cent of the respondents having high level of sustainability.

Table 4.4.5: Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Churachandpur district

n₃=80

S/N	Dimension of sustainability	Level of sustainability	f	%	Mean	SD
1.	Environment sustainability	Low (< 8.50)	28	35.00	10.05	2.55
		Medium (8.50-13.60)	45	56.25		
		High (> 13.60)	7	8.75		
2.	Social sustainability	Low (<7.55)	18	22.50	11.25	3.20
		Medium (7.551-3.95)	53	66.25		
		High (Above 13.95)	9	11.25		
3.	Economic Sustainability	Low (< 4.84)	33	41.25	8.15	3.33
		Medium (4.84-11.48)	41	51.25		
		High (> 4.84)	6	7.50		

f: Frequency & %: Percentage

Table 4.4.5 and Fig 4.4.5 presented the distribution of respondents based on the sustainability of rice-based farming system in Churachandpur district. It was observed that majority (66.25%) of the respondents had medium level of social sustainability followed by 22.50 per cent of them having low level of sustainability and 11.25 per cent of them having high level of sustainability. In context of environmental sustainability, majority (56.25%) of the respondents had medium level of sustainability followed by 35.00 per cent of them having low level of sustainability and 8.75 per cent of them having high level of sustainability.

Further in the context of economic sustainability, majority (51.25%) of the respondents having medium level of sustainability followed by 41.25 per cent of them having low level of sustainability and 7.50 per cent of the respondents having high level of sustainability.

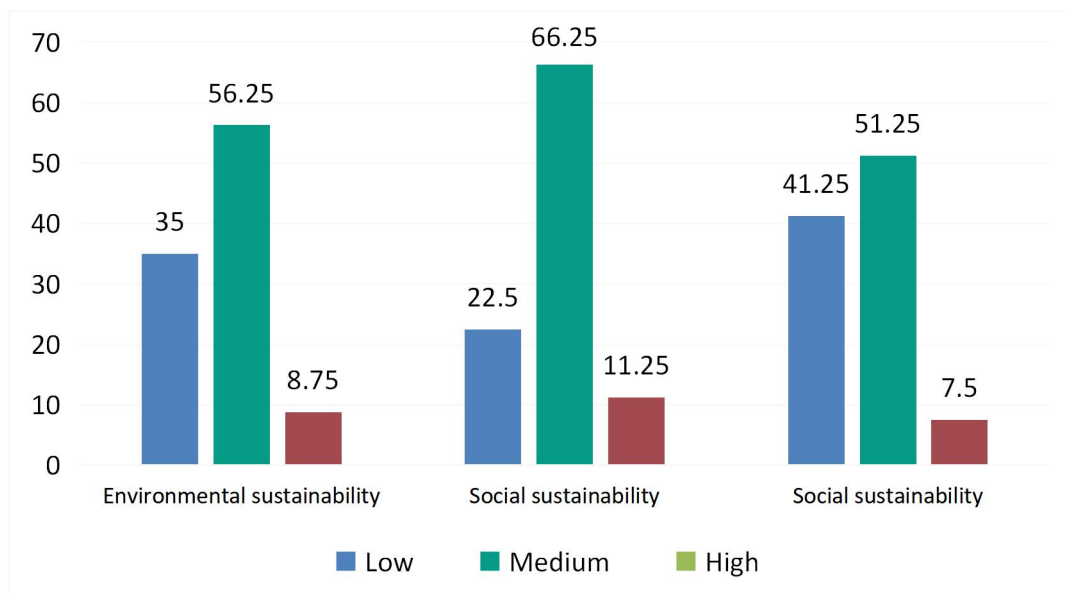


Fig 4.4.5: Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Churachandpur district

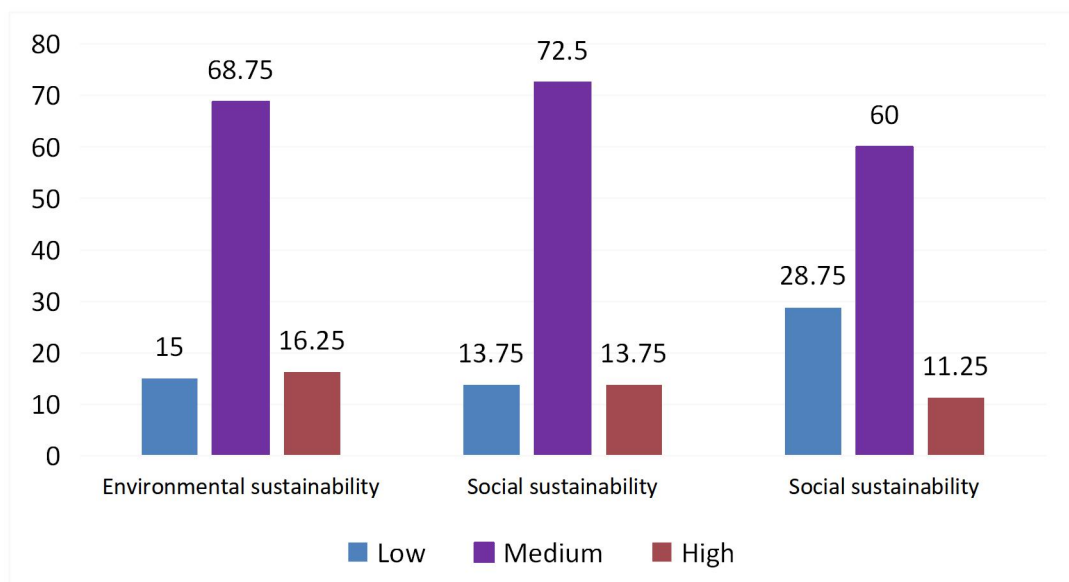


Fig 4.4.6: Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Senapati district

Table 4.4.6: Distribution of respondents based on sustainability of rice-based farming system practiced by the farmers of Senapati district

n₄=80

S/N	Dimension of sustainability	Level of sustainability	f	%	Mean	SD
1.	Environment sustainability	Low (< 9.93)	12	15.00	13.79	3.86
		Medium (9.93-17.64)	55	68.75		
		High (> 17.64)	13	16.25		
2.	Social sustainability	Low (<8.34)	11	13.75	12.93	4.58
		Medium (8.34-17.51)	58	72.50		
		High (Above 17.51)	11	13.75		
3.	Economic Sustainability	Low (<5.25)	23	28.75	8.23	2.98
		Medium (5.25-11.20)	48	60.00		
		High (>11.20)	9	11.25		

f: Frequency & %: Percentage

Table 4.4.6 and Fig 4.4.6 presented the distribution of respondents based on the sustainability of rice-based farming system in Senapati district. It was observed that majority (72.50%) of the respondents had medium level of social sustainability followed by 13.75 per cent of them having medium level of social sustainability and 13.75 per cent of the respondents having high level of social sustainability. In context of environmental sustainability, majority (68.75%) of the respondents had medium level of sustainability followed by 16.25 per cent of them having high level of sustainability and 15.00 per cent of them had low level of sustainability. Further in context of economic sustainability, majority (60.00%) of the respondents had medium level of sustainability followed by 28.75 per cent of them having low level of sustainability and 11.25 per cent of the respondents having high level of sustainability.

Table 4.4.7: Distribution of overall respondents based on the level of sustainability of rice-based farming system

n=320

S/N	Dimension of sustainability	Level of sustainability	f	%	Mean	SD
1.	Environment sustainability	Low (<9.36)	68	21.25	12.18	2.82
		Medium (9.36-15)	209	65.31		
		High (>15)	43	13.44		
2.	Social sustainability	Low (<9.19)	42	13.12	13.23	4.04
		Medium (9.19-17.27)	231	72.19		
		High (>17.27)	47	14.69		
3.	Economic Sustainability	Low (< 6.13)	90	28.12	8.80	2.67
		Medium (6.13-11.47)	195	60.94		
		High (> 11.47)	35	10.94		

f: Frequency & %: Percentage

Table 4.4.7 and Fig 4.4.7 presented the overall distribution of respondents among all the four selected districts based on the level of sustainability under rice-based farming system. It was observed that majority (72.19%) of the respondents had medium level of sustainability of social sustainability followed by 14.69 per cent of the respondents having high level of sustainability and 13.13 per cent of them had low level of sustainability. In context of environmental sustainability, majority (65.31%) of the respondents had medium level of sustainability followed by 21.25 per cent of them having high level of sustainability and 13.44 per cent of the respondents having low level of sustainability. Further in context of social sustainability, majority (60.94%) of the respondents had medium level of sustainability followed by 28.13 per cent of the respondents having low level of sustainability and 10.93 per cent of the respondents having high level of sustainability.

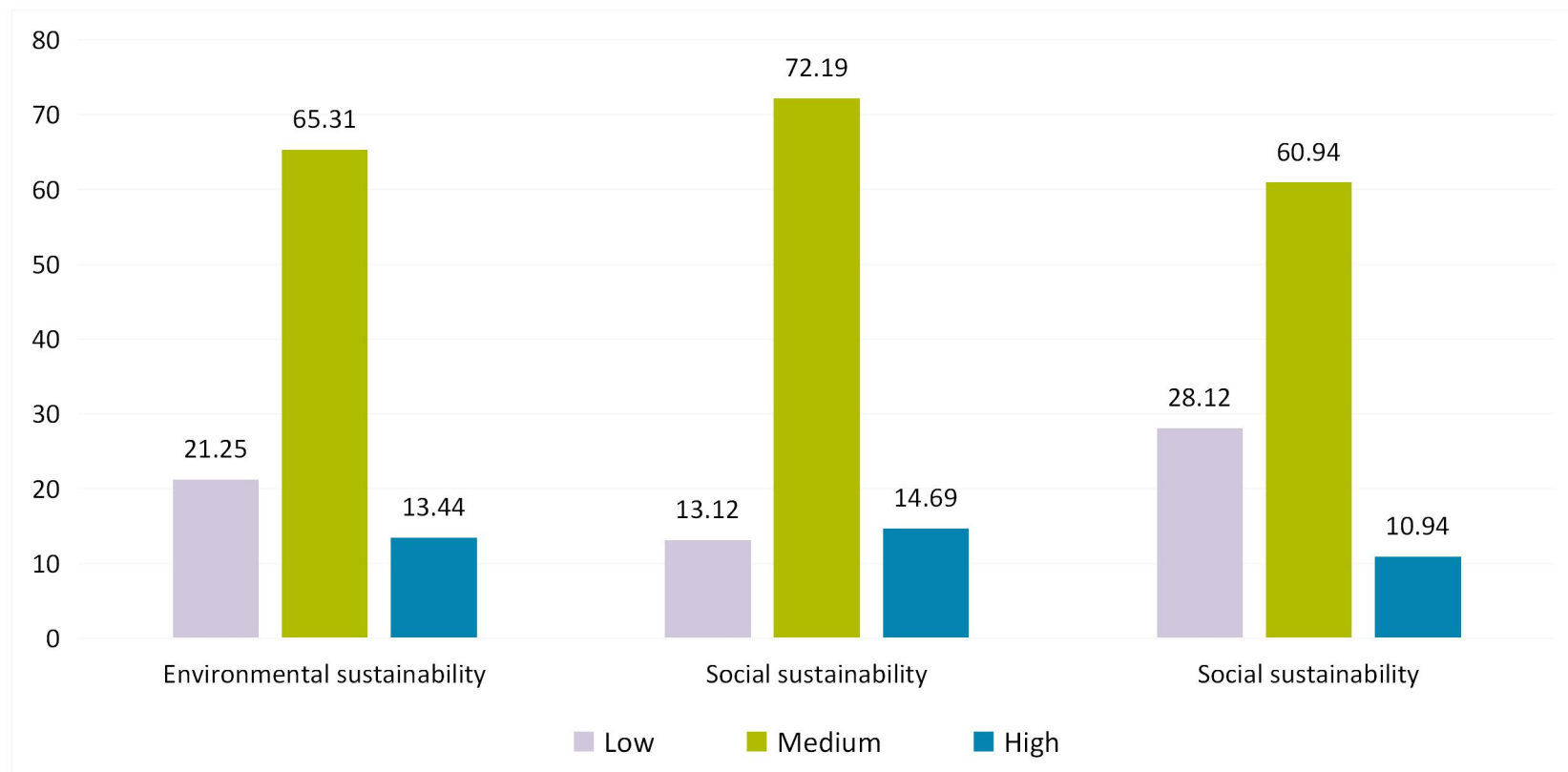


Fig 4.4.7: Distribution of overall respondents based on the level of sustainability of rice-based farming system

Table 4.4.8: Predictors of environmental sustainability of rice-based farming system

Model	Unstandardized Coefficients		t	Sig.
	b	Std. Error SE(b)		
(Constant)	0.56	0.386	1.449	0.148
Use of organic manures (X ₁)	1.386	0.141	9.835	< 0.001
Conservation irrigation (X ₂)	1.414	0.138	10.26	< 0.001
Preparation FYM at farm (X ₃)	1.454	0.146	9.93	< 0.001
Plantation of cover crop(X ₄)	1.495	0.144	10.40	< 0.001
Construction of proper trenches & bundles(X ₅)	1.344	0.287	4.68	< 0.010
Crop residue management(X ₆)	0.807	0.231	5.018	< 0.010
Non-occurrence of draught(X ₇)	1.026	0.132	7.78	< 0.001
Crop mulching(X ₈)	0.942	0.142	6.657	< 0.010
Setting up of vermi-compost pit(X ₉)	1.445	0.141	10.275	< 0.001
Non-occurrence of flood(X ₁₀)	1.006	0.136	7.394	< 0.001
Preservation of beneficial insects(X ₁₁)	1.149	0.151	7.62	< 0.001
No use of chemicals(X ₁₂)	1.075	0.134	7.996	< 0.001
No occurrence of landslide(X ₁₃)	1.302	0.175	7.439	< 0.001
Availability of water source in nearby stream(X ₁₄)	0.857	0.289	5.425	< 0.010
Practice crop rotation(X ₁₅)	0.797	0.169	4.723	< 0.010
Set up well/ponds in the field(X ₁₆)	0.83	0.182	4.571	< 0.010
Maintaining proper drainage system(X ₁₇)	0.897	0.303	2.965	< 0.010

Table 4.4.8.1: Model of environmental sustainability on rice-based farming system showing the effectiveness of variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
17	.941	.885	.879	1.121	2.088

$$\text{Environmental Sustainability (Y}_1\text{)} = 0.56 + 1.386X_1 + 1.414X_2 + 1.454X_3 + 1.495X_4 + 1.344X_5 + 0.807X_6 + 1.026X_7 + 0.942X_8 + 1.445X_9 + 1.006X_{10} + 1.149X_{11} + 1.075X_{12} + 1.302X_{13} + 0.857X_{14} + 0.797X_{15} + 0.83X_{16} + 0.897X_{17} + 1.121$$

Where,

X_1 =Use of organic manure, X_2 = Conservation irrigation water, X_3 =Preparation FYM at farm, X_4 =Plantation of cover crop, X_5 =Construction of proper trenches & bundles, X_6 =Crop residue management, X_7 =Non-occurrence of draught, X_8 =Crop mulching, X_9 =Setting up of vermi-compost pit, X_{10} =Non-occurrence of flood, X_{11} =Preservation of beneficial insects, X_{12} =No use of chemicals, X_{13} =No occurrence of landslide, X_{14} =Availability of water source in nearby stream, X_{15} =Practice crop rotation, X_{16} =Set up well/ponds in the field and X_{17} =Maintaining proper drainage system.

Table 4.4.8 presented the result of linear regression model to identify the contribution of variables to the environmental sustainability of rice-based farming systems. The results obtained from the linear regression model on the environmental sustainability indicators showed that R square of the fitted model explained 89% of the variability towards environmental sustainability in rice-based farming system. The role of the individual variables in the environmental sustainability of rice-based farming system was also explored.

As per the Table 4.4.3 all the variables (X_1 , X_2 , X_3 , X_4 , X_5 , X_6 , X_7 , X_8 , X_9 , X_{10} , X_{11} , X_{12} , X_{13} , X_{14} , X_{15} , X_{16} & X_{17}) had positive regression coefficients which are significant at 1% level which implied that increase in the utilization of these factors

increase the probability of increasing environmental sustainability (Y_1) of rice-based farming systems.

