

MAPPING OF SALI RICE AREAS OF MEGHALAYA USING REMOTE SENSING AND GROUND BASED OBSERVATIONS

(Based on Resourcesat 2A LISS-IV data of 2017-18)



Sponsored by
Directorate of Agriculture
Government of Meghalaya, Shillong.



North Eastern Space Applications Centre
Department of Space, Government of India
Meghalaya, Umiam-793103

Mapping of Sali rice areas of Meghalaya using Remote Sensing, GIS and ground based observations

(Based on Resourcesat 2A LISS-IV data of 2017-18)

**Sponsored by
Directorate of Agriculture, Government of Meghalaya
Shillong**

**North Eastern Space Applications Centre
Department of Space
Government of India
Umiam, Meghalaya**

August, 2019

2019

© All rights reserved

North Eastern Space Applications Centre
Department of Space, Govt. of India, Umiam, Meghalaya

&

Directorate of Agriculture, Government of Meghalaya, Shillong

Printed at
Eastern Panorama Press, Shillong

North Eastern Space Applications Centre Document Control Sheet

Document No	NESAC-SR-199-2019
Security classification	Unrestricted
Title	Mapping of Sali rice areas of Meghalaya using Remote Sensing, GIS and ground based observations
Type of Document	Project Report
Number of Pages	
Authors	Project team
Approved by	Director, NESAC
Sponsored by	Directorate of Agriculture, Govt. of Meghalaya, Shillong
Abstract	<p>The project was undertaken at the instance of Directorate of Agriculture, Govt. of Meghalaya, Shillong, with three major objectives i) Identification and mapping of Block wise sali paddy (winter rice) areas in Meghalaya using remotely sensed data, GIS techniques and ground based observations at 1:10,000 Scale, ii) Stratified analysis of sali rice growing areas (Ecosystems) by systematic physiographic analysis of the terrain, iii) Development of block wise, geo referenced base maps consisting of road network and village location,. The project was carried out at NESAC with support from Directorate of Agriculture (DoA), Govt. of Meghalaya, Shillong, during field verification. The study gives an example that geospatial technology is very useful in identifying sali rice (winter rice) areas which size is more than 0.01ha. The study revealed that sali rice cultivation is distributed in all 39 blocks of 11 districts of Meghalaya covering 1027.9 Sq. Km area which is 4.6% of the total geographical during 2017-18. The study shows that sali rice cultivation is highest in Selsella block of West Garo Hills district followed by Betasang and Zikzak block of South West Garo hills district. It is also found that cultivation of low altitude rice is highest in the state that cover 64.2% area followed by mid altitude (20%) and high altitude rice (15.8). The low altitude rice is grown in all districts of the state. The high altitude rice is grown only in 5 districts of Khasi and Jaintia hills where as medium altitude rice is grown in all districts except North Garo, South Garo and South West Garo hills districts.</p>
Distribution	NESAC and DoA guidelines
Reproduction Rights	The report and its content is property of NESAC/DoA and shall not be reproduced in part or whole without the written permission of Director, NESAC and Director of Agriculture, Govt. of Meghalaya.

PROJECT TEAM

NESAC, Shillong

Shri PLN Raju, Director, NESAC

Ms Pratibha Thakuria Das, Sci/Engr.'SE'

Ms. Priyanka Longmailai, Project Assistant

Mr. Ranjit Singh, Project Assistant

Mr. Dharmendra Kumar Jha, Project Assistant

Mr. Bipul Saikia, Project Assistant

Directorate of Agriculture, Shillong

Smt. B.N.War, Director of Agriculture

Smt. S. Mihsil, Director MAMETI

Research Officers of East Khasi Hills, West Jaintia Hills and West Garo Hills

Shri Ian Saiborne, Assistant Director of Agriculture (Soil Survey)

Smt. V. Rynthlei, Horticulture Officer (FP)

Smt. L. Kharkrang, Deputy Director of Agriculture (Planning)

Shri W. Pakyntein, District Agriculture Officer, Ri-Bhoi

Smt. T.Shylla, Agriculture Information Officer

Shri C.S. Shabong, Assistant Director of Agriculture (Info)

EXECUTIVE SUMMARY

The economy of Meghalaya is mainly depends on Agriculture. Even though, 81% of the state's population depends on agriculture, the net cropped area is very less and it is only about 12.8% of the total geographical area of the state. Amongst different crops, rice is a major food crop of Meghalaya occupying an average annual area of 111178 ha with total production of 301076 Metric Tons during the period 2016-17. However, food security is uncertain, as current annual rice consumption has exceeded annual rice production. The food grains produced in the state is not sufficient to feed a population of 2.9 million. To bridge the deficit, the Government of Meghalaya launched the Meghalaya State Rice Mission (MSRM) in the year 2013, consisting of an integrated set of programs aimed at narrowing the gap between rice production and consumption by doubling the production of rice - a major staple food of the state. One major objective of the mission is to map the spatial distribution of rice ecosystem by using Remote sensing & GIS technique for prioritization and planning. Therefore, Directorate of Agriculture has proposed to create scientific database on Sali rice areas (Winter Rice) which will be utilised by the department of agriculture for planning, targeting and increasing production and productivity of sali rice in order to promote food security goals of the State. Based on the requirement of Directorate of Agriculture, Govt. of Meghalaya, NESAC has taken up the project on mapping of block wise sali rice (winter rice) areas of Meghalaya using remotely sensed data, GIS techniques and ground based observations.

The sali rice areas has been mapped by using standard visual interpretation technique. Resourcesat-2A Ortho rectified LISS IV (multispectral) image of year 2017-18 and CartoDEM (10m) has been used for the study. The map has been verified with field data collected from 350 locations covering the entire state, high resolution Kimsat image (multispectral) and Google images. The map has been finalised in consultation with the user department. The village location map has been prepared by using Google earth images and Soil Health Card data. The road network map was prepared from Komsat satellite images by following visual interpretation technique.

The study shows that in Meghalaya, sali rice is cultivated in 102574.3 ha area which is 4.6% of the total geographical area. Sali rice is cultivated in all 39 blocks of 11 districts of the state. Amongst 11 districts of the state, sali rice cultivation is highest in West Garo Hills district that cover 21.9 % of the total sali rice growing areas where as the lowest area i.e 2117.5 ha (2.1%) is found in South West Khasi Hills district. Selsella block of West Garo Hills district is having the highest sali rice growing areas followed by Betasang and Zikzak block. The lowest area is found in Pynursla block followed by Gambegre, Ranikor, Myllem Shella Bholaganj block. From accuracy assessment it is found that the accuracy of the mapping is 90%. The 10% error in the mapping is due to misclassification of the vegetable growing areas and rice fallow land as sali rice. The vegetable growing areas and rice fallow lands adjacent to sali rice fields are situated in the same physiographic condition and field size is smaller than 0.01 ha has contributed to mapping error.

Based on size of each polygon representing rice fields, the polygons were classified into 7 groups viz. 0.01-0.05 ha, 0.05-1ha, 1-2 ha, 2-4 ha, 4-10 ha, 10-100 ha and >100ha. It is observed that maximum areas under rice fields are in the class of 10-100 hectares. It is also observed that even though number of polygon is highest in the class of 0.05-1 ha and 1-2 ha but total area is less compared to other classes. It is found that rice fields with >10ha area is found highest in West Garo hills district and rice fields size between 2-10ha are found highest in West Khasi hills followed by West Garo and West Jaintia hills districts. Marginal to small fields are found highest in West Khasi hills and West Jaintia hills districts.

Based on rice growing ecosystem of Meghalaya, it is found that cultivation of low altitude rice is highest in the state that cover 64.2% area followed by mid altitude (20%) and high altitude rice (15.8%). It is also observed that the low altitude rice is the highest in West Garo Hills district and lowest in the South West Khasi hills district. Mid altitude rice is highest in West Jaintia Hills and Ribhoi district where as high altitude rice is found only in 5 districts of Khasi and Jaintia hills.



DIRECTORATE OF AGRICULTURE
Government of Meghalaya

Smt. B.N. War
Director

FORWARD

The Department of Agriculture has been continuously striving to narrow the gap of food grains, specially rice production and consumption, through multi dimensional approaches, of which technology intervention, being one of the key components towards reaching this major goal.

Based on the Meghalaya State Rice Mission document prepared by Dr.Sushil Pandey, Ex. Agricultural Economist, International Rice Research Institute (IRRI), Los Banos, Manila, Philippines, the report states that "Sali rice is widely grown throughout the State and, hence, the production growth of Sali rice clearly, will be very important for achieving the mission targets". Since Sali rice (winter) constitute the main rice season, with an estimated area of 63,601 hectares and annual production of 1,58,920 Metric Tonnes (2015-16), hence one of the major mission goal is oriented towards achieving the targeted increase in Sali rice production, which constitutes maximum area under rice rainfed ecosystem found in Meghalaya.