Variables 'Plantation of cover crop' ($t=10.404$, $p<0.001$ & $\beta=1.495$) 'Setting up of vermi-compost pit' ($t=10.275$, $p<0.001$ & $\beta=1.445$), 'Conservation irrigation water' ($t=10.26$, $p<0.001$ & $\beta=1.414$), 'Preparation of FYM at farm' ($t=9.93$, $p<0.001$ & $\beta=1.454$), 'Used of organic manure' ($t=9.835$, $p<0.001$ & $\beta=1.386$) was found positively significant and had large t value which means these variables play most significant role in the environmental sustainability (Y_1) of rice-based farming system.

The other important variables in explaining the environmental sustainability (Y_1) of rice-based farming system are 'No use of chemicals' ($t=7.996$, $p<0.001$ & $\beta=1.075$), 'Non-occurrence of draught' ($t=7.78$, $p<0.001$ & $\beta=1.026$), 'Preservation of beneficial insect' ($t=7.62$, $p<0.001$ & $\beta=1.149$), 'Not occurrence of landslide' ($t=7.439$, $p<0.001$ & $\beta=1.302$) and 'Non-occurrence of flood' ($t=7.394$, $p<0.001$ & $\beta=1.006$) was positively significant and play significant role in the environmental sustainability of rice-based farming.

Some other variables which contributed a significant role in explaining environmental sustainability (Y_1) of rice-based farming system were 'Crop mulching' ($t=6.657$, $p<0.010$ & $\beta=0.942$), 'Source out water nearby stream' ($t=5.425$, $p<0.010$ & $\beta=0.857$), 'Crop residue management' ($t=5.018$, $p<0.010$ & $\beta=0.807$), 'Practice crop rotation' ($t=4.723$, $p<0.010$ & $\beta=0.797$), 'Construction of proper trenches & bundles' ($t=4.68$, $p<0.010$ & $\beta=1.344$), 'Set up well/ponds in the field' ($t=4.571$, $p=0.010$ & $\beta=0.830$), 'Maintaining proper drainage system' ($t=2.965$, $p<0.010$ & $\beta=0.897$).

Table 4.4.9: Predictors of social sustainability of rice-based farming systems

Model	Unstandardized Coefficients		t	p - value
	b	Std. Error SE(b)		
(Constant)	0.68	0.213	3.187	0.002
Household type (X ₁)	0.838	0.274	3.058	< 0.010
Family labour (X ₂)	2.248	0.157	14.341	< 0.001
Women involvement in farming (X ₃)	1.234	0.136	9.082	< 0.001
Training participation (X ₄)	1.543	0.154	9.989	< 0.001
Education (X ₅)	1.300	0.152	8.528	< 0.010
Equal wages of women and man(X ₆)	1.281	0.23	5.559	< 0.010
Participation in local activities (X ₇)	1.428	0.137	10.406	< 0.001
Experience in farming (X ₈)	1.856	0.124	14.945	< 0.001
Adoption of HYV (X ₉)	1.202	0.131	9.177	< 0.001
Children sent for education (X ₁₀)	1.564	0.16	9.744	< 0.001
Risk taking ability (X ₁₁)	1.129	0.137	8.271	< 0.010
Framers' motivation (X ₁₂)	1.132	0.135	8.358	< 0.010
Affordable daily nutrient requirement (X ₁₃)	1.002	0.147	6.792	< 0.010
Regular contact from expert (X ₁₄)	1.076	0.153	7.049	< 0.010
Knowledge on farm resource conservation (X ₁₅)	0.575	0.151	3.801	< 0.010
Availability of food throughout the year (X ₁₆)	0.836	0.231	3.618	< 0.010
Social recognition (X ₁₇)	0.880	0.258	3.405	< 0.010

Table 4.4.9.1: Model of social sustainability on rice-based farming system showing the effectiveness of variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-watson
17	.974	.949	.946	1.022	1.623

The specified model of social sustainability is as follows:

$$\text{Social Sustainability (Y}_2\text{)} = 0.122 + 0.838X_1 + 2.248X_2 + 1.234X_3 + 1.543X_4 + 1.3X_5 + 1.281X_6 + 1.428X_7 + 1.856X_8 + 1.202X_9 + 1.564X_{10} + 1.129X_{11} + 1.132X_{12} + 1.002X_{13} + 1.076X_{14} + 0.575X_{15} + 0.836X_{16} + 0.88X_{17} + 1.022$$

Where,

X₁=Household type, X₂= Family member labour, X₃=Women involvement in farming, X₄=Training participation, X₅=Education, X₆=Equal wages of woman and man, X₇=Participation in local activities, X₈=Experience in farming, X₉=Adoption of HYV, X₁₀=Children sent for education, X₁₁=Risk taking ability, X₁₂=Farmers' motivation, X₁₃=Affordable daily nutrient requirement, X₁₄ =Regular contact from expert, X₁₅ =Knowledge on farm resource conservation, X₁₆=Availability of food throughout the year and X₁₇=Social recognition.

Table 4.4.9 presented the result of linear regression model to identify the contribution of variables to the social sustainability of rice-based farming systems. The results obtained from the linear regression model on the social sustainability indicators data of rice-based farming system showed that R square of the fitted model explained 95% of the variability towards social sustainability in rice-based farming systems. The role of the individual variables in the social sustainability of rice-based farming system was also explored.

As per the Table 4.4.4.1 all the variables ($X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}, X_{16}$ & X_{17}) had positive regression coefficient which are significant at 1% level implies that increase in the utilization of these factors increase the probability of increasing social sustainability (Y_2) of rice-based farming systems.

Variables ‘Participation in local activities’ ($t=10.406, p<0.001$ & $\beta=1.428$), ‘Children sent for education’ ($t=9.744, p<0.001$ & $\beta=1.564$), ‘Adoption of HYV’ ($t=9.177, p<0.001$ & $\beta=1.202$), ‘Training participation’ ($t=9.989, p<0.001$ & $\beta=1.543$), ‘Women involvement in farming’ ($t=9.082, p<0.001$ & $\beta=1.234$), ‘Education’ ($t=8.528, p<0.001$ & $\beta=1.300$), ‘Farmers’ motivation’ ($t=8.358, p<0.001$ & $\beta=1.132$) and ‘Risk taking ability’ ($t=8.271, p<0.001$ & $\beta=1.129$) was found positively significant and play most significant role in the social sustainability (Y_2) of rice-based farming systems.

The other important variables in explaining the social sustainability (Y_2) of rice-based farming systems are ‘Regular contact of expert’ ($t=7.049, p<0.010$ & $\beta=1.076$), ‘Affordable daily nutrient requirement’ ($t=1.002, p<0.010$ & $\beta=6.792$), ‘Equal wages of woman and man’ ($t=5.559, p<0.010$ & $\beta=1.281$), ‘Social recognition’ ($t=3.405, p<0.010$ & $\beta=0.880$), ‘Household type’ ($t=3.058, p<0.010$ & $\beta=0.838$), and ‘Knowledge on farm resource conservation’ ($t=0.575, p<0.010$ & $\beta=3.801$).

Table 4.4.10 Predictors of economic sustainability of rice-based farming systems

Model	Unstandardized Coefficients		t	p - value
	b	Std. Error SE(b)		
(Constant)	1.033	0.157	6.599	< 0.010
Well connect to market (X ₁)	1.154	0.103	11.199	< 0.001
Bank loan (X ₂)	1.043	0.11	9.521	< 0.001
Profitability (X ₃)	1.048	0.103	10.123	< 0.001
Availability of farm inputs (X ₄)	1.089	0.098	11.071	< 0.001
Indebtedness (X ₅)	1.074	0.093	11.490	< 0.001
Government subsidies on farm inputs (X ₆)	1.244	0.103	12.115	< 0.001
High productivity (X ₇)	1.139	0.092	12.355	< 0.001
Grant from government schemes (X ₈)	1.062	0.103	10.320	< 0.001
Stable price of farm product (X ₉)	0.855	0.103	8.296	< 0.010
Satisfaction of farm return (X ₁₀)	1.071	0.101	10.654	< 0.001
Availability of market near farm area (X ₁₁)	1.122	0.112	10.048	< 0.001
Benefit from NGOs/local bodies (X ₁₂)	0.647	0.102	6.373	< 0.010
Crop insurance (X ₁₃)	0.744	0.2	3.713	< 0.010

Table 4.4.10.1: Model of economic sustainability on rice-based farming system showing the effectiveness of variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-watson
13	.932	.929	.76447	.003	1.897

The specified model of economic sustainability is as follows:

$$\text{Economic Sustainability (Y}_3\text{)} = 1.033 + 1.154X_1 + 1.043X_2 + 1.048X_3 + 1.089X_4 + 1.074X_5 + 1.244X_6 + 1.139X_7 + 1.062X_8 + 0.855X_9 + 1.071X_{10} + 1.122X_{11} + 0.647X_{12} + 0.744X_{13} + 1.003$$

Where,

X₁=Direct connect to market, X₂= Bank loan, X₃=Profitability, X₄=Availability of farm inputs, X₅=Indebtedness, X₆=Government subsidies on farm inputs, X₇=High productivity, X₈=Grant from government schemes, X₉=Stable price of farm product, X₁₀=Satisfaction of farm return, X₁₁=Availability of market near farm area, X₁₂=Benefit from NGOs/local bodies and X₁₃=Crop insurance.

Table 4.4.10 presented the result of linear regression model to identify the contribution of variables to the economic sustainability (Y₃) of rice-based farming systems. The results obtained from the linear regression model on the economic sustainability indicators showed that R square of the fitted model explained 93% of the variability towards economic sustainability in rice-based farming systems. The role of the individual variables in the economic sustainability of rice-based farming system was also explored.

As per the Table 4.4.10 all the variables (X₁, X₂, X₃, X₄, X₅, X₆, X₇, X₈, X₉, X₁₀, X₁₁, X₁₂ & X₁₃) had positive regression coefficient which are significant at 1% level which implies that increase in the utilization of these factors increase the probability of increasing economic sustainability (Y₃) of rice-based farming systems.

Variables ‘High productivity’ (t=1.139, p=<0.001 & β=12.355), ‘Government subsidies on farm input’ (t=12.115, p=<0.001 & β=1.244),

‘Indebtedness’ ($t=11.490$, $p<0.001$ & $\beta=1.074$), Availability of farm inputs ($t=11.071$, $p<0.001$ & $\beta=1.089$), ‘Well connect to market’ ($t=11.199$, $p<0.001$ & $\beta=1.154$) was found positively significant and had largest t value which means these variables play most significant role in the economic sustainability (Y_3) of rice-based farming system.

The other important variables in explaining the economic sustainability(Y_3) of rice-based farming systems are ‘Satisfaction of farm return’($t=10.654$, $p<0.001$ & $\beta=1.071$), ‘Grant from government schemes’ ($t=10.320$, $p<0.001$ & $\beta=1.062$), ‘Availability of market near farm area’ ($t=10.048$, $p<0.001$ & $\beta=1.122$), ‘Profitability’ ($t=10.123$, $p<0.001$ & $\beta=1.048$) and ‘Bank loan’ ($t=9.521$, $p<0.001$ & $\beta=1.043$) are positively significant and play significant role in the economic sustainability of rice-based farming system.

4.5 Income and employment generation from livelihood enterprises under rice-based farming system

Table 4.5.1 Employment generation in mandays (per hectare per year) under the rice-based farming system

S/N	Activities under rice-based farming system	Types of farming system (All districts n=320)					
		RFFS		RMFS		RVFS	
		Average Mandays	Contribution of practices (%)	Average Mandays	Contribution of practices (%)	Average Mandays	Contribution of practices (%)
1.	Land preparation (LP)	23.01	9.59	20.17	10.00	27.25	10.86
2.	Trench/Bundles preparation (TBP)	22.33	9.30	3.11	1.54	7.47	2.98
3.	Sowing (SO)	13.67	5.70	12.25	6.07	19.11	7.61
4.	Seeds treatment (ST)	11.32	4.72	10.33	5.12	15.14	6.03
5.	Transplantation (TP)	14.31	5.96	16.10	7.98	20.21	8.05
6.	Feed management of fish (FMF)	28.01	11.67	-	-	-	-
7.	Fertilizers application (FA)	16.92	7.05	17.45	8.65	19.03	7.58
8.	Irrigation (IT)	23.44	9.77	21.15	10.48	24.44	9.74
9.	Weed management (WM)	7.81	3.25	17.03	8.44	22.52	8.97
10.	Diseases protection (DP)	17.92	7.46	20.25	10.04	22.24	8.86
11.	Insect and pest protection (IPP)	14.31	5.96	15.92	7.89	18.53	7.38
12.	Harvesting (HT)	22.66	9.44	21.06	10.44	26.28	10.47
13.	Transportation (TT)	14.90	6.21	10.47	5.19	17.10	6.81
14.	Post harvest management (PHM)	9.43	3.93	16.44	8.15	11.66	4.65
15.	Total Mandays	240.02	100.00	201.74	100.00	250.99	100.00

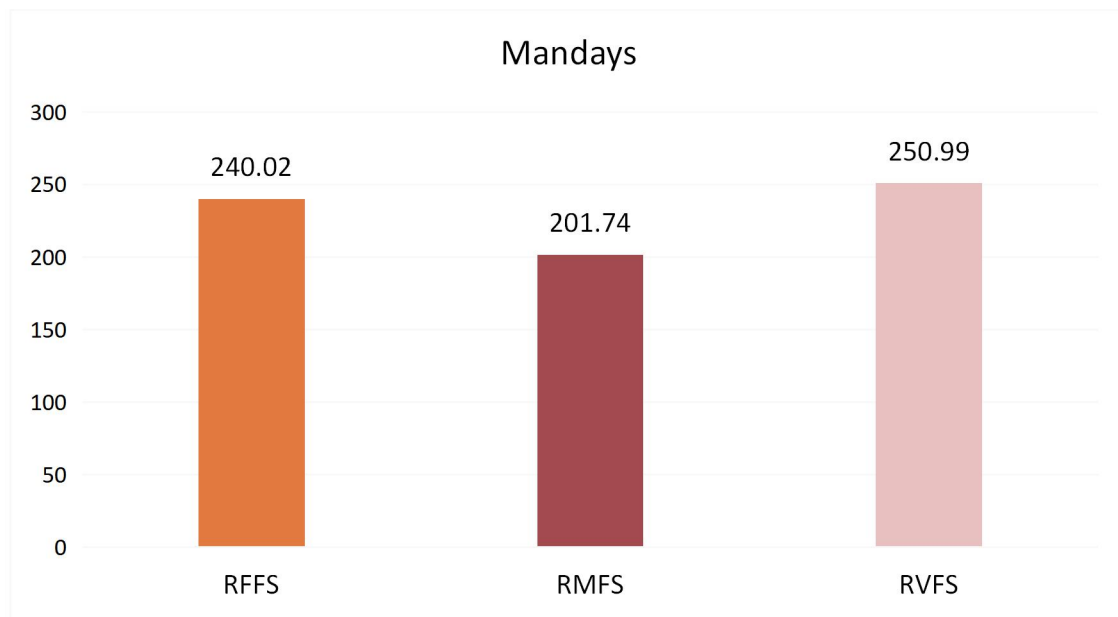


Fig 4.5.1.1 Employment generation (mandays) under the selected farming system

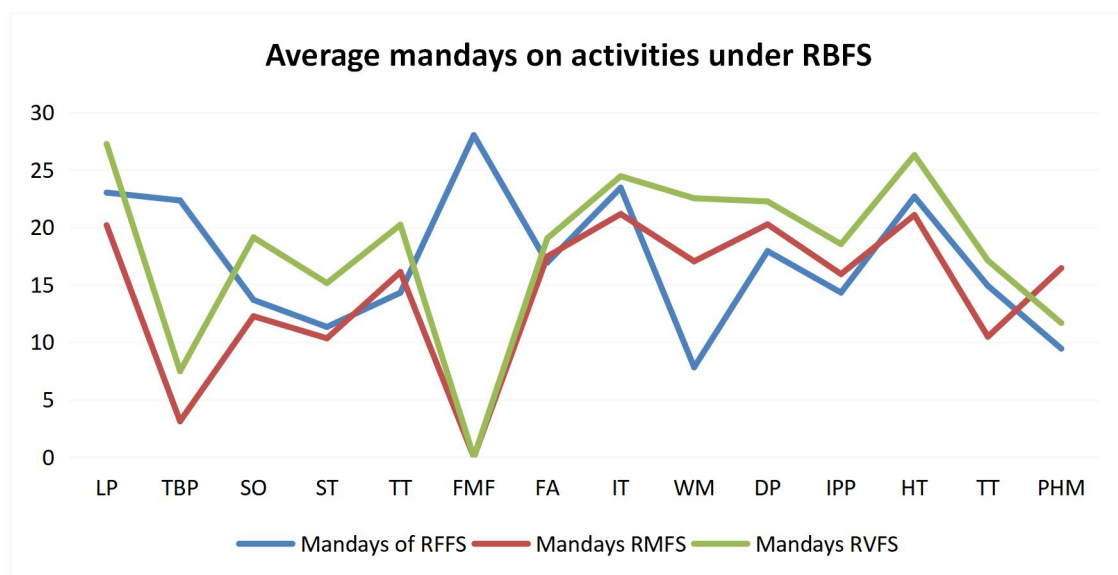


Fig 4.5.1.2 Employment generation (mandays) in activities under the selected farming system

In the present study, three rice based farming systems (RBFS) were prominently observed viz., rice-fish farming system (RFFS), rice-vegetables farming system (RVFS) and rice-mustard farming system (RVFS). Employment generation and its contribution of RBFS in the different crop production operations were presented in Table 4.5.1. and Fig 4.5.1.

Table 4.5.1. and Fig 4.5.1. revealed that rice-vegetable farming system (RVFS) had the highest 251 mandays. Under this farming system 27 mandays (10.86%) were contributed in 'LP', 26 mandays (10.47%) were contributed in 'HT', 22 mandays (8.97%) were contributed in 'WM', 22 mandays (8.86%) were contributed in 'DP', 20 mandays (8.05%) were contributed in 'TP', 19 mandays (7.61%) were contributed in 'SO', 19 mandays (7.58%) were contributed in 'FA', 17 mandays (6.81%) were contributed in 'TT', 15 mandays (6.03%) were contributed in 'ST', 11 mandays (4.65%) were contributed in 'PHM' and 7 mandays (2.98%) were contributed in 'TBP'.

It was further revealed that rice-fish farming system (RFFS) had the second highest mandays (240). Under this farming system 28 mandays (11.67%) were contributed in 'FMF', 23 mandays (9.77%) were contributed in 'IT', 23 mandays (9.59%) in 'LP', 22 mandays (9.44%) were contributed in 'HT', 22 mandays (9.30%), 17 mandays (7.46%) were contributed in 'DP', 16 mandays (7.05%) were contributed in 'FA', 14 mandays (5.96%) were contributed in 'TP', 14 mandays (5.96%) were contributed in 'IPP', 11 mandays (4.72%) were contributed in 'ST', 7 mandays (3.93%) were contributed in 'PHM' and 7 mandays (3.25%) were contributed in 'WM'. Rice-mustard farming system generated the least mandays (201).

It contributed 21 mandays (10.44%) were contributed in 'HT', 20 mandays (10.04%) were contributed in 'DP', 20 mandays (10.00%) were contributed in 'LP', 17 mandays (8.65%) were contributed in 'FA', 17 mandays (8.44%) were contributed in 'WM', 16 mandays (7.98%) were contributed in 'TP', 15 mandays (7.89%) were contributed in 'IPP', 12 mandays (6.07%) were contributed in 'SO', 10 mandays (5.19%) were contributed in 'TT' and 3 mandays (1.54%) were contributed in 'TBP'. From the above findings it was inferred that the total employment generation from the three systems (RFFS, RMFS & RVFS) under rice-based farming system was 691 mandays/ha/year.

Table 4.5.2 Cost of cultivation and income generated under rice-based farming system (RBFS) in Thoubal district

S/N	Cost of cultivation per hectare Parameters	Thoubal district (n=80)	
		RFFS	RMFS
2.	Cost of land preparation (Rs.)	14869.57	12802.27
3.	Cost of irrigation (Rs)	2489.13	1826.26
4.	Cost of Seedling (Rs) ▪ Seeds ▪ Fingerlings	2782.61 42500.00	5238.61 ---
5.	Cost of transplantation or sowing (Rs) ▪ Rice ▪ Mustard	17980.98 ----	17288.27 2375.71
6.	Cost of fertilizer (Rs)	2413.04	10580.86
7.	Cost of feed supplements for fish (Rs)	14565.22	---
8.	Cost of weeding for rice (Rs)	--	15918.37
9.	Cost of transportation (Rs) ▪ Rice ▪ Fish ▪ Mustard Total	3652.72 4483.70 ---- 8,136.42	3857.61 --- 3485.08 7342.69
10.	Cost of harvesting (Rs) ▪ Rice Cutting ▪ Rice Threshing ▪ Catching Fish ▪ Mustard Cutting ▪ Mustard Threshing	13317.93 12664.13 8250.00 ---- ---	13931.12 12419.39 --- 9272.63 8199.90
11.	Total harvested (Kg) ▪ Rice ▪ Fish ▪ Mustard	4629.89 1273.33 ----	3847.75 --- 1761.80
12.	Sold (RS/kg) ▪ Rice ▪ Fish ▪ Mustard	36.00 209.50 ---	36.00 --- 67.69
13.	Total cost of cultivation (Rs)	139969.00	117196.10
14.	Gross income (Rs) ▪ Rice ▪ Fish ▪ Mustard Total	1,66,676.09 2,66,761.83 --- 4,33,437.91	138519.20 --- 119256.00 257775.10
15.	Net income (Rs)	2,93,468.91	140579.00

Table 4.5.2 presented the cost, revenue and returns of rice-fish farming system (RFFS) in Thoubal district. It was revealed that the highest cost was incurred in ‘fingerlings’ operation (Rs. 42500.00) followed by cost of ‘rice transplantation’ (Rs 17980.98), cost of ‘land preparation’ (Rs 14869.57), cost of ‘fish feed supplements’ (Rs 14565.22), cost of ‘rice cutting’ (Rs 13317.93), cost of ‘rice threshing’ (Rs 12664.13), cost of ‘fish catching’ (Rs 8250.00), cost of ‘rice transportation’ (Rs 4629.89), cost of ‘rice seeds’ (Rs 2782.61), cost of ‘irrigation’ (Rs 2489.13), cost of ‘fertilizers’ (Rs 2413.04), cost of ‘fish transportation’ (Rs 1273.33). The total cost of cultivation in RFFS was (Rs 139969.00) and the gross income was (Rs 4,33,437.91).

Table 4.5.2 presented the cost, revenue and returns of rice-mustard farming system (RMFS) in Thoubal district. It was revealed that the highest cost was incurred in cost of ‘rice transplantation’ (Rs 17288.27) followed by cost of ‘rice weeding’ (Rs 15918.37), cost of ‘rice cutting’ (Rs 13931.12), cost of ‘land preparation’ (Rs 12802.27), cost of ‘rice threshing’ (Rs 12419.39), cost of ‘fertilizers’ (Rs 10580.86), cost of ‘mustard cutting’ (Rs 9272.63), cost of ‘mustard threshing’ (Rs 8199.90), cost of ‘seedlings’ (Rs 5238.61), cost of ‘rice transportation’ (Rs 3857.61), cost of ‘mustard transportation’ (Rs 3485.08) and cost of ‘mustard sowing’ (Rs 2375.71). The total cost of RMFS cultivation was found (Rs 117196.10) and the gross income was (Rs 257775.10).

Table 4.5.2.1 Cost of cultivation and income generated under rice-based farming system (RBFS) in Thoubal district per hectare area

S/N	Parameters	Thoubal district (n=80)	
	Cost of cultivation per hectare (Rs)	RFFS	RMFS
1.	X ₁ : Cost of land preparation (Rs)	14869.57	12802.27
2.	X ₂ : Cost of irrigation (Rs)	2489.13	1826.27
3.	X ₃ : Cost of Seedling (Rs)	40934.78	5238.61
4.	X ₄ : Cost of transplantation or sowing (Rs)	17980.98	19663.98
5.	X ₅ : Cost of fertilizer (Rs)	2413.04	10580.86
6.	X ₆ : Cost of feed for fish (Rs)	14565.22	0.00
7.	X ₇ : Cost of weeding (Rs)	0.00	15918.37
8.	X ₈ : Cost of transportation (Rs)	8136.41	7342.69
9.	X ₉ : Cost of harvesting (Rs)	34232.07	43823.04
10.	Total cost of cultivation (Rs)	139969.02	117196.10
11.	Gross income (Rs)	433437.91	257775.14
12.	Net income/ha (Rs)	293468.90	140579.00
13.	Yield (Kg/ha) ▪ Rice ▪ Fish ▪ Mustard	4629.89 1271.73 ---	3847.76 --- 1761.80
14.	BCR	3.20	2.20

From Table 4.5.2.1 it was revealed that in Thoubal district the total cost of of RFFS cultivation was Rs 135621.00 and the gross income was Rs 433437.91 with net income of Rs 297816.90. The yield of rice under RFFS was 4629.89 kg/ha and the yield of fish was 1271.73 kg/ha. BCR of RFFS was 3.20. In RMFS, the total cost of cultivation was Rs 117196.10 and the gross income was Rs 257775.14 with the net income of Rs 140579.10. The yield of rice under RMFS was 3847.76 kg/ha and yield of mustard was 1761.80 kg/ha. BCR of RMFS was 2.20. From the findings it can be inferred that RFFS give higher rice yield and income than the RMFS, hence RFFS have higher BCR than RMFS.

Table 4.5.3 Cost of cultivation and income generated under rice-based farming system (RBFS) in Imphal East district

S/N	Parameters	Imphal East district (n=80)	
		RFFS	RMFS
2.	Cost of land preparation (Rs)	16251.35	16959.79
3.	Cost of irrigation (Rs)	4508.02	4808.50
4.	Cost of Seedling (Rs)		
	▪ Seeds	5090.91	7650.62
	▪ Fingerlings	41283.42	---
5.	Cost of transplantation or sowing (Rs)		
	▪ Rice	15925.13	16360.12
	▪ Mustard	----	4327.12
6.	Cost of fertilizer (Rs)	2839.56	11154.10
7.	Cost of feed supplement for fish (Rs)	13048.13	---
8.	Cost of weeding for rice (Rs)	---	18809.52
9.	Cost of transportation (Rs)		
	▪ Rice	4109.55	5857.69
	▪ Fish	4106.945	----
	▪ Mustard	---	4642.86
10.	Harvesting (Rs)		
	▪ Rice Cutting	15988.64	14041.67
	▪ Rice Threshing	15172.73	13299.4
	▪ Catching Fish	8554.55	---
	▪ Mustard Cutting	----	11806.43
	▪ Mustard Threshing	---	10693.57
11.	Total harvested (Kg)		
	▪ Rice	3732.73	3337.95
	▪ Fish	1318.51	---
	▪ Mustard	---	1505.95
12.	Sold (RS/kg)		
	▪ Rice	40.00	40.00
	▪ Fish	215.94	---
	▪ Mustard	---	78.67
13.	Total cost of cultivation (Rs)	146878.90	140411.40
14.	Gross income (Rs)		
	▪ Rice	149309.10	133518.10
	▪ Fish	284718.90	---
	▪ Mustard	---	118473.30
	Total	434028.00	251991.40
15.	Net income (Rs)	287149.10	111580.00
16.	BCR	2.90	1.79

Table 4.5.3 presented the cost, revenue and returns of rice-fish farming system (RFFS) in Imphal district. It was revealed that the highest cost was incurred in ‘fingerlings’ operation (Rs 41283.42) followed by cost of ‘land preparation’ (Rs 16251.35), cost of ‘rice cutting’ (Rs 15988.64), cost of ‘rice threshing’ (Rs 15172.73) cost of ‘rice transplantation’ (Rs 15925.13), cost of ‘fish feed supplement’ (Rs 13048.13), cost of ‘fish catching’ (Rs 8554.55), cost of ‘rice seeds’ (Rs 5090.91), cost of ‘irrigation’ (Rs 4508.02) and cost of ‘fertilizers’ (Rs 2839.56). The total cost of RFFS cultivation was Rs 146878.90 and the gross income was 434028.00.

Table 4.5.3 presented the based cost, revenue and returns of rice-mustard farming system in Imphal district. It was revealed that the highest cost was incurred in ‘rice weeding’ operation (Rs 18809.52) followed by cost of ‘land preparation’ (Rs 16959.79), cost of ‘rice transplantation’ (Rs 16360.12), cost of ‘rice cutting’ (Rs 14041.67), cost of ‘rice threshing’ (Rs 13299.4), cost of ‘mustard threshing’ (Rs 10693.57), cost of ‘fertilizer’ (Rs 11154.10), cost of ‘mustard cutting’ (Rs 11806.43), cost of ‘seedlings’ (Rs 7650.62), cost of ‘rice transportation’ (Rs 5857.69), cost of ‘irrigation’ (Rs 4808.50), cost of ‘mustard transportation’ (Rs 4642.86), cost of ‘sowing mustard’ (Rs 4327.12). The total cost of cultivation in RMFS was Rs 140411.40 and the gross income was 251991.40.

Table 4.5.3.1 Cost of cultivation and income generated under rice-based farming system (RBFS) in Imphal East district per hectare area

S/N	Parameters	Imphal east district (n=80)	
	Cost of cultivation per hectare	RFFS	RMFS
1.	X ₁ : Cost of land preparation (Rs)	16251.35	16959.79
2.	X ₂ : Cost of irrigation (Rs)	4508.02	4808.50
3.	X ₃ : Cost of Seedling (Rs)	42737.96	7650.62
4.	X ₄ : Cost of transplantation or sowing (Rs)	15925.13	20687.24
5.	X ₅ : Cost of fertilizer (Rs)	2839.56	11154.1
6.	X ₆ : Cost of feed supplement for fish (Rs)	13048.13	0.00
7.	X ₇ : Cost of weeding (Rs)	0.00	18809.52
8.	X ₈ : Cost of transportation (Rs)	8216.491	10500.55
9.	X ₉ : Cost of harvesting (Rs)	39715.91	49841.07
10.	Total cost of cultivation (Rs)	1,49,309.09	140411.40
11.	Gross income (Rs)	434027.94	251991.40
12.	Net income/ha	287149.04	111580.00
13.	Yield/ha		
	▪ Rice	3580.00	3337.95
	▪ Fish	1318.51	---
	▪ Mustard	---	1267.86
14.	BCR	2.90	1.79

From Table 4.5.3.1 it was revealed that in Imphal East district the total cost of RFFS cultivation was Rs 1,49,309.09 and the gross income was Rs 434027.94 with net income of Rs 287149.04. The yield of rice under RFFS was 3580.00 kg/ha and yield of fish was 1318.51kg/ha. The BCR of RFFS was 2.95. In RMFS, the total cost of cultivation was Rs 140411.40 and the gross income was Rs 251991.40 with net income of Rs 111580.00. The yield of rice under RMFS was 3337.95 kg/ha and yield of mustard was 1267.86 kg/ha. The BCR of RMFS was 1.79. From the findings it can be inferred that RFFS give higher rice yield and income than the RMFS, hence RFFS have higher BCR than RMFS.

Table 4.5.4 Cost of cultivation and the income generated under rice-based farming system (RBFS) in Senapati district

S/N	Parameters	Senapati district (n ₃ =80)	
		RFFS	RVFS
1.	Cost of land preparation (Rs)	17419.12	28342.59
2.	Cost of irrigation (Rs)	0.00	3579.63
3.	Cost of Seedling (Rs)		
	▪ Seeds	3529.41	10268.52
	▪ Fingerlings	39044.12	---
4.	Cost transplantation or sowing (Rs)		
	▪ Rice	17911.76	20981.48
	▪ Vegetables	---	15027.78
5.	Cost of fertilizer (Rs)	2647.06	7518.52
6.	Cost of weeding (Rs)	--	32648.15
7.	Transportation (Rs)		
	▪ Rice	9588.97	6620.37
	▪ Fish	7963.24	-----
	▪ Vegetables	-----	7504.63
8.	Harvesting (Rs)		
	▪ Rice Cutting	19643.38	18072.22
	▪ Rice Threshing	20955.88	19444.44
	▪ Catching Fish	4967.65	---
	▪ Vegetables	----	9740.74
9.	Total harvested (Kg)		
	▪ Rice	2827.24	2629.63
	▪ Fish	581.85	---
	▪ Vegetables	----	2925.00
10.	Sold (RS/kg)		
	▪ Rice	40.00	40.00
	▪ Fish	298.25	---
	▪ Vegetables	---	56.00
11.	Total cost of cultivation (Rs)	143670.60	179749.10
12.	Gross income (Rs)		
	▪ Rice	113089.40	105185.20
	▪ Fish	173537.60	---
	▪ Vegetables	----	163800.00
	Total	286627.10	268985.20
13.	Net income (Rs)	142956.50	89236.10

Table 4.5.4 presented the based cost, revenue and returns of rice-fish farming system (RFFS) in Senapati district. It was revealed that the highest cost was incurred

in 'fingerlings' operation (Rs 39044.12) followed by cost of 'rice threshing' (Rs 20955.88), cost 'rice cutting' (Rs 19643.38), cost of 'rice transplantation' (Rs 17911.76), cost of 'land preparation' (Rs17419.12), cost of 'rice transportation' (Rs 9588.97), cost of 'fish transportation' (Rs 27963.24), cost of 'fish catching' (4967.65), cost of 'rice seeds' (Rs 3529.41). The total cost of RFFS cultivation was Rs 143670.60 and the gross income was Rs 286627.10.