In this context, mapping out the size and spatial distribution of Sali rice ecosystem for prioritising and targeting, being the 1st mini

August 1, 2019

mission goal, utilising latest GIS and Remote Sensing tools and techniques, is critical for development and implementation of rice productivity program in a scientific manner. Precise Mapping of Sali Rice areas in the State, based on geography and rice ecosystem is a major step in the right direction for preparation of a detailed and accurate database for planning and implementation.

I express my thankfulness to all the Officers of the Department of Agriculture who have contributed towards the project formulation, planning, field investigation and final preparation of this report for their dedication, hard work and sincerity. I am also grateful to the Director of NESAC, Shri. P.L.N. Raju and the team of dedicated Scientists whose expertise and resources have made this scientific and detailed report possible within the project timeline.

Finally, I am optimistic that the key findings of this report will help the department to plan, strategies and implement the Rice Mission Scheme with better targeted and precision based approach in order to achieve the goal of increased production and productivity of rice in the State.

Smt. B.N.War

उत्तर पूर्वी अंतरिक्ष उपयोग केंद्र
भारत सरकार, अंतरिक्ष विभाग
उमियम- 793103, मेघालय
दूरभाष: 0364-2570141, 257014
फैक्स: 0364-2570043
ईमेल: director@nesec.gov.in

PLN RAJU
Director

PREFACE

It is a matter of great satisfaction that the project titled “Mapping of Sali rice areas of Meghalaya using Remote Sensing, GIS and ground based observations” is taken up and successfully completed by NESAC, Department of Space, Government of India at the specific request of Directorate of Agriculture, Govt. of Meghalaya, Shillong. The project demonstrated the use of remote sensing data, GIS and ground truth data in delineating the sali rice areas, characterization of rice fields based on physiographic condition and size of individual fields and generating village level information.

The sali rice areas has been mapped from Resourcesat-2A Ortho rectified LISS IV (multispectral) image of 2017-18 by using standard visual interpretation technique. Digital Elevation Model prepared from Cartosat images has been used for characterizing the sali areas. The map has been verified with field data collected by visiting different places of the state, high

August 1, 2019

NORTH EASTERN SPACE APPLICATIONS CENTRE

Government of India, Department of Space

Umiam - 793 103, Meghalaya


Tele : 0364 -2570141, 25701

Fax: 0364-2570043

email: director@nesec.gov.in

resolution foreign satellite images (Komsat) and Google images. The map has been finalised by incorporating the feedback of the user department. The village location map has been prepared from Google earth images and Soil Health Card data. The road network map has been prepared from very high resolution satellite images by following visual interpretation technique.

Application of geospatial techniques for mapping of sali rice at 1:10,000 scale has been attempted for the first time in the state. The project output will provide valuable information for the user department. This Atlas contains the maps and statistics generated as the project output along with the description of methodology adopted and results observed. I am sure the Atlas will serve as a useful document for planning, targeting and increasing production and productivity of sali rice in the state of Meghalaya.


(PLN Raju)

ACKNOWLEDGEMENTS

The project team would like to extend its sincere gratitude to Director NESAC for all assistance extended to the project and Director of Agriculture, Directorate of Agriculture, Govt. of Meghalaya, Shillong who has entrusted the responsibility of executing this project on Identification of block wise sali paddy (winter rice) areas in Meghalaya using remote sensing GIS and ground based observations to North Eastern Space Applications Centre. The project team is indebted to Smt. B.N. War, Director of Agriculture for her keen interests and whole-hearted support. Sincere appreciation extended to Shri PLN Raju, Director, NESAC for his support and guidance throughout the project period. Sincere support and help extended by the Research Officers of East Khasi Hills, West Jaintia Hills and West Garo Hills is

hereby acknowledged. The technical assistance provided by Shri Ian Saiborne, Assistant Director of Agriculture (Soil Survey), Smt. V. Rynthlei, Horticulture Officer (FP), Smt. L. Kharkrang, Deputy Director of Agriculture (planning), Shri W. Pakyntein, District Agriculture Officer, Ri-Bhoi, Shri C.S. Shabong, Assistant Director of Agriculture (Info) is duly acknowledged. The supported extended by all the District Agriculture Officers of the State towards the project during field visits by the team from NESAC is also placed on record. Finally the project team would like to thank Shri. Gopi Saddala, Sr. Consultant GIS, Hyderabad for providing valuable inputs during project formulation and all the Scientists/Engineers of NESAC and other staff members for their support and help in successful completion of the project.

Pratibha

Pratibha Thakuria Das

Project Investigator

PROJECT TEAM

NESAC, Shillong

Shri PLN Raju, Director, NESAC

Ms Pratibha Thakuria Das, Sci/Engr.'SE'

Ms. Priyanka Longmailai, Project Assistant

Mr. Ranjit Singh, Project Assistant

Mr. Dharmendra Kumar Jha, Project Assistant

Mr. Bipul Saikia, Project Assistant

Directorate of Agriculture, Shillong

Smt. B.N.War, Director of Agriculture

Smt. S. Mihsil, Director MAMETI

Research Officers of East Khasi Hills, West Jaintia Hills and West Garo Hills

Shri Ian Saiborne, Assistant Director of Agriculture (Soil Survey)

Smt. V. Rynthlei, Horticulture Officer (FP)

Smt. L. Kharkrang, Deputy Director of Agriculture (Planning)

Shri W. Pakyntein, District Agriculture Officer, Ri-Bhoi

Smt. T.Shylla, Agriculture Information Officer

Shri C.S. Shabong, Assistant Director of Agriculture (Info)

EXECUTIVE SUMMARY

The economy of Meghalaya is mainly depends on Agriculture. Even though, 81% of the state's population depends on agriculture, the net cropped area is very less and it is only about 12.8% of the total geographical area of the state. Amongst different crops, rice is a major food crop of Meghalaya occupying an average annual area of 111178 ha with total production of 301076 Metric Tons during the period 2016-17. However, food security is uncertain, as current annual rice consumption has exceeded annual rice production. The food grains produced in the state is not sufficient to feed a population of 2.9 million. To bridge the deficit, the Government of Meghalaya launched the Meghalaya State Rice Mission (MSRM) in the year 2013, consisting of an integrated set of programs aimed at narrowing the gap between rice production and consumption by doubling the production of rice - a major staple food of the state. One major objective of the mission is to map the spatial distribution of rice ecosystem by using Remote sensing & GIS technique for prioritization and planning. Therefore, Directorate of Agriculture has proposed to create scientific database on Sali rice areas (Winter Rice) which will be utilised by the department of agriculture for planning, targeting and increasing production and productivity of sali rice in order to promote food security goals of the State. Based on the requirement of Directorate of Agriculture, Govt. of Meghalaya, NESAC has taken up the project on mapping of block wise sali rice (winter rice) areas of Meghalaya using remotely sensed data, GIS techniques and ground based observations.

The sali rice areas has been mapped by using standard visual interpretation technique. Resourcesat-2A Ortho rectified LISS IV (multispectral) image of year 2017-18 and CartoDEM (10m) has been used for the study. The map has been verified with field data collected from 350 locations covering the entire state, high resolution Kimsat image (multispectral) and Google images. The map has been finalised in consultation with the user department. The village location map has been prepared by using Google earth images and Soil Health Card data. The road network map was prepared from Komsat satellite images by following visual interpretation technique.

The study shows that in Meghalaya, sali rice is cultivated in 102574.3 ha area which is 4.6% of the total geographical area. Sali rice is cultivated in all 39 blocks of 11 districts of the state. Amongst 11 districts of the state, sali rice cultivation is highest in West Garo Hills district that cover 21.9 % of the total sali rice growing areas where as the lowest area i.e 2117.5 ha (2.1%) is found in South West Khasi Hills district. Selsella block of West Garo Hills district is having the highest sali rice growing areas followed by Betasang and Zikzak block. The lowest area is found in Pynursla block followed by Gambegre, Ranikor, Myllem Shella Bholaganj block. From accuracy assessment it is found that the accuracy of the mapping is 90%. The 10% error in the mapping is due to misclassification of the vegetable growing areas and rice fallow land as sali rice. The vegetable growing areas and rice fallow lands adjacent to sali rice fields are situated in the same physiographic condition and field size is smaller than 0.01 ha has contributed to mapping error.

Based on size of each polygon representing rice fields, the polygons were classified into 7 groups viz. 0.01-0.05 ha, 0.05-1ha, 1-2 ha, 2-4 ha, 4-10 ha, 10-100 ha and >100ha. It is observed that maximum areas under rice fields are in the class of 10-100 hectares. It is also observed that even though number of polygon is highest in the class of 0.05-1 ha and 1-2 ha but total area is less compared to other classes. It is found that rice fields with >10ha area is found highest in West Garo hills district and rice fields size between 2-10ha are found highest in West Khasi hills followed by West Garo and West Jaintia hills districts. Marginal to small fields are found highest in West Khasi hills and West Jaintia hills districts.