Table 4.5.4 presented the based cost, revenue and returns of vegetable farming system (RVFS) in Senapati district. It was revealed that the highest cost was incurred in 'weeding' operation (Rs 32648.15) followed by cost of 'rice transplantation' (Rs 20981.48), cost of 'rice threshing' (Rs 19444.44), cost of 'rice cutting' (Rs 18072.22), cost of 'land preparation' (Rs 28342.59), cost of 'seedlings' (Rs 10268.52), cost of 'vegetables transplantation' (Rs15027.78), cost of 'vegetables transportation' (Rs 7504.63), cost of 'vegetables harvesting' (Rs2925.00), cost of 'rice transportation' (Rs 6620.37), cost of 'irrigation' (Rs 3579.63). The total cost of cultivation in RVFS was Rs 179749.10 and the gross income was Rs 268985.20.

Table 4.5.4.1 Cost of cultivation and income generated under rice-based farming system (RBFS) in Senapati district per hectare area

S/N	Parameters	Senapati district (n ₃ =80)	
	Cost of cultivation per hectare	RFFS	RVFS
1.	X ₁ : Cost of land preparation (Rs)	17419.12	28342.59
2.	X ₂ : Cost of irrigation (Rs)	0.00	3579.63
3.	X ₃ : Cost of Seedling (Rs)	42573.53	10268.52
4.	X ₄ : Cost of transplantation or sowing (Rs)	17911.76	36009.26
5.	X ₅ : Cost of fertilizer (Rs)	2647.059	7518.519
6.	X ₆ : Cost of feed supplement for fish (Rs)	0.00	0.00
7.	X ₇ : Cost of weeding (Rs)	0.00	32648.15
8.	X ₈ : Cost of transportation (Rs)	17552.21	14125.00
9.	X ₉ : Cost of harvesting (Rs)	45566.91	47257.41
10.	Total cost of cultivation (Rs)	143670.60	179749.10
11.	Gross income (Rs)	286627.10	268985.20
12.	Net income/ha	142956.50	89236.11
13.	Yield/ha		
	▪ Rice	2827.24	2629.63
	▪ Fish	581.85	--
	▪ Vegetables	---	2925.00
14.	BCR	2.00	1.50

From Table 4.5.4.1 it was revealed that in Senapati district the total cost of RFFS cultivation was Rs 143670.60 and the gross income was Rs 286627.10 with net income of Rs 142956.50. The yield of rice under RFFS was 2827.24 kg/ha and yield of fish was 581.85 kg/ha. The BCR of RFFS was 2.00. In RMFS, the total cost of cultivation was Rs 179749.10 and the gross income was Rs 268985.20 with net income of Rs 89236.11. The yield of rice under RMFS was 2629.63 kg/ha and yield of mustard was 2925.00 kg/ha. The BCR of RMFS was 1.50. From the findings it can be inferred that RFFS give higher rice yield and income than the RVFS, hence RFFS have higher BCR than RVFS.

Table 4.5.5 Cost of cultivation and the income generated under rice-based farming system (RBFS) in Churachandpur district

S/N	Churachandpur district (n ₄ =80)		
	Parameters	RMFS	RVFS
1.	Average area	0.43 acre (0.17ha)	0.78 acre (0.32 ha)
2.	Cost of land preparation (Rs)	19040.53	22322.31
3.	Cost of irrigation (Rs)	2682.71	6574.75
4.	Cost of Seedling (Rs)		
	▪ Seeds	12671.29	8964.47
5.	Cost of transplantation or sowing (Rs)		
	▪ Rice	16068.53	17126.56
	▪ Mustard	2941.176	---
	▪ Vegetables	---	14276.97
6.	Cost of fertilizer (Rs)	7979.24	3443.63
7.	Cost of weeding (Rs)	11789.35	30453.44
8.	Cost of transportation (Rs)		
	▪ Rice	8555.47	7772.34
	▪ Mustard	6788.94	---
	▪ Vegetables	---	9232.59
9.	Harvesting (Rs)		
	▪ Rice Cutting	18455.88	13562.50
	▪ Rice Threshing	16412.35	12437.50
	▪ Mustard Cutting	9446.35	---
	▪ Mustard Threshing	8910.05	---
	▪ Vegetables	---	8795.97
10.	Total harvested (Kg)		
	▪ Rice	2705.88	2625.00
	▪ Mustard	1058.82	---
	▪ Vegetables	---	2530.63
11.	Sold (RS/kg)		
	▪ Rice	39.78	39.78
	▪ Mustard	74.12	---
	▪ Vegetables	---	58.18
12.	Total cost of cultivation (Rs)	141741.90	154963.00
13.	Gross income (Rs)		
	▪ Rice	107640.00	104422.50
	▪ Mustard	78480.00	---
	▪ Vegetables	---	147231.80
	Total	186120.00	251654.30
14.	Net income (Rs)	44378.10	96691.25

Table 4.5.5 presented the based cost, revenue and returns of rice-mustard farming system (RMFS) in Churachandpur district. It was revealed that the highest cost was incurred in 'rice cutting' operation (Rs 18455.88) followed by cost of 'land preparation' (Rs 19040.53), cost of 'rice threshing' (Rs 16412.35), cost of 'rice cutting' (Rs 18455.88), cost of 'rice transplantation' (Rs 16068.53), cost of 'seedling' (Rs. 12671.29), cost of 'mustard cutting' (Rs 9446.35), cost of 'mustard threshing' (Rs 8910.05), cost of 'rice transplantation' (Rs. 16068.53), cost of 'fertilizers' (Rs 7979.24), cost of 'mustard transportation' (Rs 6788.94), cost of 'mustard sowing' (Rs 2941.18), cost of 'irrigation' (Rs 2682.71). The total cost of cultivation in RMFS was Rs 141741.90. and the gross income was Rs 186120.00.

Table 4.5.5. presented the based cost, revenue and returns of rice-vegetable farming system (RVFS) in Churachandpur district. It was revealed that the highest cost was incurred in 'weeding' operation (Rs 30453.44) followed by cost of 'land preparation' (Rs 22322.31), cost of 'rice transplantation' (Rs 17126.56), cost of 'seedling' (Rs 8964.47), cost of 'vegetables transplantation' (Rs 14276.97), cost of 'rice cutting' (Rs 13562.50), cost of 'rice threshing' (Rs 12437.50), cost of 'vegetables transportation' (Rs 9232.59), cost of 'vegetables harvesting' (Rs 2530.63) , cost of 'rice transportation' (Rs 7772.34), cost of 'irrigation' (Rs 6574.75), and cost of 'fertilizers' (Rs 3443.63). The total cost of cultivation in RVFS was Rs 154963.00 and the gross income was Rs 251654.30.

Table 4.5.5.1 Cost of cultivation and the income generated under rice-based farming system (RBFS) in Churachandpur district per hectare area

S/N	Parameters	Churachandpur (n ₄ =80)	
	Cost of cultivation per hectare	RMFS	RVFS
1.	X ₁ : Cost of land preparation (Rs)	19040.53	22322.31
2.	X ₂ : Cost of irrigation (Rs)	2682.71	6574.75
3.	X ₃ : Cost of Seedling (Rs)	12671.29	8964.47
4.	X ₄ : Cost of transplantation/ or sowing (Rs)	19009.71	31403.53
5.	X ₅ : Cost of fertilizer (Rs)	7979.24	3443.625
6.	X ₆ : Cost of feed supplement for fish (Rs)	0.00	0.00
7.	X ₇ : Cost of weeding (Rs)	11789.35	30453.44
8.	X ₈ : Cost of transportation (Rs)	15344.41	17004.94
9.	X ₉ : Cost of harvesting (Rs)	53224.65	34795.97
10.	Total cost of cultivation (Rs)	141741.90	154963.00
11.	Gross income (Rs)	186120.00	251654.30
12.	Net income/ha	44378.10	96691.30
13.	Yield/ha		
	▪ Rice	2705.88	2625.00
	▪ Mustard	1,058.82	--
	▪ Vegetables	---	2530.63
14.	BCR	1.31	1.62

From Table 4.5.5.1 it was revealed that in Churachandpur district the total cost of RMFS cultivation was Rs 141741.90 and the gross income was Rs 186120.00 with net income of Rs 44378.10. The yield of rice under RMFS was 2705.88 kg/ha and yield of fish was 1,058.82 kg/ha. The BCR of RMFS was 1.31. In RVFS, the total cost of cultivation was Rs 154963.00 and the gross income was Rs 251654.30 with net income of Rs 96691.30. The yield of rice under RVFS was 2625.00 kg/ha and yield of vegetables was 2530.63kg/ha. The BCR of RMFS was 1.62. From the findings it can be inferred that RVFS give higher rice yield and income than the RMFS, hence RVFS have higher BCR than RMFS.

Table 4.5.6: Distribution of average income and crop yield under the selected rice-based farming system (RBFS)

S/N	Districts	Average Income rice-based farming system per hectare				Productivity of rice (kg/ha)	BCR
		Farming system	Total cost	Gross income (Rs.)	Net income (Rs.)		
1.	Thoubal (THB)	RFFS	139969.02	433437.91	293468.90	4629.89	3.20
		RMFS	117196.10	257775.14	140579.00	3847.76	2.20
2.	Imphal East (IME)	RFFS	146878.90	427918.86	281039.96	3580.00	2.91
		RMFS	140411.40	251991.40	111580.00	3337.95	1.79
3.	Churachandpur (CCP)	RMFS	141741.90	186120.00	44378.10	2705.88	1.31
		RVFS	154963.00	251654.30	96691.30	2625.00	1.62
4.	Senapati (SNP)	RFFS	143670.60	286627.10	142956.50	2827.24	2.00
		RVFS	179749.10	268985.19	89236.11	2629.63	1.50

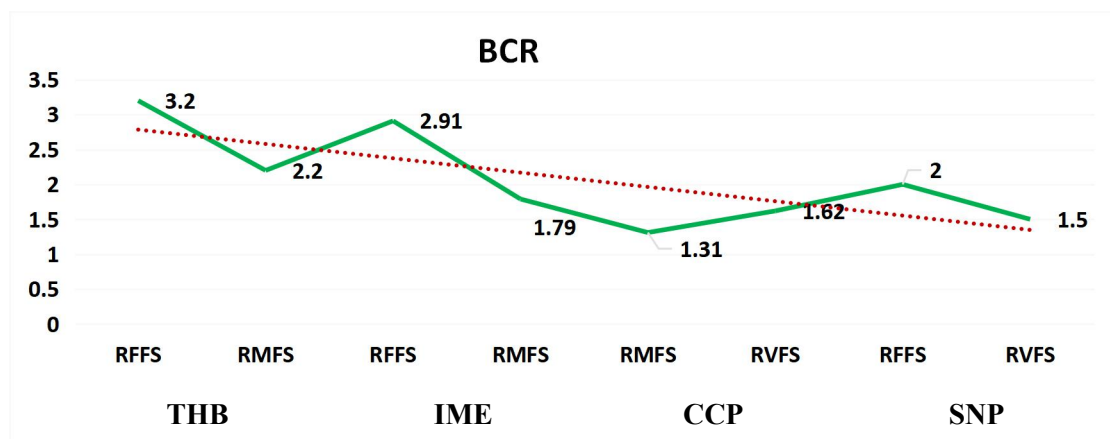


Fig 4. 5.6.1 Distribution of BCR under rice-based farming system (RBFS)

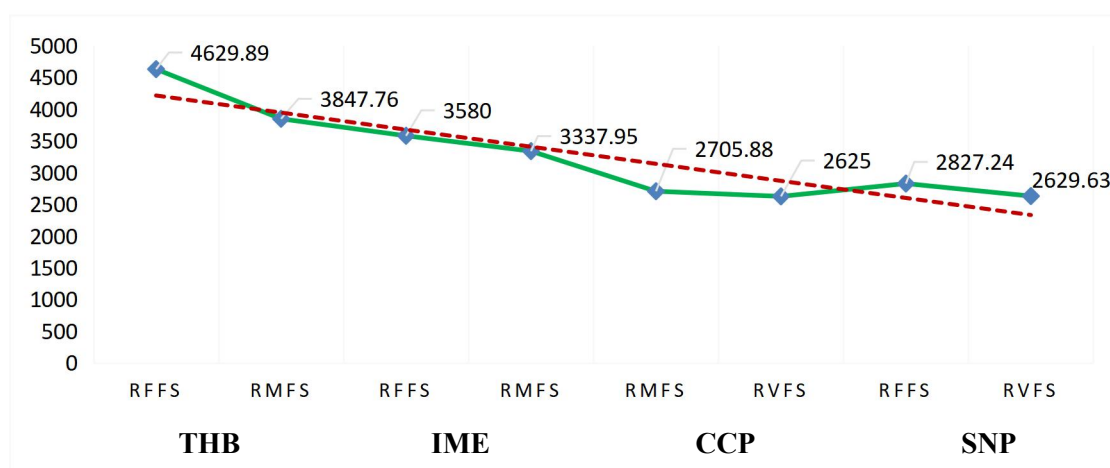


Fig 4.5.6.2 Distribution of rice productivity (kg/ha) under rice-based farming system (RBFS)

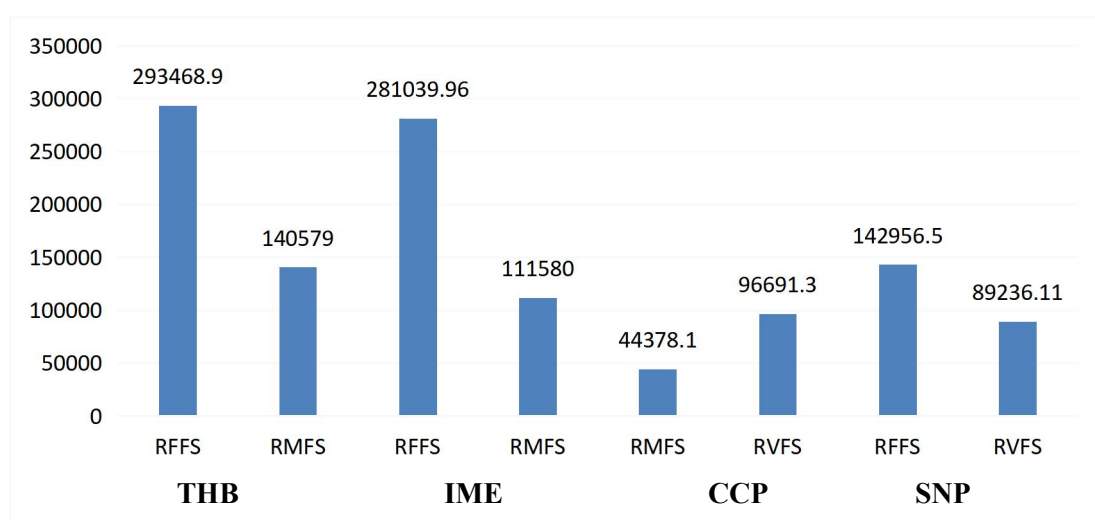


Fig 4.5.6.3 Distribution of net income (Rs/ha) under rice-based farming system (RBFS)

Table 4.5.6 evident that in Thoubal district had the highest net income (Rs 293,468.90/ha) having highest 4629.89 kg/ha rice productivity with 3.20 BCR and Imphal East obtained net income of Rs 281,039.96/ha having rice productivity 3847.76 kg/ha with BCR 2.91, Senapati district (Rs 142,956.50/ha) having rice productivity 2827.24 kg/ha with BCR 2.00 under rice-fish farming system. In context of rice-mustard farming system, Thoubal district had the highest net income (Rs 140,579.00/ha) having rice productivity 3847.76 kg/ha with BCR 2.20, Imphal East had net income (Rs 111,580.00/ha) having rice productivity 3337.95 kg/ha with BCR 1.79 and Churachandpur district had net income (Rs 96691.30/ha) having rice productivity 2625.00 kg/ha with BCR 1.62. Further in context of rice-vegetables farming system, Senapati district had net income (Rs 89236.11/ha) having rice productivity 2629.63 kg/ha with BCR 1.50 and Churachandpur district had net income (Rs 44378.10/ha) having rice productivity 2705.88 kg/ha with 1.31. According to the results, the rice-fish farming system (RFFS) produced the highest income and productivity when compared to other farming systems', while the rice-mustard farming system (RMFS) produced the lowest income and productivity. RFFS had the highest rice productivity and income, this could be because of the symbiotic relationship with the farming components. Fish excreta adds organic fertilizers to the soil, fish activity increases soil aeration and mineralization, and fish movement improves rice tillering, fish eat harmful insects and control weeds. Additionally, RFFS cut labour costs associated with weeding, fertilizer, insecticides, and other chemical costs. Rice productivity in the districts of Churachandpur district and Senapati district was lower than Thoubal district and Imphal East district. This difference in productivity could be attributed to a number of factors, including poor soil management, a reliance on traditional cultural practices, and the use of local varieties. Furthermore, the slope and topography of the hill districts Churachandpur and Senapati could have been the major contributing factor to the lower crop production and income. Additional factors that may contribute include the unavailability of improved variety seeds, inadequate irrigation systems, small and dispersed land holdings, poor soil depth, severe soil erosion, challenging topography, and a high frequency of disease incidence, as documented by Jethi *et*

al., (2020). The implementation of appropriate local technology and demonstrated its wider adaptability, profitability, and acceptance in maximizing crop yields in hilly areas.