Based on rice growing ecosystem of Meghalaya, it is found that cultivation of low altitude rice is highest in the state that cover 64.2% area followed by mid altitude (20%) and high altitude rice (15.8%). It is also observed that the low altitude rice is the highest in West Garo Hills district and lowest in the South West Khasi hills district. Mid altitude rice is highest in West Jaintia Hills and Ribhoi district where as high altitude rice is found only in 5 districts of Khasi and Jaintia hills.

TABLE OF CONTENTS

1	INTRODUCTION	1
	1.1. Background	1
	1.2 Objectives of the present project	2
2	MATERIALS AND METHOD	2
	2.1 Identification and mapping of Block wise sali paddy (winter rice) areas in Meghalaya using remotely sensed data, GIS techniques and ground based observations at 1:10,000 Scale	2
	2.2 Stratified analysis of sali rice growing areas by systematic physiographic analysis of the terrain	2
	2.3 Development of block wise, geo referenced base maps consisting of road network and village location	2
3	RESULTS AND DISCUSSION	3
	3.1 Identification and mapping of Block wise sali paddy (winter rice) areas in Meghalaya	3
	3.2 Stratified analysis of sali rice growing areas by systematic physiographic analysis of the terrain	5
	Field photographs	7
	Annexure-I	12
	State maps and Statistics	13
	District wise maps and Statistics	20
	Block wise maps	43
	Block wise list of villages within one kilometer distance from rice fields	122

LIST OF FIGURES

Figure 1: Location of places visited for field verification	14
Figure 2: Sali rice map of Meghalaya	15
Figure 3: Classification of rice fields of Meghalaya as per size (area in ha)	16
Figure 4: Elevation map of Meghalaya	17
Figure 5: Distribution of rice in different rice ecosystem of Meghalaya	18
Figure 6: Distribution of various sizes of rice field at different rice ecosystem of Meghalaya	19
Figure 7: Classification of rice fields of South West Garo Hills district as per size (area in ha)	21
Figure 8: Rice ecosystem of South West Garo Hills district of Meghalaya	22
Figure 9: Classification of rice fields of West Garo Hills district as per size (area in ha)	23
Figure 10: Rice ecosystem of West Garo Hills district of Meghalaya	24
Figure 11: Classification of rice fields of North Garo Hills district as per size (area in ha)	25
Figure 12: Rice ecosystem of North Garo Hills district of Meghalaya	26
Figure 13: Classification of rice fields East Garo Hills district as per size (area in ha)	27
Figure 14: Rice ecosystem of East Garo Hills district of Meghalaya	28
Figure 15: Classification of rice fields of South Garo Hills district as per size (area in ha)	29
Figure 16: Rice ecosystem of South Garo Hills district of Meghalaya	30
Figure 17: Classification of rice fields of West Khasi Hills district as per size (area in ha)	31
Figure 18: Rice ecosystem of West Khasi Hills district of Meghalaya	32
Figure 19: Classification of rice fields of South West Khasi Hills district as per size (area in ha)	33
Figure 20: Rice ecosystem of South West Khasi Hills district of Meghalaya	34
Figure 21: Classification of rice fields of East Khasi Hills district as per size (area in ha)	35
Figure 22: Rice ecosystem of East Khasi Hills district of Meghalaya	36
Figure 23: Classification of rice fields of Ri Bhoi district as per size (area in ha)	37
Figure 24: Rice ecosystem of Ri Bhoi district of Meghalaya	38
Figure 25: Classification of rice fields of West Jaintia Hills district as per size (area in ha)	39
Figure 26: Rice ecosystem of West Jaintia Hills district of Meghalaya	40
Figure 27: Classification of rice fields of East Jaintia Hills district as per size (area in ha)	41

Figure 28: Rice ecosystem of East Jaintia Hills district of Meghalaya	42
Figure 29: Classification of rice fields of Betasing Block of South West Garo Hills district as per size (area in ha)	44
Figure 30: Rice ecosystem of Betasing Block of South West Garo Hills district	45
Figure 31: Classification of rice fields of Zikzak Block of South West Garo Hills district as per size (area in ha)	46
Figure 32: Rice ecosystem of Zikzak Block of South West Garo Hills district	47
Figure 33: Classification of rice fields of Dadenggre Block of West Garo Hills district as per size (area in ha)	48
Figure 34: Rice ecosystem of Dadenggre Block of West Garo Hills district	49
Figure 35: Classification of rice fields of Dalu Block of West Garo Hills district as per size (area in ha)	50
Figure 36: Rice ecosystem of Dalu Block of West Garo Hills district	51
Figure 37: Classification of rice fields of Gambegre Block of West Garo Hills district as per size (area in ha)	52
Figure 38: Rice ecosystem of Gambegre Block of West Garo Hills district	53
Figure 39: Classification of rice fields of Rongram Block of West Garo Hills district as per size (area in ha)	54
Figure 40: Rice ecosystem of Rongram Block of West Garo Hills district	55
Figure 41: Classification of rice fields of Selsella Block of West Garo Hills district as per size (area in ha)	56
Figure 42: Rice ecosystem of Selsella Block of West Garo Hills district	57
Figure 43: Classification of rice fields of Tikrikilla Block of West Garo Hills district as per size (area in ha)	58
Figure 44: Rice ecosystem of Tikrikilla Block of West Garo Hills district	59
Figure 45: Classification of rice fields of Kharkutta Block of North Garo Hills district as per size (area in ha)	60
Figure 46: Rice ecosystem of Kharkutta Block of North Garo Hills district	61
Figure 47: Classification of rice fields of Resubelpara Block of North Garo Hills district as per size (area in ha)	62
Figure 48: Rice ecosystem of Resubelpara Block of North Garo Hills district	63
Figure 49: Classification of rice fields of Rongjeng Block of East Garo Hills district as per size (area in ha)	64
Figure 50: Rice ecosystem of Rongjeng Block of East Garo Hills district	65
Figure 51: Classification of rice fields of Songsak Block of East Garo Hills district as per size (area in ha)	66
Figure 52: Rice ecosystem of Songsak Block of East Garo Hills district	67
Figure 53: Classification of rice fields of Samanda Block of East Garo Hills district as per size (area in ha)	68
Figure 54: Rice ecosystem of Samanda Block of East Garo Hills district	69
Figure 55: Classification of rice fields of Gasuapara Block of South Garo Hills district as per size (area in ha)	70
Figure 56: Rice ecosystem of Gasuapara Block of South Garo Hills district	71
Figure 57: Classification of rice fields of Chokopot Block of South Garo Hills district as per size (area in ha)	72

Figure 58: Rice ecosystem of Chokopot Block of South Garo Hills district	73
Figure 59: Classification of rice fields of Baghmara Block of South Garo Hills district as per size (area in ha)	74
Figure 60: Rice ecosystem of Baghmara Block of South Garo Hills district	75
Figure 61: Classification of rice fields of Rongara Block of South Garo Hills district as per size (area in ha)	76
Figure 62: Rice ecosystem of Rongara Block of South Garo Hills district	77
Figure 63: Classification of rice fields of Mawshynrut Block of West Khasi Hills district as per size (area in ha)	78
Figure 64: Rice ecosystem of Mawshynrut Block of West Khasi Hills district	79
Figure 65: Classification of rice fields of Nongstoin Block of West Khasi Hills district as per size (area in ha)	80
Figure 66: Rice ecosystem of Nongstoin Block of West Khasi Hills district	81
Figure 67: Classification of rice fields of Mawthadraishan Block of West Khasi Hills district as per size (area in ha)	82
Figure 68: Rice ecosystem of Mawthadraishan Block of West Khasi Hills district	83
Figure 69: Classification of rice fields of Mairang Block of West Khasi Hills district as per size (area in ha)	84
Figure 70: Rice ecosystem of Mairang Block of West Khasi Hills district	85
Figure 71: Classification of rice fields of Mawkyrwat Block of South West Khasi Hills district as per size (area in ha)	86
Figure 72: Rice ecosystem of Mawkyrwat Block of South West Khasi Hills district	87
Figure 73: Classification of rice fields of Ranikor Block of South West Khasi Hills district as per size (area in ha)	88
Figure 74: Rice ecosystem of Ranikor Block of South West Khasi Hills district	89
Figure 75: Classification of rice fields of Mawryngkneng Block of East Khasi Hills district as per size (area in ha)	90
Figure 76: Rice ecosystem of Mawryngkneng Block of East Khasi Hills district	91
Figure 77: Classification of rice fields of Mawkdok Block of East Khasi Hills district as per size (area in ha)	92
Figure 78: Rice ecosystem of Mawkdok Block of East Khasi Hills district	93
Figure 79: Classification of rice fields of Mawkynrew Block of East Khasi Hills district as per size (area in ha)	94
Figure 80: Rice ecosystem of Mawkynrew Block of East Khasi Hills district	95
Figure 81: Classification of rice fields of Mawphlang Block of East Khasi Hills district as per size (area in ha)	96
Figure 82: Rice ecosystem of Mawphlang Block of East Khasi Hills district	97
Figure 83: Classification of rice fields of Mawsynram Block of East Khasi Hills district as per size (area in ha)	98
Figure 84: Rice ecosystem of Mawsynram Block of East Khasi Hills district	99
Figure 85: Classification of rice fields of Myllem Block of East Khasi Hills district as per size (area in ha)	100
Figure 86: Rice ecosystem of Myllem Block of East Khasi Hills district	101
Figure 87: Classification of rice fields of Pynursla Block of East Khasi Hills district as per size (area in ha)	102

Figure 88: Rice ecosystem of Pynursla Block of East Khasi Hills district	103
Figure 89: Classification of rice fields of Shella Bholaganj Block of East Khasi Hills district as per size (area in ha)	104
Figure 90: Rice ecosystem of Shella Bholaganj Block of East Khasi Hills district	105
Figure 91: Classification of rice fields of Jirang Block of Ri Bhoi district as per size (area in ha)	106
Figure 92: Rice ecosystem of Jirang Block of Ri Bhoi district	107
Figure 93: Classification of rice fields of Umling Block of Ri Bhoi district as per size (area in ha)	108
Figure 94: Rice ecosystem of Umling Block of Ri Bhoi district	109
Figure 95: Classification of rice fields of Umsning Block of Ri Bhoi district as per size (area in ha)	110
Figure 96: Rice ecosystem of Umsning Block of Ri Bhoi district	111
Figure 97: Classification of rice fields of Amlarem Block of West Jaintia Hills district as per size (area in ha)	112
Figure 98: Rice ecosystem of Amlarem Block of West Jaintia Hills district	113
Figure 99: Classification of rice fields of Laskien Block of West Jaintia Hills district as per size (area in ha)	114
Figure 100: Rice ecosystem of Laskien Block of West Jaintia Hills district	115
Figure 101: Classification of rice fields of Thadlaskien Block of West Jaintia Hills district as per size (area in ha)	116
Figure 102: Rice ecosystem of Thadlaskien Block of West Jaintia Hills district	117
Figure 103: Classification of rice fields of Khliehriat Block of East Jaintia Hills district as per size (area in ha)	118
Figure 104: Rice ecosystem of Khliehriat Block of East Jaintia Hills district	119
Figure 105: Classification of rice fields of Saipung Block of East Jaintia Hills district as per size (area in ha)	120
Figure 106: Rice ecosystem of Saipung Block of East Jaintia Hills district	121
Figure 107: Villages within 1 kilometer distance from rice field of size 2-4 ha in Betasing block of South West Garo Hills district.	123
Figure 108: Villages within 1 kilometer distance from rice field of size 2-4 ha in Zikzak Block of South West Garo Hills district	124
Figure 109: Villages within 1 kilometer distance from rice field of size 2-4 ha in Dadenggre Block of West Garo Hills district	125
Figure 110: Villages within 1 kilometer distance from rice field of size 2-4 ha in Dalu Block of West Garo Hills district	126
Figure 111: Villages within 1 kilometer distance from rice field of size 2-4 ha in Gambegre Block of West Garo Hills district	127
Figure 112: Villages within 1 kilometer distance from rice field of size 2-4 ha in Rongram Block of West Garo Hills district	128
Figure 113: Villages within 1 kilometer distance from rice field of size 2-4 ha in Sellsella Block of West Garo Hills district	129
Figure 114: Villages within 1 kilometer distance from rice field of size 2-4 ha in Tikrikilla Block of West Garo Hills district	130
Figure 115: Villages within 1 kilometer distance from rice field of size 2-4 ha in Kharkutta Block of North Garo Hills district	131
Figure 116: Villages within 1 kilometer distance from rice field of size 2-4 ha in Resubelpara Block of North Garo Hills district	132

Figure 117: Villages within 1 kilometer distance from rice field of size 2-4 ha in Rongjeng Block of East Garo Hills district	133
Figure 118: Villages within 1 kilometer distance from rice field of size 2-4 ha in Songsak Block of East Garo Hills district	134
Figure 119: Villages within 1 kilometer distance from rice field of size 2-4 ha in Samanda Block of East Garo Hills district	135
Figure 120: Villages within 1 kilometer distance from rice field of size 2-4 ha in of Gasuapara Block of South Garo Hills district	136
Figure 121: Villages within 1 kilometer distance from rice field of size 2-4 ha in Chokopot Block of South Garo Hills district	137
Figure 122: Villages within 1 kilometer distance from rice field of size 2-4 ha in Baghmara Block of South Garo Hills district	138
Figure 123: Villages within 1 kilometer distance from rice field of size 2-4 ha in Rongara Block of South Garo Hills district	139
Figure 124: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawshynrut Block of West Khasi Hills district	140
Figure 125: Villages within 1 kilometer distance from rice field of size 2-4 ha in Nongstoin Block of West Khasi Hills district	141
Figure 126: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawthadraishan Block of West Khasi Hills district	142
Figure 127: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mairang Block of West Khasi Hills district	143
Figure 128: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawkyrwat Block of South West Khasi Hills district	144
Figure 129: Villages within 1 kilometer distance from rice field of size 2-4 ha in Ranikor Block of South West Khasi Hills district	145
Figure 130: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawryngkneng Block of East Khasi Hills district	146
Figure 131: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawkdok Block of East Khasi Hills district	147
Figure 132: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawkynrew Block of East Khasi Hills district	148
Figure 133: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawphlang Block of East Khasi Hills district	149
Figure 134: Villages within 1 kilometer distance from rice field of size 2-4 ha in Mawsynram Block of East Khasi Hills district	150
Figure 135: Villages within 1 kilometer distance from rice field of size 2-4 ha in Myllem Block of East Khasi Hills district	151
Figure 136: Villages within 1 kilometer distance from rice field of size 2-4 ha in Pynursla Block of East Khasi Hills district	152
Figure 137: Villages within 1 kilometer distance from rice field of size 2-4 ha in Shella Bholaghanj Block of East Khasi Hills district	153
Figure 138: Villages within 1 kilometer distance from rice field of size 2-4 ha in Jirang Block of Ri Bhoi district	154
Figure 139: Villages within 1 kilometer distance from rice field of size 2-4 ha in Umling Block of Ri Bhoi district	155
Figure 140: Villages within 1 kilometer distance from rice field of size 2-4 ha in Umsning Block of Ri Bhoi district	156
Figure 141: Villages within 1 kilometer distance from rice field of size 2-4 ha in Amlarem Block of West Jaintia Hills district	157
Figure 142: Villages within 1 kilometer distance from rice field of size 2-4 ha in Laskien Block of West Jaintia Hills district	158
Figure 143: Villages within 1 kilometer distance from rice field of size 2-4 ha in Thadlaskien Block of West Jaintia Hills district	159
Figure 144: Villages within 1 kilometer distance from rice field of size 2-4 ha in Khliehriat Block of East Jaintia Hills district	160
Figure 145: Villages within 1 kilometer distance from rice field of size 2-4 ha in Saipung Block of East Jaintia Hills district	161

Figure 146: Village within 1 kilometer distance from rice field of size 4-10 in Betasing Block of South West Garo Hills district	162
Figure 147: Village within 1 kilometer distance from rice field of size 4-10 in Zikzak Block of South West Garo Hills district	163
Figure 148: Village within 1 kilometer distance from rice field of size 4-10 in Dadengre Block of West Garo Hills district	164
Figure 149: Village within 1 kilometer distance from rice field of size 4-10 in Dalu Block of West Garo Hills district	165
Figure 150: Village within 1 kilometer distance from rice field of size 4-10 in Gambegre Block of West Garo Hills district	166
Figure 151: Village within 1 kilometer distance from rice field of size 4-10 in Rongram Block of West Garo Hills district	167
Figure 152: Village within 1 kilometer distance from rice field of size 4-10 in Selsella Block of West Garo Hills district	168
Figure 153: Village within 1 kilometer distance from rice field of size 4-10 in Tikrikilla Block of West Garo Hills district	169
Figure 154: Village within 1 kilometer distance from rice field of size 4-10 in Kharkutta Block of North Garo Hills district	170
Figure 155: Village within 1 kilometer distance from rice field of size 4-10 in Resubelpara Block of North Garo Hills district	171
Figure 156: Village within 1 kilometer distance from rice field of size 4-10 in Rongjeng Block of East Garo Hills district	172
Figure 157: Village within 1 kilometer distance from rice field of size 4-10 in Songsak Block of East Garo Hills district	173
Figure 158: Village within 1 kilometer distance from rice field of size 4-10 in Samanda Block of East Garo Hills district	174
Figure 159: Village within 1 kilometer distance from rice field of size 4-10 in Gasuapara Block of South Garo Hills district	175
Figure 160: Village within 1 kilometer distance from rice field of size 4-10 in Chokopot Block of South Garo Hills district	176
Figure 161: Village within 1 kilometer distance from rice field of size 4-10 in Baghmara Block of South Garo Hills district	177
Figure 162: Village within 1 kilometer distance from rice field of size 4-10 in Rongara Block of South Garo Hills district	178
Figure 163: Village within 1 kilometer distance from rice field of size 4-10 in Mawshynrut Block of West Khasi Hills district	179
Figure 164: Village within 1 kilometer distance from rice field of size 4-10 in Nongstoin Block of West Khasi Hills district	180
Figure 165: Village within 1 kilometer distance from rice field of size 4-10 in Mawthadraishan Block of West Khasi Hills district	181
Figure 166: Village within 1 kilometer distance from rice field of size 4-10 in Mairang Block of West Khasi Hills district	182
Figure 167: Village within 1 kilometer distance from rice field of size 4-10 in Mawkyrwat Block of South West Khasi Hills district	183
Figure 168: Village within 1 kilometer distance from rice field of size 4-10 in Ranikor Block of South West Khasi Hills district	184
Figure 169: Village within 1 kilometer distance from rice field of size 4-10 in Mawryngkneng Block of East Khasi Hills district	185
Figure 170: Village within 1 kilometer distance from rice field of size 4-10 in Mawkdok Block of East Khasi Hills district	186
Figure 171: Village within 1 kilometer distance from rice field of size 4-10 in Mawkynrew Block of East Khasi Hills district	187
Figure 172: Village within 1 kilometer distance from rice field of size 4-10 in Mawphlang Block of East Khasi Hills district	188
Figure 173: Village within 1 kilometer distance from rice field of size 4-10 in Mawsynram Block of East Khasi Hills district	189
Figure 174: Village within 1 kilometer distance from rice field of size 4-10 in Myllem Block of East Khasi Hills district	190