4.6 Constraints faced by farmers in adoption of sustainable farming system

Constraints in adopting sustainable farming system under rice-based farming system (RBFS) under rice-based farming system (RBFS) were identified using Garrett's ranking method in the selected four districts viz., Thoubal district, Imphal East, Senapati district and Churachandpur district. By following the thumb rule of Garrett's ranking a unique rank was allotted to each problem between 1 to 12 and presents in Table 4.6.1., Table 4.6.2. and Table 4.6.3.

Table 4.6.1 Constraints faced by the respondents under sustainable rice-based farming systems

n=320

S/N	Statements	Total Garret score	Mean value	Ranking
1.	Lack of irrigation source	25252	79.16	1
2.	Lack of improved technology for rice-based cultivation	24925	78.13	2
3.	Difficult to continue rice base farming due to monsoon change	24196	76.16	3
4.	Lack of government subsidies and financial support	23977	75.16	4
5.	Requirement of higher investment at first cropping	23905	74.94	5
6.	Lack of training and awareness about the sustainable farming practices	23475	73.59	6
7.	Lack of technical guidance about soil nutrient and water management	23435	73.46	7
8.	Unavailability of farm inputs distributed by departments	23238	72.85	8
9.	Farm inputs cost are high	22887	71.75	9
10.	Difficulty to control infested diseases and pests	22331	70.00	10
11.	This farming practice required larger land holding area	22060	69.15	11
12.	Agronomical practices need to be observed carefully and regularly	21396	67.07	12

From Table 4.6.1 based on the result of Garret's ranking technique it was revealed that "Lack of irrigation source" was the major constraints with Rank I followed by "Lack of improved technology for rice-based cultivation" with Rank II, "Difficult to continue rice base farming due to monsoon change" with Rank III, "Lack of government subsidies and financial support" with Rank IV, "Requirement of higher investment at first cropping" with Rank V, "Lack of training and awareness about the sustainable farming practices" with Rank VI, "Lack of technical guidance about soil nutrient and water management" with Rank VI, "Lack of technical guidance about soil nutrient" and "water management" with Rank VII, "Unavailability of farm inputs distributed by departments" with Rank VIII, "Farm inputs cost are high" with Rank IX, "Difficulty to control infested diseases and pests" with Rank X, "Rice based farming practice required larger land holding area" with Rank XI, "Agronomical practices need to be observed carefully and regularly" with Rank XII.

The findings of the study showed that lack of irrigation source, lack of improved technology, monsoon change and higher investment were the top major constraints faced by the farmers. To address the issue of inadequate irrigation facilities and monsoon change it is suggested to invest on improved irrigation systems, promoting crop diversification, and developing drought-resistant crop varieties. By doing so, it will be possible to reduce the risks associated with reliance on the monsoon and guarantee the long-term viability of its agriculture sector. Farmers are reporting that the monsoon season has become more unpredictable, which has caused crop failures and the loss of their livelihoods. Uneven rainfall distribution can cause floods or droughts, which can affect the quantity and quality of crops. Therefore, it is advised that the government start the policy of giving technical support for the building of irrigation infrastructure and climate adaptation technologies.

Lack of financing accessibility was one of the main issues farmers faced. In the absence of sufficient financial assistance and risk management strategies, farmers encounter challenges in maintaining their farming operations. It is challenging for farmers to invest in cutting-edge machinery, superior seeds, and

enhanced agricultural techniques due to a shortage of finance facilities. This may lead to decreased profitability, a greater susceptibility to crop losses, and lower productivity. In a similar vein, farmers who do not have agricultural insurance are at danger from disasters like floods, droughts, pests, and illnesses. The government need to implement several measures, including the Pradhan Mantri Fasal Bima Yojana (PMFBY), which offers farmers reasonably priced crop insurance, to help them with finance and insurance support. Through a number of programs, including the Interest Subvention Scheme and the Kisan Credit Card, the government should provide loans to farmers. To guarantee that farmers can take full advantage of these programs, more education and outreach are necessary. Additionally, more creative and specialized financial solutions that are suited to the unique requirements of various farmer groups are required.

4.6.2 Constraint in adopting sustainable rice-fish farming system (RFFS)

Constraints in adopting sustainable rice-fish farming system (RBFS) were identified using Garrett's ranking method in the selected four districts viz., Thoubal district, Imphal East and Senapati district. By following the thumb rule of Garrette's ranking a unique rank was allotted to each problem between 1 to 11 and presents in Table 4.6.2.

From Table 4.6.2 based on the result of Garret's ranking technique it was revealed that "High irrigation cost" was the major problem with Rank I, followed by "Difficult to balance the yield of both rice and fish" with Rank II, "Difficult to control diseases in rice crop" with Rank III, "Difficult to harvest rice crop in rice-based cultivation" with Rank IV, "Initial field preparation required large investment" with Rank V, "Difficult to eliminate excessive mosses" with Rank VI, "Due to increase ammonia level at rice reproductive stage reduced rice yield" with Rank VII, "Predator or thieves reduced the fish stock" with Rank VIII, "Prolong water exposure on soil caused lodging in rice crop" with Rank IX, "Difficult to control flood during rainy season" with Rank X, "Construction of bunds and ponds wasted cultivable land" with Rank X.

Table 4.6.2: Ranking of the constraints faced by the respondents in adopting sustainable rice-fish farming system

n=120

S/N	Statements	Total Garret score	Mean value	Ranking
1.	High irrigation cost	9616	80.13	1
2.	Difficult to balance the yield of both rice and fish	9488	79.07	2
3.	Difficult to control diseases in rice crop	9363	78.03	3
4.	Difficult to harvest rice crop in rice-based cultivation	9117	75.98	4
5.	Initial field preparation required large investment	9064	75.53	5
6.	Difficult to eliminate excessive mosses	8943	74.53	6
7.	Due to increase ammonia level at rice reproductive stage reduced rice yield	8824	73.53	7
8.	Predator or thieves reduced the fish stock	8706	72.55	8
9.	Prolong water exposure on soil caused lodging in rice crop	8576	71.47	9
10.	Difficult to control flood during rainy season	8490	70.75	10
11.	Construction of bunds and ponds wasted cultivable land	8242	68.68	11

The findings of the study showed that high irrigation cost was the major constraints it may be due to the used of inefficient irrigation method and lack of water sources. Therefore, careful supervision is needed to ensure proper operation, schedule irrigation and use of an inexpensive irrigation technique. It is suggested to collect rain water, runoff water in ponds or ditches near the edge of the field. In case of difficult to control diseases in rice crop, it may be due the responses of biological or organic control method are slower than the chemical control method. In RFFS farmers never use chemicals or pesticides to control diseases which makes

it difficult to control the diseases once its infested. Early treatment and proper identification of diseases is very important to avoid the further crop damages therefore it is crucial to consult local specialists or experts to prevent further infestation through the use of appropriate treatments. It's also advised to utilize high-quality, pathogen-free seeds and preserve soil fertility.

4.6.3 Constraints faced in adopting sustainable rice-mustard farming system (RMFS)

Constraints in adopting sustainable rice-mustard farming system (RMFS) were identified using Garrett's ranking method in the selected four districts viz., Thoubal district, Imphal East and Churachandpur district. By following the thumb rule of Garrette's ranking a unique rank was allotted to each problem between 1 to 11 and presents in Table 4.6.3.

Table 4.6.3: Constraints faced by the respondents under sustainable rice-mustard farming system (RMFS)

n=120

S/N	Statements	Total Garret score	Mean value	Ranking
1.	Lack of seeds availability from the agriculture department	9501	79.45	1
2.	Low crop yield	9412	78.80	2
3.	Failure of early sowing due to seeds unavailability	9354	78.30	3
4.	Lack of knowledge on crop residue management	9171	76.88	4
5.	Unable to identify good quality seeds for oil production	8944	75.13	5
6.	Unavailability of fertilizer during the season	8819	74.08	6
7.	Low germination due to moisture stress	8644	72.73	7
8.	Less oil contains	8414	70.83	8
9.	Late sowing caused increases of diseases infestation	8284	69.80	9
10.	Predators like cow damaged the crop	8103	68.42	10
11.	High labour cost	8024	67.73	11

From Table 4.6.3 it was revealed that “Lack of seeds availability from the agriculture department” was the major problem with Rank I followed by “Moisture stress caused low crop yield” with Rank II, “Failure of early sowing due to seeds unavailability” with Rank III, “Lack of knowledge on crop residue management” with Rank IV, “Unable to identify good quality seeds for oil production” with Rank V, “Unavailability of fertilizer during the season” with Rank VI, “Low germination due to moisture stress” with Rank VII, “Less oil contain” with Rank VIII, “Late sowing caused increases of diseases infestation” with Rank IX, “Predators like cow damaged the crop” with Rank X, “High labour cost” with Rank XI.

The findings of the study showed that lack of seeds availability, low crop yield, lack of knowledge on crop residue management, unable to identify good seeds for oil production were the major constraints in rice-mustard farming system. Farmers seeded their crops in late November due to a lack of seeds availability, which resulted in aphid infestations and decreased agricultural yields. Therefore, it is suggested more extension services should be disseminate to impart knowledge and skills about rice-mustard farming technology.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

5.1 Introduction

Rice (*Oriza Sativa* L.) is one of the major food crops in India. Rice plays a crucial role in reducing the disparity between food grain demand and supply. Nevertheless, the monoculture of rice production method results in anthropogenic changes that have a negative influence on the soil's physico-chemical and biochemical indicators, leading to a loss of biodiversity and a deterioration of the natural resource base, ultimately rendering farming unsustainable. Rice-based agriculture is an alternative to eliminate the negative impact of rice-monoculture. This method of farming regenerate and conserved soil, eliminates synthetic pesticides and fertilizers, and decreased negative effects by ensuring agriculture beneficial on the environment. This method of farming adheres to the sustainable development principle and it seeks to maintain high levels of productivity.

The present study identified the best and most efficient farming methods within the rice-based farming system to combat poverty and unsustainable agriculture in addition to contributing to the discussion on rice based farming in Manipur. This study provides a new viewpoint on ways to increase the state's agriculture sustainability that may help to build an appropriate model of a sustainable rice-based farming system. The goal of this study was to better understand the phenomenon of sustainable rice base farming in Manipur.

The study was undertaken with the following objectives:

5.2 Objectives

- 5.2.1 To study the socio-economic and psychological characteristics of rice-based cultivation farmers
- 5.2.2 To examine the cropping pattern and farm resource management under rice-based farming system followed by the respondents

- 5.2.3 To measure the attitude and extent of adoption of sustainable practices by respondents under rice-based farming system
- 5.2.4 To examine the factors determining the sustainability of rice-based farming system
- 5.2.5 To analyse income and employment generation from livelihood enterprises under rice-based farming system
- 5.2.6 To identify the constraints faced by the farmers in sustainable rice-based farming system

5.3 Research Methodology

Ex-post facto research design was used in the present study and multistage purposive cum random sampling design was followed for the study. Rice is the main food crop in Manipur which is cultivated in both plain and hilly area. Since the need and importance of rice crops cannot be replaced with other crops, many farmers have adopted a rice-based farming technique in an effort to increase revenue and farm sustainability. To study and analyse the farming practices of different rice-based farming system, the state of Manipur was selected for the present study. Out of nine districts, four districts were purposively selected for the current study based on productivity and cultivated area of rice. Two districts in each category viz., Imphal East and Thoubal district representing valley area and Churachandpur and Senapati district representing the hill area of Manipur. From each of the selected districts, two blocks were selected randomly. Thus, a total number of eight blocks were selected for the present study. Further two villages from each of the selected blocks were randomly selected including a total sixteen villages and 20 respondents from each villages comprising a total number of 320 respondents were included for the present study.

The variables age, sex, family size, family type, education, experience in rice-base cultivation, Total landholding size, Size of land under rice-base farming, annual income, income from rice-base farming, training exposure, extension contact, informal information sources utilization, formal information sources

utilization, social media information sources utilization and mass media information sources utilization, knowledge of sustainable agricultural practices, scientific orientation, innovativeness, risk orientation, production orientation, market orientation, perception towards climate change, attitude towards sustainable agricultural practices, extent of adoption of sustainable rice-based farming system were measured.

The required data were collected from the respondents in an informal atmosphere by using a pre-tested interview schedule and by conducting personnel interview. For data analysis SPSS software was used.

5.4 Results

5.4.1 Socio-economic and personal characteristics of the respondents

From the findings it was found that majority (53.43%) of the respondents were middle aged, majority (66.88%) of the respondents were male, majority (58.12%) of the respondents had nuclear family, majority (70.31%) of the respondents belonged to medium family size, majority (35.31%) of the respondents had education upto secondary level, majority (43.12%) of the respondents had high experience on rice-based farming, majority (46.88%) of the respondents belonged to small landholding area, majority (60.31%) of the respondents belonged to area (less than 1 acre) under rice-based farming system, majority ((60.31%) of the respondents had an average annual income of Rs. 40269.59, majority (42.19%) of the respondents had an average income of Rs 48844.05 under rice-based farming system, majority (77.19%) of the respondents had no training exposure, majority (74.69%) of the respondents needed training on IPM.

Majority (60.94%) of the respondents had medium level of extension contact, majority (60.94%) of the respondents had medium level of information sources utilized, majority (61.25%) of the respondents had medium knowledge level on sustainable agricultural practices, majority (73.13%) of the respondents had medium level of scientific orientation, majority (73.44%) of the respondents had medium level of innovativeness, majority (70.31%) of the respondents had

medium level of risk orientation, majority (81.87%) of the respondents had medium level of production orientation, majority (70.63%) of the respondents had medium level of market orientation, majority (90.94%) of the respondents don't perceived heavy hailstorm.

Based on correlation analysis, it was found that variables total size of land under agriculture, size of land under rice-based farming and innovativeness had negative and significant association with dependent variable 'Knowledge' at 1% probability. The variables experience in agriculture, information sources utilization, perception towards climate change and production orientation had positive and significant association with the dependent's variable 'Knowledge' at 5% probability.

5.4.2 Cropping pattern and farm resource management under rice-based farming system

Three major cropping patterns were found in the study viz., rice-fish farming system, rice-mustard farming system and rice-vegetable farming system. Out of these, 37.50 per cent respondents practiced rice-fish farming system (RFFS), 37.50 per cent of them practiced rice-mustard farming system (RMFS) and 25.00 per cent respondents practiced rice-vegetables farming system (RVFS).

In farm resources management of rice-based farming system it was found that majority (57.50%) of the respondents practiced both machine and manual methods in land preparation. Majority (46.25%) of them practiced both (local and HYV variety) in selection of crop varieties majority (64.69%) of them practiced organic nutrient management, majority (58.44%) practiced rainfed water management, majority (60.63%) of the respondents practiced cultural control method in weed management, majority (43.13%) of them practiced cultural control method of pest management, majority (42.81%) of them practiced cultural control method of diseases management, majority (69.69%) of the respondents practiced manual methods of harvesting the crops and majority (55.00%) of the respondents used crop residue residue for animal feed and plant nutrients.

Farming system I (RFFS): In rice-fish farming system (RFFS) trench, dyke and ponds were constructed in rice field to provide a suitable area for fish. In Thoubal district and Imphal East district farmers were cultivated RFFS in two crop cycles i.e., First crop cycle (Kharif season) and Second crop cycle (Pre Kharif season). In the first crop cycle (Kharif season) from June-July to November i.e., 150 days and harvested in during the month of November around 3rd week on the occasion of one of the biggest festivals of Manipur, Ningol Chakhouba. In the second crop cycle (Pre Kharif season) duration of about 90 days from Feb-March to May and harvest in the 3rd week of May. In Senapati district, rice cultivation started from May and harvested in the first week of October and fish cultivation continue from October to April.

Farming system II (RMFS): Rice-mustard farming system (RMFS) was mainly cultivated in Imphal East district, Thoubal district and Churachandpur district. In this farming system mustard-rapeseed was cultivated in Rabi season after harvesting rice crop. No irrigation is required in the rapeseed-mustard as it is sown on residual soil moisture in rice field. And the duration of practicing zero tillage RMFS in the selected study area was from November to March (Rabi season) and rice cultivation from June- November (Kharif season). In nutrients and farm components interaction in RFFS, it was observed that rice residue act as fertilizer and mulching with rice straw results in conserving soil moisture, reduces weed problems and maintains soil temperature.

Farming system III (RVFS): Rice-vegetable farming system (RVFS), was majorly cultivated in Senapati and Churachandpur district. In this farming practices rice is cultivated in Kharif season from May to October and vegetables cultivation starts during Rabi season from November to March- April. In RVFS rice residues are the important component of the component cycle.

5.4.3 Attitude and extent of adoption of sustainable agricultural practices under rice-based farming system

5.4.3.1 Attitude

From the findings, it was found that in Thoubal district majority (73.75%) of the respondents had favourable attitude towards the adoption of sustainable agricultural practices with an attitude index of 64.29. In Imphal East district, majority (67.50%) of the respondents had favourable attitude towards the adoption of sustainable agricultural practices with an attitude index of 68.41. In Churachandpur district, majority (75.00%) of the respondents had favourable attitude towards the adoption of sustainable agricultural practices with an attitude index of 66.00. In Senapati district, majority (73.75%) of the respondents had favourable attitude towards the adoption of sustainable agricultural practices with an attitude index of 62.91. Comprising all the selected districts it was found that majority (72.50%) of the respondents had favourable attitude towards the adoption of sustainable agricultural practices with an attitude index of 65.40.

Based on correlation analysis, it was found that variables family size, extension contacts, mass media information sources utilization, social media information sources utilization, experience, perception towards climate change , production orientation and innovativeness had positive and significant association with attitude towards adoption of sustainable agricultural practices.

5.4.3.2 Extent of adoption of sustainable agricultural practices

It was observed that in Imphal East district majority (78.75%) of the respondents had medium level of adoption of sustainable agricultural practices with an adoption index of 53.75. In Senapati district, majority (68.75%) of the respondents had medium level of adoption of sustainable agricultural practices with an adoption index 46.90. In Thoubal district, majority (56.25%) of the respondents had medium level of adoption of sustainable agricultural practices with an adoption index of 52.12. In Churachandpur district, majority (53.75%) of the respondents had medium level of adoption of sustainable agricultural practices

with an adoption index of 41.48. Overall, it was found that majority (64.38%) of the respondents had medium level of adoption with an attitude index of 48.56.

5.4.3.3 Extent of adoption of rice-based farming system

In adoption of rice-fish farming system (RFFS), it was revealed that in Senapati district majority (75.00%) of the respondents had medium level of adoption of the recommended practices of rice-fish farming system with an adoption index of 53.50. In Thoubal district, majority (45.00%) of the respondents had medium level of adoption of the recommended practices of rice-fish farming system with an adoption index of 69.00. In Imphal East district, majority (42.50%) of the respondents had medium level of adoption of the recommended practices of rice-fish farming system with an adoption index of 67.75. Overall, it was found that majority (54.17%) of the respondents had medium level of adoption of the recommended practices of rice-fish farming system with an adoption index of 63.42.

In adoption of rice-mustard farming system (RMFS), it was revealed that in Churachandpur district majority (67.50%) of the respondents had medium level of adoption of rice-mustard farming system with an adoption index of 47.63. In Thoubal district, majority (60.00%) of the respondents had medium level of adoption of the recommended practices of rice-mustard farming system with an adoption index of 47.63. In Imphal East district, majority (57.50%) of the respondents had medium level of adoption of the recommended practices of rice-mustard farming system with an adoption index of 74.88. Overall, it was found that majority (61.67%) of the respondents had medium level of adoption of the recommended practices of rice-mustard farming system with an adoption index of 63.69.

In adoption of rice-vegetable farming system (RVFS), it was revealed that in Churachandpur district majority (85.00%) of the respondents had medium level of adoption of rice-vegetable farming system. In Senapati district, majority (97.50%) of the respondents had medium level of adoption of recommended practices of rice-vegetables farming system. Overall, it was found that majority

(81.25%) of the respondents had medium level of adoption of recommended practices of rice-vegetables farming system. And the recommended practices of rice-vegetable farming system had an attitude index of 58.31.

Based on Correlation analysis, it was found that variables age, annual income, income from rice-based farming, mass media information sources utilization, perception towards climate change, market orientation and innovativeness, size of land under rice-based farming and training exposure had positive and significant association with adoption of rice-based farming system.

5.4.3.3.1 Path coefficients of selected variables on adoption of rice-based farming system

Based on the path coefficient analysis it was found that the highest direct positive influence on adoption of rice-based farming system was exerted by income from rice-based farming system (0.164). In the total indirect effect on adoption of rice-based farming system the highest total indirect effect was exerted by annual income (0.172) and highest negative effect on adoption of rice-based farming system was exerted by experience in rice-based farming system (-0.272). In total effect, the highest positive total effect on adoption of rice-based farming system was exerted by experience in agriculture (0.188). The three largest variables through which indirect effect are channelized was age through experience in agriculture (0.118), through annual income (0.022) and through total land under agriculture (0.019).

5.4.3.3.2 Factor influencing the sustainability of rice-based farming system

Based on factor analysis, nine factors (sex, training exposure and production orientation) accounted for 69.59 per cent of the variability. Factor 1 (Personal information) accounted for 15.13 per cent of the total variation embedded with the sustainability of rice-based farming. Factor 2 (Communication and economic attributes) accounted for 10.85 per cent of the total variation embedded with the sustainability of rice-based farming. Factor 3 (Economic attributes) accounted for 8.461 per cent of the total variation embedded with the sustainability of rice-based farming. Factor 4 (Informativeness) accounted 8.330

per cent of the total variation embedded with the sustainability of rice-based farming. Factor 5 (Household members) accounted 7.044 per cent of the total variation embedded with the sustainability of rice-based farming. Factor 6 (Entrepreneurial attributes) accounted 5.590 per cent of the total variation embedded with the sustainability of rice-based farming. Factor 7 (Information access) accounted 5.116 per cent of the total variation embedded with the sustainability of rice-based farming. Factor 8 (Innovative farmers) accounted 4.603 per cent of the total variation embedded with the sustainability of rice-based farming. Factor 9 (Production training) accounted 4.451 per cent of the total variation embedded with the sustainability of rice-based farming.

5.5 Sustainable of rice-based farming systems in the selected districts of Manipur

In Thoubal district, social sustainability had the highest (67.38) sustainability index. In Imphal East district, social sustainability had the highest (64.26) sustainability index. In Churachandpur district, environmental sustainability had the highest (60.59) sustainability index. In Senapati district, environmental sustainability had the highest (68.07) sustainable index.

Among all the selected districts, environmental sustainability had the highest (63.32) sustainability index followed by social sustainability index (60.51) and economic sustainability index (59.52) under rice-based farming systems in Manipur.

Under rice-based farming systems, Thoubal districts was ranked first having the highest sustainable index (65.44), followed by Imphal East district which ranked II with sustainability index of 62.05, Senapati district ranked III having sustainability index of 60.34 and Churachandpur district ranked IV having sustainability index of 58.47.

Thoubal district and Imphal East district representing valley region had higher sustainability score of (63.75) than Churachandpur district and Senapati district, representing hill region with sustainability score (59.41). Overall sustainability index of rice-based farming system was found to be moderate (61.58).

Rice-fish farming systems had the highest (65.49) sustainable index followed by rice-mustard farming system (59.06) sustainable index and rice-vegetables farming system (58.89) sustainable index.

Based on the level of sustainability under rice-based farming system It was observed that majority (72.19%) of the respondents had medium level of sustainability of social sustainability. In context of environmental sustainability, majority (65.31%) of the respondents had medium level of sustainability. Further in context of social sustainability, majority (60.94%) of the respondents had medium level of sustainability.

5.5.1 Predictors of environmental sustainability of rice-based farming system

The regression analysis on specific predictor variables showed that environmental sustainability was influenced by use of organic manure, conservation irrigation water, preparation of FYM, plantation of cover crop, construction of proper trenches & bundles, crop residue management, non-occurrence of drought, crop mulching, setting up of vermi-compost pit, non-occurrence of flood, preservation of beneficial insects, non use of chemicals, no occurrence of landslide, source of water nearby stream, practice of crop rotation, set up well/ponds in the field and maintaining proper drainage system because each of them has p-value less than 0.50. These predictors had a significant contribution in environmental sustainability and explained about 87.9 per cent variations in the environmental sustainability.

5.5.2 Predictors of social sustainability of rice-based farming system

The regression analysis on specific predictor variables showed that social sustainability was influenced by household types, family labour, women involvement in farming, training participation, education, equal wages of woman and man, participation in local activities, experience in farming, adoption of HYV, children sent for education, risk taking ability, framers' motivation, affordable daily nutrient requirement, regular contact of expert, knowledge on farm resource conservation, availability of food and social recognition because each of them has p-value less than 0.50. These predictors had a significant contribution in social

sustainability and explained about 94.9 per cent variations in the social sustainability.

5.5.3 Predictors of economic sustainability of rice-based farming system

The regression analysis on specific predictor variables showed that economic sustainability was influenced by direct link to market, bank loan, profitability, availability of farm inputs, indebtedness, good source of income, government subsidies on farm inputs, high productivity, grant from government schemes, stable price of farm product, satisfaction of farm return, availability of market near farm area, benefit from NGOs and local bodies and crop insurance each of them has p-value less than 0.50. These predictors had a significant contribution in economic sustainability and explained about 92.9 per cent variations in the economic sustainability.

5.6 Employment generation and income from livelihood enterprises under rice-based farming system.

5.6.1 Employment generation under rice-based farming system

It was revealed that the maximum employment generation was found in Rice-vegetables farming system (RVFS) with 251 mandays followed by rice-fish farming system (RFFS) with 240 mandays and rice-mustard farming system (RMFS) with 201 mandays. RVFS generated more employment and mandays as compared to RFFS and RMFS.

5.6.2 Income under rice-based farming system

1. In Thoubal district it was revealed that the total cost of of RFFS cultivation was Rs 135621.00 and the gross income was Rs 433437.91 with net income of Rs 297816.90. The yield of rice under RFFS was 4629.89 kg/ha and the yield of fish was 1271.73 kg/ha. BCR of RFFS was 3.20. In RMFS, the total cost of cultivation was Rs 117196.10 and the gross income was Rs 257775.14 with the net income of Rs 140579.10. The yield of rice under RMFS was 3847.76 kg/ha and yield of mustard was 1761.80 kg/ha. BCR of RMFS was 2.20.

2. In Imphal East district it was revealed that the total cost of RFFS cultivation was Rs 1,49,309.09 and the gross income was Rs 434027.94 with net income of Rs 287149.04. The yield of rice under RFFS was 3580.00 kg/ha and yield of fish was 1318.51 kg/ha. The BCR of RFFS was 2.95. In RMFS, the total cost of cultivation was Rs 140411.40 and the gross income was Rs 251991.40 with net income of Rs 111580.00. The yield of rice under RMFS was 3337.95 kg/ha and yield of mustard was 1267.86 kg/ha. The BCR of RMFS was 1.79.
3. In Senapati district it was revealed that the total cost of RFFS cultivation was Rs 143670.60 and the gross income was Rs 286627.10 with net income of Rs 142956.50. The yield of rice under RFFS was 2827.24 kg/ha and yield of fish was 581.85 kg/ha. The BCR of RFFS was 2.00. In RMFS, the total cost of cultivation was Rs 179749.10 and the gross income was Rs 268985.20 with net income of Rs 89236.11. The yield of rice under RMFS was 2629.63 kg/ha and yield of mustard was 2925.00 kg/ha. The BCR of RMFS was 1.50.
4. In Churachandpur district it was revealed that the total cost of RMFS cultivation was Rs 141741.90 and the gross income was Rs 186120.00 with net income of Rs 44378.10. The yield of rice under RMFS was 2705.88 kg/ha and yield of fish was 1,058.82 kg/ha. The BCR of RMFS was 1.31. In RVFS, the total cost of cultivation was Rs 154963.00 and the gross income was Rs 251654.30 with net income of Rs 96691.30. The yield of rice under RVFS was 2625.00 kg/ha and yield of vegetables was 2530.63 kg/ha. The BCR of RMFS was 1.62.
5. In rice-fish farming system, Thoubal district had the highest net income (Rs 293468.90/ha) having highest 4629.89 kg/ha rice productivity with 3.20 BCR followed by Imphal East district and Senapati district.
6. In rice-mustard farming system, Thoubal district had the highest net income (Rs 140579.00/ha) having rice productivity 3847.76 kg/ha with BCR 2.20 followed by Imphal East district and Churachandpur district.

7. In rice-vegetables farming system, Senapati district had higher net income (Rs 89236.11/ha) having rice productivity 2629.63 kg/ha with BCR 1.50 than Churachandpur district.

5.7 Constraints faced by the farmers in sustainable farming system

In rice-based farming system, the major constraints faced by the farmers was found to be “Lack of improved technology for rice-based cultivation, difficult to continue rice-based farming due to monsoon change, lack of subsidies and financial support, requirement of higher investment at first cropping were the major constraints reported in rice-based farming system.

In rice-fish farming system, the major constraints faced by the farmers was found to be high irrigation cost, difficult to balance the yield of both rice and fish, difficult to control diseases in rice crop and difficult to harvest rice crop in rice-based cultivation.

In rice-mustard farming system, major constraints faced by the farmers was found to be lack of seeds availability from the agriculture department, moisture stress caused low crop yield, and failure of early sowing due to seeds unavailability.

5.5 Conclusions

- ❖ Majority of the respondents were male, middle age group, nuclear family, medium family size, educated upto secondary level, high experience on rice-based farming, small landholding area, average income of Rs. 55365.00, no training exposure. They had medium level of extension contact, information sources utilization, knowledge level, scientific orientation, innovativeness, risk orientation, market orientation, and they perceived increased temperature during summer.
- ❖ Rice-fish farming system (RFFS) was followed in Thoubal district, Imphal East district and Senapati district. Rice-mustard farming system was followed in Thoubal district, Imphal East district and Churachandpur district. Rice-

vegetables farming system was followed in Senapati district and Churachandpur district.

- ❖ Majority respondents practiced both machine and manual methods in land preparation, used both (local and HYV variety), used organic nutrient management and rainfed water management, practiced cultural control method of weed management, cultural control method pest management, cultural control method diseases management, harvested manually and used crop residue for animal feed and plant nutrients.
- ❖ Majority of the respondents had favourable attitude towards sustainable agricultural practices. Majority of the respondents had medium level of adoption in rice-fish farming system. Majority of the respondents had medium level of adoption in rice-mustard farming system. Majority of the respondents had medium level of adoption in rice-vegetable farming system.
- ❖ Rice-fish farming system had higher sustainable index than rice-mustard farming system and rice-vegetables farming system.
- ❖ Thoubal district, contributed the highest sustainability index followed by Imphal East, Senapati and Churachandpur district.
- ❖ Valley region had higher sustainability score than hill region with sustainability score.
- ❖ Overall sustainability index of rice-based farming system was found to be moderate.
- ❖ The predictors of environmental sustainability had a significant contribution having adjusted R^2 is 0.879 that can explain the environmental sustainability up to 0.88%. The predictors of social sustainability had a significant contribution having adjusted R^2 is 0.949 that can explain the social sustainability up to 0.95%. The predictors of economic sustainability had a significant contribution having adjusted R^2 is 0.929 R^2 that can explain the social sustainability up to 0.93%.