Figure 175: Village within 1 kilometer distance from rice field of size 4-10 in Pynursla Block of East Khasi Hills district	191
Figure 176: Village within 1 kilometer distance from rice field of size 4-10 in Shella Bholaghanj Block of East Khasi Hills district	192
Figure 179: Village within 1 kilometer distance from rice field of size 4-10 in Jirang Block of Ri Bhoi district	193
Figure 178: Village within 1 kilometer distance from rice field of size 4-10 in Umling Block of Ri Bhoi district	194
Figure 179: Village within 1 kilometer distance from rice field of size 4-10 in Umsning Block of Ri Bhoi district	195
Figure 180: Village within 1 kilometer distance from rice field of size 4-10 in Amlarem Block of West Jaintia Hills district	196
Figure 181: Village within 1 kilometer distance from rice field of size 4-10 in Laskien Block of West Jaintia Hills district	197
Figure 182: Village within 1 kilometer distance from rice field of size 4-10 in Thadlaskien Block of West Jaintia Hills district	198
Figure 183: Village within 1 kilometer distance from rice field of size 4-10 in Khliehriat Block of East Jaintia Hills district	199
Figure 184: Village within 1 kilometer distance from rice field of size 4-10 in Saipung Block of East Jaintia Hills district	200

LIST OF TABLES

Table 1: List of villages within 1 kilometer from rice filed in Betasing Block of South West Garo Hills district	202
Table 2: List of villages within 1 kilometer from rice filed in Zikzak Block of South West Garo Hills district	203
Table 3: List of villages within 1 kilometer from rice filed in Zikzak Block of South West Garo Hills district	204
Table 4: List of villages within 1 kilometer from rice filed in Zikzak Block of South West Garo Hills district	205
Table 5: List of villages within 1 kilometer from rice filed in Dadenggre Block of West Garo Hills district	206
Table 6: List of villages within 1 kilometer from rice filed in Dalu Block of West Garo Hills district	207
Table 7: List of villages within 1 kilometer from rice filed in Dalu Block of West Garo Hills district	208
Table 8: List of villages within 1 kilometer from rice filed in Gambegre Block of West Garo Hills district	209
Table 9: List of villages within 1 kilometer from rice filed in Rongram Block of West Garo Hills district	210
Table 10: List of villages within 1 kilometer from rice filed in Rongram Block of West Garo Hills district	211
Table 11: List of villages within 1 kilometer from rice filed in Selsella Block of West Garo Hills district	212
Table 12: List of villages within 1 kilometer from rice filed in Selsella Block of West Garo Hills district	213
Table 13: List of villages within 1 kilometer from rice filed in Selsella Block of West Garo Hills district	214
Table 14: List of villages within 1 kilometer from rice filed in Tikrikilla Block of West Garo Hills district	215
Table 15: List of villages within 1 kilometer from rice filed in Tikrikilla Block of West Garo Hills district	216
Table 16: List of villages within 1 kilometer from rice filed in Tikrikilla Block of West Garo Hills district	217

Table 17: List of villages within 1 kilometer from rice filed in Kharkutta Block of North Garo Hills district	218
Table 18: List of villages within 1 kilometer from rice filed in Kharkutta Block of North Garo Hills district	219
Table 19: List of villages within 1 kilometer from rice filed in Resubelpara Block of North Garo Hills district	220
Table 20: List of villages within 1 kilometer from rice filed in Resubelpara Block of North Garo Hills district	221
Table 21: List of villages within 1 kilometer from rice filed in Resubelpara Block of North Garo Hills district	222
Table 22: List of villages within 1 kilometer from rice filed in Resubelpara Block of North Garo Hills district	223
Table 23: List of villages within 1 kilometer from rice filed in Resubelpara Block of North Garo Hills district	224
List of villages within 1 kilometer from rice filed in Rongjeng Block of East Garo Hills district	225
Table 25: List of villages within 1 kilometer from rice filed in Rongjeng Block of East Garo Hills district	226
Table 26: List of villages within 1 kilometer from rice filed in Songsak of East Garo Hills district	227
Table 27: List of villages within 1 kilometer from rice filed in Songsak of East Garo Hills district	228
Table 28: List of villages within 1 kilometer from rice filed in Samanda Block of East Garo Hills district	229
Table 29: List of villages within 1 kilometer from rice filed in Gasuapara Block of South Garo Hills district	230
Table 30: List of villages within 1 kilometer from rice filed in Chokopot Block of South Garo Hills district	231
Table 31: List of villages within 1 kilometer from rice filed in Baghmara Block of South Garo Hills district	232
Table 32: List of villages within 1 kilometer from rice filed in Rongara Block of South Garo Hills district	233
Table 33: List of villages within 1 kilometer from rice filed in Mawshynrut Block of West Khasi Hills district	234
Table 34: List of villages within 1 kilometer from rice filed in Mawshynrut Block of West Khasi Hills district	235
Table 35 List of villages within 1 kilometer from rice filed in Nongstoin Block of West Khasi Hills district	236
Table 36: List of villages within 1 kilometer from rice filed in Nongstoin Block of West Khasi Hills district	237
Table 37: List of villages within 1 kilometer from rice filed in Mawthadraishan Block of West Khasi Hills district	238
Table 38: List of villages within 1 kilometer from rice filed in Mawthadraishan Block of West Khasi Hills district	239
Table 39: List of villages within 1 kilometer from rice filed in Mairang Block of West Khasi Hills district	240
Table 40: List of villages within 1 kilometer from rice filed in Mairang Block of West Khasi Hills district	241
Table 41: List of villages within 1 kilometer from rice filed in Mawkyrwat Block of South West Khasi Hills district	242
Table 42: List of villages within 1 kilometer from rice filed in Ranikor Block of South West Khasi Hills district	243
Table 43: List of villages within 1 kilometer from rice filed in Mawryngkneng Block of East Khasi Hills district	243
Table 44: List of villages within 1 kilometer from rice filed in Mawkdok Block of East Khasi Hills district	244
Table 45: List of villages within 1 kilometer from rice filed in Mawkynrew Block of East Khasi Hills district	244

Table 46: List of villages within 1 kilometer from rice filed in Mawphlang Block of East Khasi Hills district	245
Table 47: List of villages within 1 kilometer from rice filed in Mawphlang Block of East Khasi Hills district	246
Table 48: List of villages within 1 kilometer from rice filed in Mawsynram Block of East Khasi Hills district	247
Table 49: List of villages within 1 kilometer from rice filed in Mawsynram Block of East Khasi Hills district	248
Table 50: List of villages within 1 kilometer from rice filed in Myllichem Block of East Khasi Hills district	249
Table 51: List of villages within 1 kilometer from rice filed in Myllichem Pynursla Block of East Khasi Hills district	249
Table 52: List of villages within 1 kilometer from rice filed in Shella Bholaganj Block of East Khasi Hills district	249
Table 53: List of villages within 1 kilometer from rice filed in Jirang Block of Ri Bhoi district	250
Table 54: List of villages within 1 kilometer from rice filed in Umling Block of Ri Bhoi district	251
Table 55: List of villages within 1 kilometer from rice filed in Umling Block of Ri Bhoi district	252
Table 56: List of villages within 1 kilometer from rice filed in Umling Block of Ri Bhoi district	253
Table 57: List of villages within 1 kilometer from rice filed in Umsning Block of Ri Bhoi district	254
Table 58: List of villages within 1 kilometer from rice filed in Umsning Block of Ri Bhoi district	255
Table 59: List of villages within 1 kilometer from rice filed in Umsning Block of Ri Bhoi district	256
Table 60: List of villages within 1 kilometer from rice filed in Umsning Block of Ri Bhoi district	257
Table 61: List of villages within 1 kilometer from rice filed in Umsning Block of Ri Bhoi district	258
Table 62: List of villages within 1 kilometer from rice filed in Amlarem Block of West Jaintia Hills district	259
Table 63: List of villages within 1 kilometer from rice filed in Laskien Block of West Jaintia Hills district	260
Table 64: List of villages within 1 kilometer from rice filed in Thadlaskien Block of West Jaintia Hills district	261
Table 65: List of villages within 1 kilometer from rice filed in Thadlaskien Block of West Jaintia Hills district	262
Table 66: List of villages within 1 kilometer from rice filed in Khliehriat Block of East Jaintia Hills district	263
Table 67: List of villages within 1 kilometer from rice filed in Saipung Block of East Jaintia Hills district	264

1. Introduction:

1.1. Background

Rice is a major food crop of Meghalaya occupying an average annual area of 1,11,178 ha with total production of 3,01,076 Metric Tons. Rice is grown in the state in a wide range of climatic conditions ranging from deep water to high altitudes. The rice that is grown in the state has been classified into three classes i.e. Boro or Spring/Summer rice, Sali or Kharif rice / winter rice and Ahu or Autumn rice. Out of the total rice grown area, 63862 ha area is under sali rice alone that occupies 57% of the total rice cropped area producing an annual average of 160722 Metric Tons during the period 2016-17 (www.megagriculture.gov.in). The area under Boro and Ahu rice is 33646 and 13670 ha respectively. The average yield is the highest in Boro rice (4608 kg/ha) followed by Sali (2524 kg/ha) and Ahu rice (2337 kg/ha). However, food security is uncertain, as current annual rice consumption has exceeded annual rice production. The annual shortfall of food grain is estimated to be of the order of 122 thousand tones (www.megplanning.gov.in). It is therefore evident that the state is not self sufficient in the production of food grain.

The spatio-temporal distribution and dynamics of rice cultivation in a state helps to understand growing food demand, water scarcity, etc. Accurate and on-time information on spatial distribution of rice would be useful for stakeholders (cultivators, fertilizer/pesticide manufacturers and agriculture extension agencies) to effectively plan supply of inputs, market activities. Also, government agencies can plan and formulate policies regarding food security. In addition, the data on rice area would be useful as an input to estimate crop health, water demand, crop yield at field/regional level. Since problems with food security persist in the state robust and reliable tools for mapping and early forecasting of rice production are thus critical. Therefore reliable and timely estimates of rice crop areas and its production are essential for providing information for planners and decision makers to formulate policies in the case of shortfall or surplus.

It is interesting to mention that the most common and widely used methods for estimating rice cultivated areas are the use of agricultural statistical data acquired through field visits and interviewing the farmers. The methodology for mapping area under rice cultivation is basically done through annual/seasonal sample surveys based on a number of sample clusters that are constituted all over the country for measuring cultivated area during the crop growing season. Each cluster is visited many times and areas are recorded by the field staffs, checked, and then processed by regional statistical officers. Despite its invaluable ability for understanding historical trends in rice area,

this method is extremely tedious, time-consuming, less precise, costly, inconsistent, and labour-intensive [Prasad et.al. 2006, S.K. Bala and A.K.M.S Islam, 2008].

In this context, remote sensing-based methods have already been proven as an effective alternative for mapping rice area Singh et.al., 2014. The benefits of remote sensing technology include: (i) spatial coverage over a large geographic area; (ii) availability during all seasons; (iii) relatively low cost; (iv) efficient analysis; (v) they provide information in a timely manner; and (vi) they are capable of delineating detailed spatial distributions of areas under rice cultivation. The user requires fast, reliable (accurate), less costly, and least labour-intensive ways which can be achieved through remote sensing-based method. Rice area mapping at field, district, regional and national scale has been carried out in the past using various approaches which involves use of single date or time series optical as well as microwave/Synthetic Aperture RADAR (SAR) data (Qin et al., 2015, Nguyen et al., 2015, Neetu et al., 2014, Karydas et al., 2015).

Meghalaya Rice Mission is a programme to increase rice production and productivity in the state to meet the consumption requirement and to bridge the deficit between demand and availability to consumers. One major objective of the mission is to map the spatial distribution of rice ecosystem by using Remote sensing & GIS technique for prioritization and planning. Directorate of Agriculture, Govt. of Meghalaya has taken up action on the recommendations of the State Consultant, State Rice Mission, Dr. Sushil Pandey, ex Rice Economist from IRRI, Manila, Philippines. One of his recommendations suggest the department that under Mini Mission 1, GIS and RS technology to be utilised for identification, mapping of rice areas and suitability analysis for extending the boro paddy areas in the State. One action already has been taken up by Directorate of Agriculture, Govt. of Meghalaya on identification of areas suitable for expansion of Boro rice cultivation in the state which was executed by NESAC and the project is being implemented by the user department. In continuation to the above, Directorate has proposed to create scientific database on Sali rice areas (Winter Rice) which constitute about 57% of total paddy growing areas in Meghalaya. The database will be utilised by the department of agriculture for planning, targeting and increasing production and productivity of sali rice in order to promote food security goals of the State. Based on the requirement of Directorate of Agriculture, Govt. of Meghalaya, NESAC has taken up the project on Identification and mapping of Block wise sali paddy (winter rice) areas in Meghalaya using remotely sensed data, GIS techniques and ground based observations.

1.2 Objectives of the present project

This project is funded by Directorate of Agriculture, Govt. of Meghalaya, for implementation during the financial year 2018-2020. The project work is being carried out at NESAC with support from district agriculture offices for field visit with three major objectives:

- i) Identification and mapping of block wise sali rice (winter rice) areas in Meghalaya using remotely sensed data, GIS techniques and ground based observations at 1:10,000 Scale.
- ii) Stratified analysis of sali rice growing areas (Ecosystems) by systematic physiographic analysis of the terrain.
- iii) Development of block wise, geo referenced base maps consisting of road network and village location.

2. MATERIALS AND METHODS

2.1 Identification and mapping of Block wise sali rice (winter rice) areas in Meghalaya using remotely sensed data, GIS techniques and ground based observations at 1:10,000 Scale

Resourcesat-2A Ortho rectified LISS IV (multispectral) images of 2017-18 were used to derive information on the spatial distribution of sali rice areas in Meghalaya. Resourcesat-2A is an Indian Remote Sensing Satellite which has LISS IV camera with spatial resolution of 5.8m (multispectral) is suitable for preparing map of 1:10,000 scale. Based on scale of the map, the smallest area which is identifiable from this image is 0.01ha. Available information on other land use classes that was generated earlier was also referred during mapping. The methodology adopted consists of satellite data preparation, interpretation (on-screen visual), ground truth data collection, map finalization, quality checking of final maps and databases. The sali paddy areas as seen in the satellite data are delineated on screen using standard visual interpretation technique and prepared preliminary interpretation map. The preliminary interpreted map was used for collection of ground truth (GT) data from 350 locations covering

the entire state. The map was finalised by using the GT data, high resolution alternate foreign satellite images like Komsat and Google earth images. The flowchart of the methodology is given in Figure I.

2.2 Stratified analysis of sali rice growing areas by systematic physiographic analysis of the terrain

In Meghalaya three Rice ecosystems are available i.e. low altitude rice upto 800m, mid altitude 800-1300m, high altitude rice above 1300m (Source: <http://www.megagriculture.gov.in>). The elevation map was derived from Digital Elevation Model (DEM) prepared from Cartosat satellite images. The height accuracy of CartoDEM is $\pm 8m$. The elevation map was classified into three classes as per rice growing ecosystem of Meghalaya. The elevation map was overlaid with sali rice map in GIS environment and analysed the data by using analysis tool of ArcGIS software. The sali rice areas were stratified into three rice ecosystem as per package of practices of rice for Meghalaya. The flowchart of the methodology is given in Figure II.

2.3 Development of block wise, geo referenced base maps consisting of road network and village location

The sali rice map prepared by from LISS IV images by visual image interpretation technique and finalised with field data collected by visiting different rice fields was overlaid with district and block boundary in GIS environment. The administrative boundary were taken from existing database of NESAC. One single layer has been derived by GIS analysis from which district and block wise area statistics were generated and block wise georeferenced maps has been prepared by overlaying road network and village location map. The existing village location map was updated by using Google earth images and Soil Health Card data. Villages nearby large patches of sali paddy areas were identified and listed block wise. The road network map was prepared from Komsat satellite images by following visual interpretation technique.