- ❖ Rice-vegetables farming system generated (251 mandays), rice-fish farming system generated (240 mandays) and rice-mustard farming system generated (201 mandays).
- ❖ Rice-fish farming system give higher income and crop productivity.
- ❖ Thoubal district had the highest (Rs 293468.90/ha) net income having highest 4629.89 kg/ha rice productivity with 3.20 BCR under rice-fish farming system.
- ❖ Lack of irrigation source, lack of improved technology, high irrigation cost, difficult to continue rice base farming due to monsoon change, difficult to balance the yield of rice and fish, high irrigation cost, difficult to control diseases in rice crop, lack of seeds availability from the agriculture department, moisture stress caused low crop yield were the major constraints reported in rice-based farming system.

5.6 Policy implications and recommendations

Based on the findings the following policy implications and recommendations are given:

- ❖ Majority of the respondents were educated and middle aged between 35-50 years. Proper training on the sustainable crop production will motivate the farmers and it can step up the productivity by adopting sustainable agricultural practices.
- ❖ Majority of the farmers belonged to small land holding category. Therefore, it is the need of hour to go for aggregation of products and form cooperative farming. Farmer's producer's organizations may also be promoted for reaping higher levels of social and economic sustainability.
- ❖ Training exposure and frequency of use of formal information sources utilization was found low, therefore it is recommended to improve the working relationship and interaction between the research, extension service and farmers.

- ❖ To sustain the productivity of RBFS, it is essential to promote standard techniques of RBFS through locally available resources and the techniques should be cost-effective and environmental friendly.
- ❖ Sustainability and productivity were found to be low in hill region. This yield gap needs to be addressed with an effective extension service to increase the adoption of sustainable agricultural technology.
- ❖ To improve technology adoption, establishing a well-designed interface and user-friendly technology enabled feedback mechanisms to gather input from farmers can significantly enhance adoption rates.
- ❖ Government should take an appropriate action and policy interventions to provide incentives (i.e., input supplies, credit, marketing and irrigation management) for obtaining higher production.
- ❖ Synergistic interaction of the components of rice-based farming system needs to be explored in order to increase the resource use efficiency and recycling of farm by products for enhancing the sustainability of the existing rice-based farming system.
- ❖ To make a rice-fish farming system more sustainable, it is recommended to maximize the use of natural organic fertilizers while minimizing the use of inorganic fertilizers. In case of rice-fish farming system, natural food for fish can be grown simultaneously with rice crops it eliminate the need for feed costs and resulting in lower input costs and higher income of farmers facilitating the transition of smallholder farms from subsistence farming to commercial farming.
- ❖ To optimize farm stability and reduce farmer risk it is recommended that the technical package of rice-based farming system should be integrated with farmers' awareness of resource availability and management.
- ❖ Rice-based farming system provide income throughout the year and generate higher income. Therefore, it is recommended to incorporate strategic

interventions for promoting adoption of climate resilient practices for higher profitability and sustainability.

- ❖ Most of the respondents faced constraints in lack of irrigation source, lack of improved technology for rice-based cultivation, high irrigation cost, lack of seeds availability from the agriculture department. Therefore, it is recommended that the government should initiate the policy of giving technical support for the building of irrigation infrastructure and climate adaptation technologies in addition to collect rain water, runoff water in ponds or ditches near the edge of the field.
- ❖ Extension support services may be strengthened for imparting updated knowledge on climate resilient agriculture and improving the skills of farmers for increased level of adoption of sustainable farming practices thereby enhancing the level of productivity and income.

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APPENDICES

APPENDICES

SUSTAINABILITY OF RICE-BASED FARMING SYSTEM IN MANIPUR: A CRITICAL ANALYSIS

Interview Schedule

Respondent No:

Date of Interview:

House Hold No. /ward No: (M):.....

General Information:

1. Name of the respondent :
2. Name of the village:
3. Name of the CD&RD Block:
4. Name of the district:
5. Year of establishment of the village:
6. Total geographical area of the village:
7. Total cultivable land of the village:
8. Total number of households:
9. Total population:
10. Total number of household involved in Rice cultivation:
11. Type of soil:
12. Longitude and Latitude:
13. Elevation (MSL):

1. Socio-economic and psychological characteristics of rice-based cultivation farmers

1.1. Personal information

- i. Age:..... Yrs, ii. Sex : M /F, iii. Family size:...,
iv. Family type: Joint/Nuclear
v. Education: Illiterate / Primary / Middle / Higher Sec./ Sec./Graduate/PG/ above
vi. Experience in rice cultivation.....,
vii. Occupation: (Tick)

Primary	Tick	Secondary	Tick
1. Agriculture		1. Agriculture	
2. Labour		2. Labour	
3. Government service		3. Government service	
4. Business		4. Business	
5. Entrepreneur		5. Entrepreneur	

1.2 Economic diversification of farmers (Land holding size in acre)

- i. Size of the total land holding :.....acre,
ii. Own land: ...acre /Land leased in : acre;
iii. Land leased out.....acre ,Total : acre
iv. Total Annual Income: Rs.....
Income from different enterprise
v. Income from Agriculture : Rs.....
vi. Income from Business: Rs.....
vii. Income from Service: Rs.....
viii. Livestock: Rs.....
ix. Others (Pl specify) :.....

1.3. Pattern of cost and Income in agriculture

Activity	Main Crop	Crop 1	Crop 2
Name of the crop			
Variety of crop(Tick)	Ind./Imp.	Ind./Imp.	Ind./Imp.
Area production			
Cost incurred Include Implements Manures Fertilizer Plant protection Storage Transportation Any other charges			
Cost of Seeds			
Labours (No.) and cost			
Irrigation and cost			
Manures & Fertilizers (No. Of application and type of fertilizers) and cost			
Pesticides (No. of application) and cost			
Transport cost			
Rate of sale in market Rs. (Per kg)			
Home consumption (Kg/Yr)			
Qty. Sold in market(Kg)			
Income (Rs.)			
Sale through 1. middle man 2. Direct retailer 3. Customer			

1.4 Communication attributes of the farmers

A. Training exposure

i. Have you undergone training related to sustainable farming system cultivation during the last 5 years?: (Y/N). If No.....Why ? Pl tick the appropriate options.

1. You don't require training	2. You have not been selected for training
2. Training is complex	4. Undergoing training will make rice-based farming.

ii. In the past 5 years, how many formal learning/training opportunities have you participated in?

0 1 2 3 4 5 6 7 8 9 10 > 10

iii. Whether training was beneficial to you Yes/No.

Name of the organization imparting training	Year of training	Area / Topic	No. of days	Relevant/usefulness of topic Y/N
State University of Agriculture National Agriculture Extension Centre Private companies NGOs International projects Aid organizations Farmers Field School Local government Research institutions Others				

iv. Do you require more training Yes/ No

v. What are the most important information needs in your farming region? (Tick)

1.	TINM-Farmers require training about INM	
2.	TIPM-Farmers require training about IPM	
3.	TWM-Farmers require training about water management	
4.	TIT-Farmers require training about improved technology	
5.	TRBF-Farmers require training about rice based farming	
6.	TNP-Farmers require training about nursery production	

B. Social Participation

Sl. No.	Do you participate in any of these Organizations/Groups	Yes	No	If yes, what is status/position?
1.	VC / village Panchayat			
2.	Village Development Committee			
3.	SHG			
4.	Farmer's Club			
5.	Farmer's Producer Society			
6.	Any other pl specify			

C. Information Sources utilization:

i. Formal information sources:

S/N	Sources of information	Most often	Sometimes	Never
1.	VEW			
2.	AO SDAO HO			

	SDHO			
3.	KVK professionals			
4.	ATMA professionals			
5.	ICAR			
6.	NGOs			

ii. Informal information sources:

S/N	Sources of information	Most often	Sometimes	Never
1.	Friends			
2.	Relatives			
3.	Neighbours			
4.	Progressive farmers			

iii. Mass-media sources:

S/N	Sources of information	Most often	Sometimes	Never
1.	Radio programmes.....			
2.	Television programmes.....			
3.	Newspapers 1..... 2.....			
4.	Exhibition held at Year			
5.	Print media Poster..... Folder..... Leaflet.....			
6.	Mobile phones or Smart phones WhatsApp Facebook Instagram SMS based services			

D. Extension Contact: Additional information

How often do you contact the extension personnel in your area?

S/N	Extension worker	Frequency of contact			
		Once a month	Once in 15 days	When problem arises	Never
1.	Extension personnel of Agri & allied dept.				

2.	SMS of KVK				
3.	Representatives of private input agencies				
4.	Representatives of cooperative societies				
5.	Representatives of banks				

A set of statements representing are given below. Please state the degree of your agreement (SA- Strongly Agree, A- Agree, UD- Undecided, DA- Disagree, SDA- strongly disagree), about each statement.

1.5 Scientific Orientation: (scale developed by Supe 1969)

S/N	Statements	SA	A	UD	DA	SDA
1.	New methods of farming are considered better than the traditional methods.					
2.	Traditional method of farming is still the best way of farming.					
3.	Even a farmer with lots of experience in farming should use the modern technology.					
4.	Though it takes time for the farmers to learn new method, the effort is worth .					
5.	A good farmer experiments with new ideas of farming.					
6.	Traditional methods of farming have to be changed to improve the standard of living of the farmers.					

1.6. Innovativeness

S/N	Statement	A	UD	DA
1.	I am very much interested in adoption of rice base integrated farming system of sustainability			
2.	Since I am not sure of rice base integrated farming system success, I would like to wait till others adopt			
3.	Since new scientific farming method is not profitable, I am not interested in it.			
4.	I try to keep myself well informed about any new method of farming practices and try to adopt as soon as possible			
5.	New farming method are not easily adoptable and hence I do not adopt			

1.7 Risk Orientation

S/N	Statements	A	UD	DA
1.	A farmer should grow large number of crops to avoid greater risks involved in growing one or two crops			

2.	A farmer should rather take more of a change in making a big profit than to be content with a smaller but less risky profits			
3.	A farmer who is willing to take greater risks than the average farmer usually have better financial condition			
4.	It is good for a farmer to take risks when he knows his chance of success is high			
5.	It is better for a farmer not to try new farming methods, unless most other farmers have used them with success			
6.	Trying an entirely new method in farming by a farmer involves risk, but it is worth			

1.8 Management Orientation

S/N	Statements	SA	A	DA	SDA
	a. Production orientation				
1.	Everyone should think about the income generating activity available to the local areas				
2.	The amount of inputs needed for the economic activity should be assessed well in advance				
3.	It is not necessary to make prior decisions about the steps to be followed in taking up economic activity				
4.	It is not necessary to think ahead the total cost involved in starting income generating activity				
5.	One should not consult experts and experience persons for planning the economic activities				
6.	It is possible to increase the returns through production plans				
	b. Marketing orientation				
1.	Marketing information is not much necessary to rice base farming system.				
2.	A farmer can get a good price by producing good quality of crops.				
3.	Better market facilities can help the rice base farming farmers to get a better price for his produce.				
4.	One should sell his product to the nearest market irrespective of prices.				
5.	One should cultivate other crops instead of rice base farming system which has more demand in market.				
6.	A farmer should cultivate more for crops he gets subsidy rather than market demand.				

1.9 Farmers perception towards climate change impact (indicator used by Asrat, P. and Simane, B. 2018)

a. Do you feel changes towards climates variables (rainfall, temperature, flood, drought)?
Y/N. If Yes, mark the following

S/N	Incidence	Tick	
		Perceived	Not Perceived
1.	Frequent drought		
2.	Frequent flood		
3.	Increased temperature during summer		
4.	Heavy hailstorm		
5.	Frequent cold wave		
6.	Frequent heat wave		
7.	Decrease temperature during winter		
8.	Heavy rainfall		
9.	Unseasonal rainfall		
10.	Low rainfall during rainy season		
11.	Windy		
12.	Monsoon shifting		

1.10 Knowledge on sustainable agricultural practices

S/N	Factors	Dimensions of Sustainability practice	Tick (If you followed the practices)	
			Yes	No
1.	Agronomic practice	Improved variety		
		Crop rotation		
		Intercropping		
2.	Soil and water conservation	Conservation tillage		
		Water harvesting in ponds		
		Mulching		
3.	Nutrient Management	Plantation of cover crop		
		Green manure		
		Organic fertilizer		
4.	Agroforestry	Agri silviculture		
		Silvipastoral		
5.	Restoration and rehabilitation	Enrichments planting		
		Fire Management		
		Natural Regenerations		
6.	Pest control method	Physical control		
		Biological control		
		Cultural control		

7.	Diseases control method	Physical control		
		Biological control		
		Cultural control		
8.	Recycle management	Field waste		
		Animal waste		
		Plant waste		

2.Cropping pattern and farm resource management under rice-based farming system followed by the respondents.

2.1 Do you follow any cropping pattern in your farm? If Yes tick from the following table.

Cropping patterns	Types of crop	Cultivation method
I. Monocrop		
II. Mixed cropping		
III. Intercropping		
IV. Crop rotation		
V. others		

2.2 Do you followed the given practices? If yes pl tick

S/N	Particulars	Yes	No
1.	Land preparation - Only Manual - Both (Machine & manual)		
2.	Variety of crop - Only local indigenous - Only HYV - Both (local & HYV)		
3.	Nutrient Management - Only Organic - Both (Chemical & organic)		
4.	Water management - Rainfed - Both (rainfed & irrigated)		
5.	Weed management - Manual - Chemical control - Cultural control		
6.	Pest management - Chemical control - Biological control - Physical control - Cultural control		
7.	Diseases management - Chemical control - Biological control - Physical control - Cultural control		

8.	Harvesting - Manual - Machine - Both (Manual & machine)		
9.	Post harvest management - Not process for sell - Process and refine for sell		
10.	Crop residue management - Surface mulch & in situ incorporation of residues in soil - Crop residue as feed and plant nutrients		

2.3 If you follow any type of the following Cropping patterns please give the details given

Farming type	Yield/ha	Productivity	Gross Income	Investment	Waste recycle
Rice-Fish					
Rice-Mustard					
Rice-vegetable crop					
Others					

in the under following columns?

2.4 Describe about the sustainable farming practices on the farming system you followed in your farm?

3.Measure the attitude and extent of adoption of sustainable rice-based farming

3.1 Attitude towards adoption of sustainable agriculture practices (Scale developed by Thangjam, B. 2023 following Likert technique)

S/N	Statement	SA	A	UD	DA	SDA
14.	Farmers should not use excessive chemicals fertilizers to avoid harmful effect on environment. (+)					
15.	Government should make strict rules to act on the farmer who waste the natural resources. (+)					
16.	Farmers should always protect natural resources at the earliest as it belongs to all generations. (+)					
17.	Agriculture will be sustainable by attracting young farmers to take up a career in farming. (+)					
18.	In my village most of the farmers believed utilization of chemical fertilizers give better crop yield. (-)					

19.	Sustainable agricultural practices are costly and can be only adopted by rich farmers. (-)					
20.	Agricultural practices of my village are not concern about health and natural resources. (-)					
21.	In my village the farmers who practice sustainable farming system have a quality life. (+)					
22.	I look forward to participate in training and demonstration on sustainable technologies for adoption (+)					
23.	I follow Integrated farming practices to maintain cash flow throughout the year and increase sustainability. (+)					
24.	There is a lack of social support regarding environmental issues and its protection. (-)					
25.	I am not aware about the importance of natural resource conservation in agricultural practices. (-)					
26.	Cultivation without chemicals gives nutrients rich food and good health in the society. (+)					

3.2 Measure extent of adoption of sustainable rice-based farming

3.2.1 Adoption level of sustainable agriculture practices

i. Do you adopt the sustainable agriculture practices?

S/N	Dimensions of sustainable practices	Adopt	Not adopt
1	Animal manure		
2	Compost/crop residue		
3	Nitrogen fixing crop		
4	Cover crop plantation		
5	No-till farming		
6	Contour farming		
7	Terrace farming		
8	Crop rotation		
9	Mulching		
10	Drought tolerant crop		
11	Rain water harvesting		
12	Recycle water		
14	Selection of diseases free seeds		
15	Biological control		
16	Timely plantation		

17	Resistant varieties		
18	Physical control		
20	Maintain crop diversity		
22	Manual weeding		
23	Weeding by harrow or trowel		
24	Ploughing to get ride weed before seeding		
25	Reforestation		
26	Regeneration planting		

ii. Do you adopt sustainable rice-fish farming system (RFFS)?