3. Results and discussion

3.1 Identification and mapping of Block wise sali paddy (winter rice) areas in Meghalaya

The area under sali rice cultivation was identified from LISS IV images which were further verified by visiting different field covering the entire state and very high resolution foreign satellite images (Komsat and Google images). From accuracy assessment it is found that the accuracy of the mapping is 90%. The 10% error in the

mapping is due to misclassification of the vegetable growing areas and rice fallow land as sali rice. From the field visit, It is found that the vegetable growing areas and rice fallow lands adjacent to sali rice fields situated in the same physiographic condition and field size are smaller than 0.01 ha has contributed to mapping error. It is also found that misclassification of vegetable growing areas as sali rice is highest in the East Khasi hills district specially in the Myllem block. During the sali rice growing season, rice fallow lands are mostly covered with grass and it become difficult to differentiate rice and grass in the satellite image because both are looking similar. Examples of such situation is presented with field photo corresponding to LISS IV image in Annexure - I.

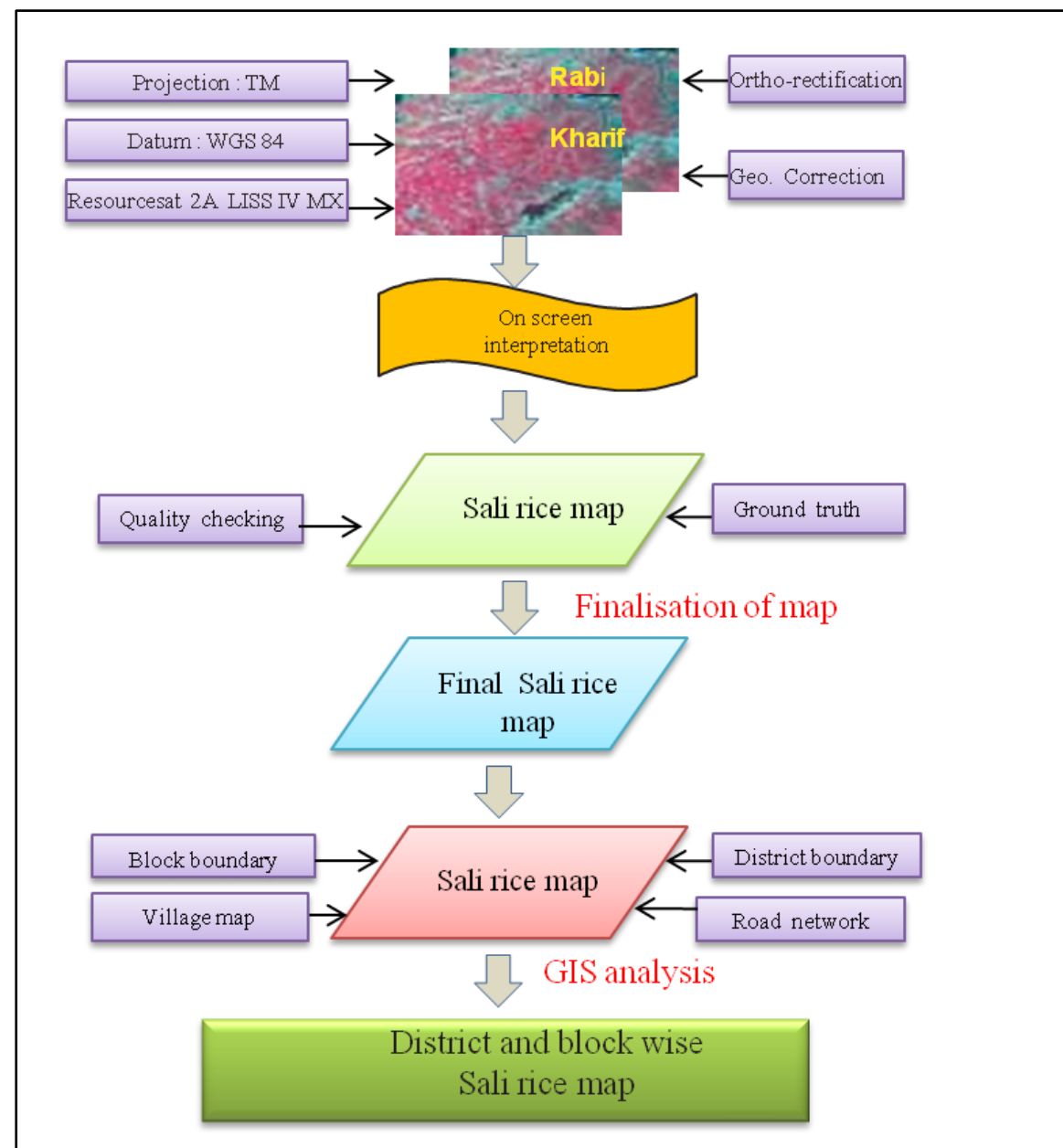


Figure I : Flow chart of the methodology for mapping of sali rice areas

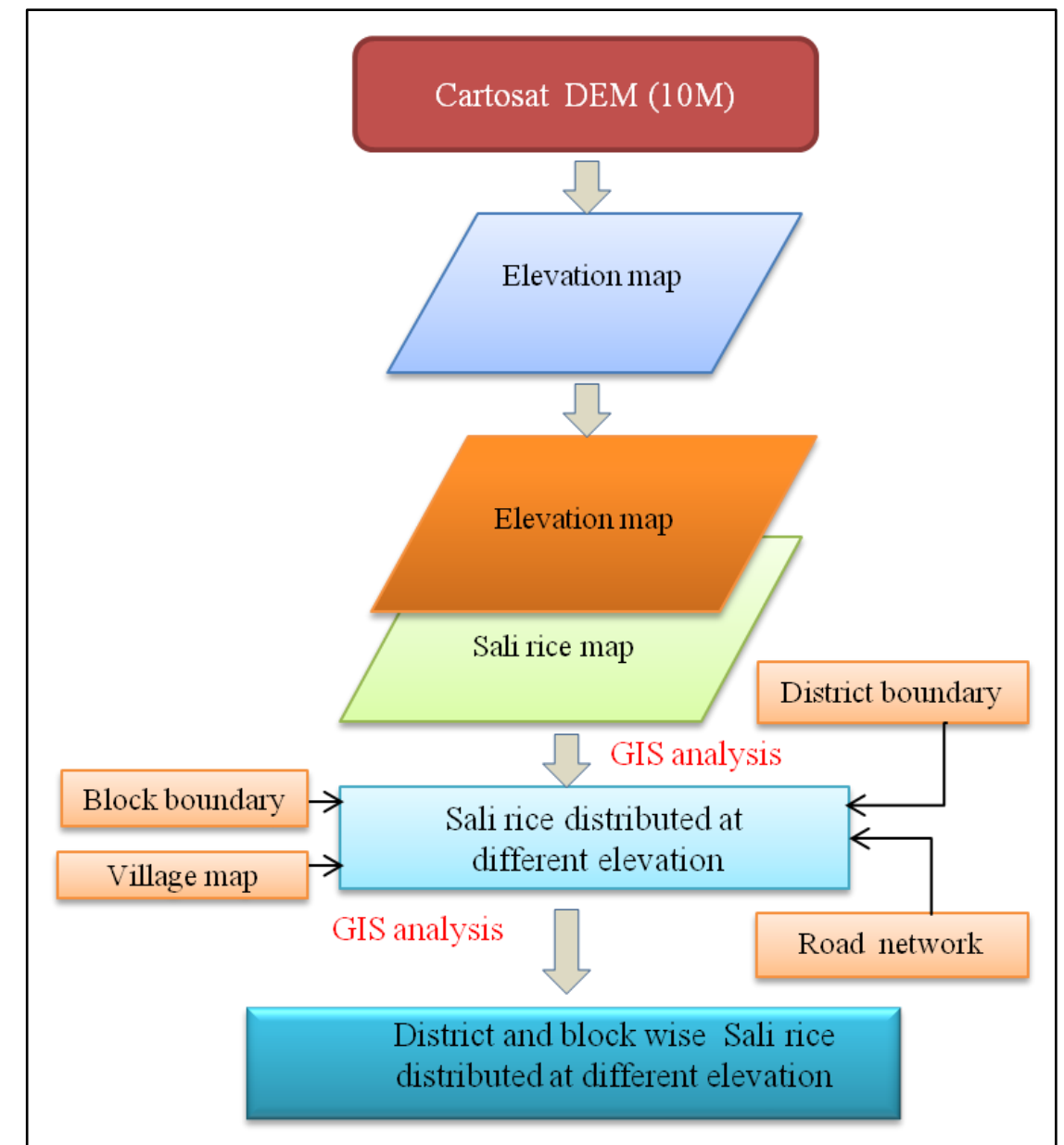


Figure II : Flow chart of the methodology for stratified analysis

Table I: District wise area statistics

District	Area (ha)	% area
South West Khasi Hills	2117.5	2.1
East Jaintia Hills	3593.0	3.5
South Garo Hills	4827.7	4.7
East Garo Hills	4943.4	4.8
East Khasi Hills	8087.7	7.9
North Garo Hills	8367.1	8.2
RiBhoi	9544.7	9.3
West Jaintia Hills	10869.4	10.6
West Khasi Hills	13569.2	13.2
South West Garo Hills	14222.7	13.9
West Garo Hills	22431.9	21.9
Total	102574.3	100.0