S/N	Practices for sustainable farm management	Full	Partia l	Nil
1.	Farm site selection -Medium deep/deep-water lowland rice ecologies, free from heavy flooding having clay soil and prolonged water retention capacity is preferred. A rectangular or a square shaped field with an area of half to one ha and more is desirable			
2.	Field design -Field design include bund (dykes 0.5-1.0 m wide) all around (5% of the area), pond or water refuge connected with trench on two sides (10% of area) and rice fields (85% of the total area), guarded with water inlets and outlet. Embankments should have a height of 40-50 cm depending upon the depth of the rice fields.			
3.	Construction -The dyke should have sufficient height to prevent fish from jumping over and escaping to the other rice fields. In the outlet, provision of wires and screens can be provided to prevent escape of fishes from the rice fields and to prevent entry of predatory fishes to the field. All around the field in the bund area, a 1.5 meter height of nylon net can be fixed with positioning bamboo poles to prevent foraging of ducks in the adjoining rice fields and to prevent outside predators entering to the rice field area			
4.	Fish Species - Catla, silver carp, column feeder-rohu, bottom feeder - mirgal and common carp, vegetation feeder and prawn juveniles.			
5.	Flooding and weeding of rice - Water level should be maintain about 0.5 meter deep and minimum of 1 meter. Weeding may be done once or grass carp can be stock after 15 days of transplanting.			
6.	Fertilization of rice - Apply FYM/manure (Cowdung or organic matter) 25 tonnes/ha as a basal application. Inorganic NPK 50 kg/ha.			
7.	Stocking of fish seeds - Fish may be stock after 1 week of rice transplantation. 1cm fingerlings (Carp/Tilapia) may be stock, average 3000-4000 fish fry density.			
8.	Water quality monitoring - Optimal pH level should range 7.5-8.5.			
9.	Harvesting time - Fish must be harvested before a week of rice harvesting.			

	Harvest fish 70-100 days.			

iii. Do you adopt sustainable rice-mustard farming system (RMFS)?

S/N	Practices for sustainable farm management	Full	Partial	Nil
1.	Selection of varieties: Toria- M-27, Local- Yella Mustard- pusa bol			
2.	Seed rate: Mustard- 6 kg/ha or 1.5 kg/sangam Toria- 8 kg/ha or 2 kg/sangam			
3.	Land preparation: Zero tillage			
4.	Sowing time: October to November.			
5.	Fertilizer management: Apply 10-15 t/ha or 2.5 to 3.8 t/ sangam of FYM at the time pf final land preparation. Fertilizers @ N : P ₂ O ₅ : K ₂ O – 60: 30: 30: kg/ha			
6.	Diseases management Cultural Method- Selection of field area, selection seeds, time of sowing, crop rotation, eradication insect vectors or others Physical method- seed treatment			
7.	Pest management: Physical method of pest control: Use of trap, security men, hunting or others, tillage, grazing, fire or others Biological method of pest control: Use of natural enemy to control population of grasshoppers and nematodes , Integrated pest Management technique or others Cultural method of pest control: Crop rotation, crop isolation, planting density and spacing, mixed cropping, inter- and intra- crop diversity, timing of seeding and planting, replacement of alternate hosts , management of nursery crops, management of surrounding environments and timing of harvesting/ others			
8.	Weed management: Hand weeding and thinning should be done			
9.	Water management: Rapeseed and Mustard are usually raised as rainfed however if available irrigation be given at the interval of 30,55 and 75 days of sowing			
10.	Harvesting time: Rapeseed and Mustard is harvested as soon as the pods turn yellowish brown			

iv. Do you adopt sustainable rice-vegetables farming system (RVFS)?

S/N	Practices for sustainable farm management	Full	Partial	Nil
1.	Selection of crops: Cabbage, pea, cauliflower, potato and colocasia.			
2.	Seed rate: Recommended seed rate of the particular crops by KVK Potato: 13-18 q/acre seed tubers of 40-50 g weights Cabbage: 200-250 g seed is sufficient for one acre area. Pea: Seed rate is 45 kg for early maturing varieties and 30 kg for main season varieties per acre Cauliflower: 250 g per acre, whereas, for early season varieties 500 g seed per acre.			
3.	Land preparation: Clean the field after harvesting paddy, 2-3 times of deep plough, planking is done during the last ploughing to make friable soil bed for transplanting. Raised beds of 1 m width, 4-5 m length and 30 cm above the soil are prepared.			
4.	Sowing time: Late sowing from mid-October to mid-November			
5.	Fertilizer management: Potato: Twenty tonnes of farmyard manure or green manuring alongwith 75 kg of N (165 kg of Urea), 25 kg of P ₂ O ₅ (155kg of Single Superphosphate) and 25 kg of K ₂ O (40 kg of Muriate of Potash) per acre should be used. Application of paddy straw mulch @ 25 q/acre saves 18 kg nitrogen. Pea: Apply 8 tonnes of farmyard manure, 20 kg of N (45 kg Urea) and 25 kg P ₂ O ₅ (155 kg Superphosphate) per acre before sowing Cauliflower & Cabbage: 40 tonnes of farmyard manure, with 50 kg of N (110 kg of Urea), 25 kg of P ₂ O ₅ (155 kg of Single Superphosphate) and 25 kg of K ₂ O (40 kg of Muriate of Potash) per acre is the optimum fertilizer dose for all varieties.			
6.	Diseases management Cultural Method- Selection of field area, selection seeds, time of sowing, crop rotation, eradication insect vectors or others Physical method- seed treatment, use disease free seed tubers, use of FYM decreases the disease incidence, regular monitoring of young plants, picking and destruction of the larvae at the early stage of the crop.			

7.	Pest management: Physical method : Use of trap, security men, hunting or others, tillage, grazing, fire or others Biological method: Use of natural enemy to control population of grasshoppers and nematodes , Integrated pest Management technique or others Cultural method : Crop rotation, crop isolation, planting density and spacing, mixed cropping, inter- and intra- crop diversity, timing of seeding and planting, replacement of alternate hosts , management of nursery crops, management of surrounding environments and timing of harvesting/ others			
8.	Weed management: Hand weeding and thinning should be done. Potato: Application of paddy straw mulch @ 24 q/acre immediately after planting provides affective control of annual weeds Pea: The field should be kept free from weeds by giving two hoeings after four and eight weeks of germination respectively. Cauliflower & Cabbage: 1-2 times of hand weeding			
9.	Water management: Potato: The total number of irrigations will be 7-8 Pea: First irrigation should be given after 15 days of sowing. Next irrigation should be given at flowering and then at fruit set if necessary. Cauliflower & Cabbage: The total number of irrigation required are 8-12.			
10.	Harvesting time: Harvest the crop at the proper edible maturity			

4.Sustainability of rice-based farming system.

4.1 SUSTAINABILITY INDEX

1) Economic dimension

1.1 Resource use:

Category	Cost	Return	Profit		
			2018	2019	2020
Farm inputs cost					

1.2 Access to funding and financial services

- Do you get farm inputs from near by market? Y/N.....
- Do you have any debt? Y/N.....
- Do you get financial support from the government? Y/N.....

- d. Do you get loan from bank? Y/N.....
- e. Do you received farm input at subsidies rate?Y/N.....
- f. Do you received crop insurance? Y/N.....
- g. Do you satisfy your farm return? Y/N.....
- h. Are you availing any loan and subsidy from banks and government schemes? Y/N

1.3 Productivity:

- a. Can you please recall the total quantity of produced on your farm during the last 5 years?

Items	2018	2019	2020
Area under different crops/enterprises			
Production			
Productivity			

1.4 Profitability:

Type of crop / enterprise	Total area	Yield	Rate of sale in market (Rs.)	Total income (Rs.)	Net income (Rs.)	Profit/unit

1.5 Accessibility of market

- a. Do you follow proper marketing linkages? Yes: ____ No: ____
- b. Do you sell your produce yourself? Yes: ____ No: ____ (if yes, price per kg: ____)
- c. Do you sell your produce through middleman? Yes: ____ No: ____ (if yes, price per kg: ____)
- d. Do you sell your produce directly to wholesaler/consumer? Yes : ____ No: ____ (if yes, price per kg: ____)
- e. Do you use any ICT tools for marketing your product? Yes : ____ No: ____ (if yes, pl tell the tools: ____)
- f. Do you sell your product in the market? Yes : ____ No: ____ (if yes, pl tell the type of the product you sell in the market?

2. Environmental dimension

2.1 Soil organic matter

Do you apply organic matter in your field for sustainable rice base farming system?
Yes/ No

If yes, which of the following do you use?

Sl. No.	Type of organic matter	No of times applied in a season	Total amount applied (kg/bigha)
1.	Cow-dung manure		

2.	Mulches made of dried leaves and paddy straw		
3.	Poultry litter		
4.	Vermicompost		
5.	Green manure or compost		
6.	Neem oil cake		
7.	Others		

2.2 Water conservation measures:

Do you conserve water for irrigation purposes? Yes/ No

If yes, which of the following means do you practice?

Sl. No.	Conservation measures	Yes	No
1.	Harvest rainwater		
2.	Set up well in the field		
3.	Set up bore well in the field		
4.	Source out water from nearby stream/ river		
5.	Store water in Jalkhund/pond/tank		
6.	Others		

2.3 Drainage system

Do you maintain drainage system in your field to prevent stagnation of water?

Yes/ No

2.4 Soil erosion

Sl. No.	Statements	Yes	No
1.	Do you prepare proper trenches in your field to prevent soil erosion?		
2.	Do you construct proper trenches in your field?		
3.	Do you leave crop residues on the soil surface after harvest to conserve the soil?		
4.	Do you mulch with black polythene to prevent soil erosion?		
5.	Do you mulch with black dry leaves and grasses to prevent soil erosion?		
6.	Do you plant trees/shrubs surrounding your field to decrease the magnitude of splash erosion?		

2.5 Biodiversity in field

Sl. No.	Statements	Yes	No
1.	Do you preserve beneficial insects like ladybird, bees, spider, etc in your field?		
2.	Do you plant beetle nut trees, neem trees and other herbaceous trees surrounding your large cardamom field?		

2.6 Use of pesticide/fungicide/herbicide/insecticide

Do you apply pesticide/insecticide in your field during large cardamom cultivation?

Yes/No

If yes, give the following details:

S/N	Pesticide/fungicide/herbicide/insecticide	Dosage	No. of times applied

2.7 Crop rotation

Do you practice crop rotation in your field? Yes/ No

If yes, which are the crops used in crop rotation? _____

2.8 Integrated Nutrient Management (INM) which of the following are used by you in your field?

S/N	Nutrients	Dosage	No. of times applied
1.	Urea		
2.	DAP		
3.	Superphosphate		
4.	Rock phosphate		
5.	Murate of potash		
6.	Farm Yard Manure		
7.	Vermicompost		
8.	Oil cakes (Neem, castor)		
9.	Green manuring (cowpea, sunhemp, etc)		

10.	Biofertilizers (azotobacter,		
11.	Azolla		
12.	Any other		

2.9 Integrated Pest Management (IPM)

For pest management, do you practice Integrated Pest Management (IPM)? Yes/ No, If yes, do you follow the following and give details.

S/N	Management	Yes	No	If yes, no of times practiced in season/ Dosage
1.	Weeding			
2.	Infected plants and plant parts removed			
3.	Cover crops are planted			
4.	Rat traps and sticky insect traps are prepared			
5.	Cowdung slurry, neem cake/ tobacco solution is prepared			
6.	Drainage system is well maintained			
7.	Suckers are treated with <i>trichoderma</i>			
8.	Trap crops are planted			
9.	Any others			

2.10 Recycling of nutrients

Do you recycle the waste in your field? Yes/No, If yes, do you follow these practices?

S/N	Practice	Yes	No	If no, why
1.	Setting up vermicompost pit			
2.	Setting up compost pit			
3.	Farm Yard Manure (FYM) is prepared			
4.	Pineapple leaves are used as mulch			
5.	Dry leaves and grasses, paddy straw, weeds are used as mulches			
6.	Poultry litter is utilized as manure			
7.	Any others			

3. Social dimension

S/N	Statements	Yes	No
1.	Formation of SHG		
	a. Are you a member of any SHG?		
	b. Are you actively involved in the activities of your SHG?		
2.	Formation of Co- operative societies		
	a. Are you a part of any co-operative societies?		
	b. Are you actively involved in the activities of your society?		
3.	Formation of FPOs		
	a. Are there any FPOs in your locality?		
	b. Are you a member of the FPO?		

3.1 Information Self-Reliance

Mention the extent of dependency for information on the following areas on yourself and others

Information areas	Source of information		
	Self	Partly others	Others
1. Selection of suitable seeds/ planting material			
2. Time of sowing			
3. Soil management practices			
4. Manures and fertilizers			
5. Use of bio-fertilizers			
6. Plant protection			
7. Weed management			
8. Water management			
9. Harvesting			
10. Storage			

11. Marketing			
12. Tools and implements			

3.2 Access to latest knowledge of sustainable rice base integrated farming

S/N	Are you getting any information/knowledge on sustainable large cardamom cultivation practices from	Yes	No	If yes, how many times during the last 5 years
1.	Extension agencies from Horticulture department			
2.	KVK			
3.	ATMA			
4.	CIH			
5.	Farmers' Association			
6.	Mass media (Newspaper/ Television/Magazine/ SMS/ Mobile apps			
7.	Training/ Seminar/ Workshop/ Field trip			
8.	Friends			
9.	Neighbour			

3.3 Women Involvement in farm activities

- Does your family women involve in farming activities? Yes/No
- Does women get equal wages with man? Yes/No

3.4 Food availability

- Are you able to afford food for your family whole year round?
- Are you able to provide nutritious food to your family

3.5 Are you able to send your children to school with the profit earned from farming?
Yes/No If yes what are the source of income?.....

3.6 Are you able to utilize the profit from farming to pay your home expenses?

1.5 Dependency on external labour:

S/N	Number of labour hired (Male & female)	Charge of labour/day	Total working days	Total cost (Rs.)

4. Employment generation from livelihood enterprises under rice-based farming system

4.1 Mandays generated

S/ N	Years	Category Male/Female	Charge of labour/day	Total working days/annum	Total cost (Rs.)
1.	2018				
2.	2019				
3.	2020				
4.	2021				

4.2 Diversity of production

List of cultivated crop	Type and method of cultivation	Income

4.3 Livelihood sources of the farmers

a. Status of farmers livelihood

Source of livelihood	Reason for selecting	Profit from the selected option	Problem faced	Competition of livelihood	Standard of living	Satisfaction Yes/No

5. Constraints faced by the farmers in sustainable rice-based farming system

5.1 Constraints faced by the respondents under sustainable rice-based farming system

S/N	Statements	Low (1)	Medium (2)	High (3)
1.	Lack of irrigation source			
2.	Lack of improved technology for rice-based cultivation			
3.	Difficult to continue rice base farming due to monsoon change			
4.	Lack of government subsidies and financial support			
5.	Requirement of higher investment at first cropping			

6.	Lack of training and awareness about the sustainable farming practices			
7.	Lack of technical guidance about soil nutrient and water management			
8.	Unavailability of farm inputs distributed by departments			
9.	Farm inputs cost are high			
10.	Difficulty to control infested diseases and pests			
11.	This farming practice required larger land holding area			
12.	Agronomical practices need to be observed carefully and regularly			

5.2 Constraints faced by the respondents in sustainable rice-fish farming system

S/N	Statements	Low (1)	Medium (2)	High (3)
1.	Increased irrigation cost			
2.	Difficult to balance the yield of both rice and fish			
3.	Difficult to control diseases in rice crop			
4.	Difficult to harvest rice crop in rice-based cultivation			
5.	Initial field preparation required large investment			
6.	Difficult to eliminate excessive mosses			
7.	Due to increase ammonia level at rice reproductive stage reduced rice yield			
8.	Predator or thieves reduced the fish stock			
9.	Prolong water exposure on soil caused lodging in rice crop			
10.	Difficult to control flood during rainy season			
11.	Construction of bunds and ponds wasted cultivable land			

5.3 Constraints faced by the respondents under sustainable rice-mustard farming system (RMFS)

S/N	Statements	Low (1)	Medium (2)	High (3)
1.	Lack of seeds availability from the agriculture department			
2.	Low crop yield			
3.	Failure of early sowing due to seeds unavailability			
4.	Lack of knowledge on crop residue management			
5.	Unable to identify good quality seeds for oil production			
6.	Unavailability of fertilizer during the season			
7.	Low germination due to moisture stress			
8.	Less oil contain			
9.	Late sowing caused increases of diseases infestation			
10.	Predators like cow damaged the crop			
11.	High labour cost			

PLATES



Plate 8: Data collection activities



Plate 9: Field visit for observation and records



Plate 10: Field structure of rice-based farming system



Plate 11: Farmers activities in the field