Table IV : District wise distribution of rice fields based on size

Districts	Rice field size (ha)							Total rice fields
	0.01-0.05	0.05-1	1-2	2-4	4-10	10-100	100-943	
East Garo Hills	2	1419	577	264	131	53	2	2448
East Jaintia Hills	80	2435	436	248	131	38	-	3368
East Khasi Hills	18	1312	482	361	252	172	2	2599
North Garo Hills	-	1087	469	319	247	167	8	2297
RiBhoi	20	2079	704	439	285	152	9	3688
South Garo Hills	1	356	200	146	134	120	4	961
South West Garo Hills	-	229	173	197	203	207	23	1032
South West Khasi Hills	1	403	143	79	74	45	-	745
West Garo Hills	4	3390	1022	608	394	282	37	5737
West Jaintia Hills	74	4129	1055	588	338	165	1	6350
West Khasi Hills	64	6703	1309	694	449	162	8	9389
Total rice fields	264	23545	6570	3945	2638	1563	94	38619

Table II: Block wise area statistics

District	Block	Area(ha)	% Area
East Garo Hills	Rongjeng	3278.5	3.1
	Samanda	611.1	0.6
	Songsak	1110.8	1.0
East Jaintia Hills	Khliehriat	2019.3	1.9
	Saipung	1607.4	1.5
East Khasi Hills	Mawkdok	776.9	0.7
	Mawkynrew	862.4	0.8
	Mawphlang	1566.8	1.5
	Mawryngkneng	818.2	0.8
	Mawsynram	3350.6	3.2
	Myllem	565.1	0.5
	Pynursla	63.5	0.1
	Shella	604.3	0.6
	North Garo Hills	Kharkutta	1748.6
Resubelpara		6679.5	6.3
RiBhoi	Jirang	972.9	0.9
	Umling	3072.9	2.9
	Umsning	5828.7	5.5
South Garo Hills	Bagmara	1018.0	1.0
	Chokpot	1383.9	1.3

District	Block	Area(ha)	% Area
South Garo Hills	Gasuapara	2138.0	2.0
	Rongara	689.2	0.6
South West Garo Hills	Betasing	8227.6	7.7
	Zikzak	6774.4	6.4
South West Khasi Hills	Mawkyrwat	1712.8	1.6
	Ranikor	515.5	0.5
West Garo Hills	Dadenggre	2030.2	1.9
	Dalu	2934.3	2.8
	Gambegre	501.4	0.5
	Rongram	950.6	0.9
	Selsella	11511.5	10.8
	Tikrikilla	5131.0	4.8
West Jaintia Hills	Amlarem	945.0	0.9
	Laskien	3379.8	3.2
	Thadlaskien	6688.3	6.3
West Khasi Hills	Mairang	4141.5	3.9
	Mawshynrut	2252.7	2.1
	Mawthadraisha	4505.1	4.2
	Nongstoin	3267.3	3.1
Total		102574.3	100.0

Table III: Grouping of rice fields based on its size (ha)

Sl. No.	Size of polygon (ha)	Class name	Area (ha)	Polygon numbers
1	0.01-0.05	Very marginal	5.1	264
2	0.05-1	Marginal	10457.7	23545
3	1-2	Small	9316.8	6570
4	2-4	Semi medium	10830.1	3945
5	4-10	Medium	15536.7	2638
6	10-100	Large	37229.0	1563
7	100-943	Very large	19199.5	94
	Total		102574.3	38619

From the study it is observed that sali rice is grown in 102574.3 ha which is 4.6% of the total geographical area of Meghalaya during 2017-18. It is observed that sali rice is cultivated in all 39 blocks of 11 districts of the state. The study shows that sali rice cultivation is highest in West Garo Hills district which cover 21.9 % of the total sali rice growing areas where as the lowest area i.e 2117.5 ha (2.1%) is found in South West Khasi Hills district (Table I). From the study it is found that Selsella block of West Garo Hills district is having the highest sali rice growing areas followed by Betasang and Zikzak block (Table II).

Based on size of each polygon representing rice fields, the polygons were classified into 7 groups viz. 0.01-0.05 ha, 0.05-1ha, 1-2 ha, 2-4 ha, 4-10 ha, 10-100 ha and >100ha. It is observed that maximum rice fields are in the class of 10-100 hectares. It is also observed that even though number of polygon is highest in the class of 0.05-1 ha (23545) and 1-2 ha (6570) but total area is less compared to other class (Table III). It is found that rice fields with >10ha area is found highest in West Garo hills district and rice fields size between 2-10ha are found highest in West Khasi hills followed by West Garo and West Jaintia hills districts. Marginal to small fields are found highest in West Khasi and West Jaintia hills districts (Table IV).

Table V : Area under different rice ecosystem

Elevation	Rice ecosystem	Area_ha	% area
0-800m	Low altitude	65857.0	64.2
800-1300m	Mid altitude	20500.3	20.0
>1300m	High altitude	16217.0	15.8
	Total	102574.3	100.0

The rice fields which size is less than 10ha was used for finding out the list of villages which are falling within one kilometer distance. Block wise map showing villages within one kilometer distance of rice fields are presented in maps (Figure 107-184) and name of villages are listed in tables (Table 1-67).

3.2 Stratified analysis of sali rice growing areas by systematic physiographic analysis of the terrain

Based on rice growing ecosystem of Meghalaya, the elevation map was classified into three classes viz. <800m, 800-1300m and >1300m. The elevation map was overlaid with the sali rice map of Meghalaya in GIS and stratified the sali rice areas. From the analysis it is found that cultivation of low altitude rice is highest in the state (Table V and Table VI) that cover 64.2% area followed by mid altitude (20%) and high altitude rice (15.8%). It is also observed that the low altitude rice is the highest in West Garo Hills district and lowest in the South West Khasi hills district. Mid altitude rice is highest in West Jaintia Hills and Ribhoi district where as high altitude rice is found only in 5 districts of Khasi and Jaintia hills.

Table VI : District wise area under different rice ecosystem

Districts	0-800m	800-1300m	>1300m	Total
East Garo Hills	4894.2	49.2	-	4943.4
East Jaintia Hills	547.8	2964.6	74.5	3586.9
East Khasi Hills	1796.7	1335.8	4955.2	8087.7
North Garo Hills	8367.1	-	-	8367.1
RiBhoi	5788.6	3756.2	-	9544.8
South Garo Hills	4827.7	-	-	4827.7
South West Garo Hills	14222.7	-	-	14222.7
South West Khasi Hills	515.5	15.3	1586.7	2117.5
West Garo Hills	22411.4	20.5	-	22431.9
West Jaintia Hills	541.4	8820.2	1508.0	10869.6
West Khasi Hills	1938.6	3537.9	8092.8	13569.4
Total	65857.2	20500.4	16217.1	102574.3

4. References

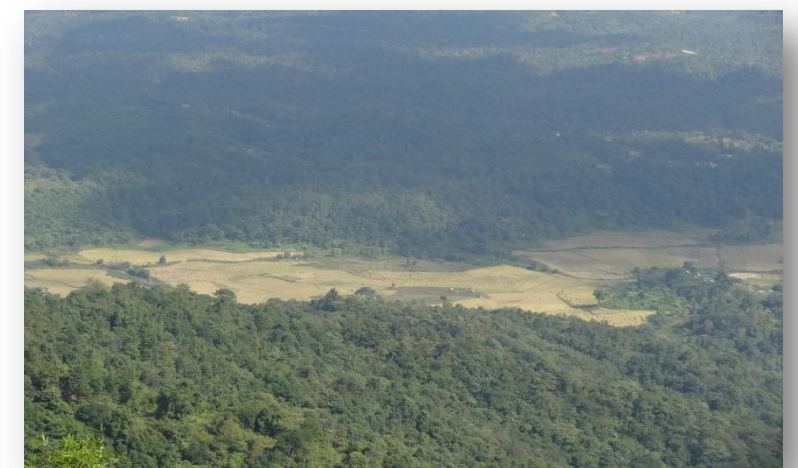
1. Prasad A.K., Chai L., Singh R.P., Kafatos M. Crop yield estimation model for Iowa using remote sensing and surface parameters. *Int. J. Appl. Earth Obs. Geoinf.* 2006;8:26–33. [[Google Scholar](#)]
2. Bala S.K., Islam A.K.M.S. Estimation of Potato Yield in and around Munshiganj Using Remote Sensing NDVI Data. Institute of Water and Flood Management; Dhaka, Bangladesh: 2008. p. 79. [[Google Scholar](#)]
3. Singh S.K., Srivastava P.K., Gupta M., Thakur J.K., Mukherjee S. Appraisal of land use/land cover of mangrove forest ecosystem using support vector machine. *Environ. Earth Sci.* 2014;71:2245–2255. [[Google Scholar](#)]
4. Rahman A., Roytman L., Krakauer N.Y., Nizamuddin M., Goldberg M. Use of vegetation health data for estimation of Aha rice yield in Bangladesh. *Sensors.* 2009;9:2968–2975. [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]
5. GeliZhang., XiangmingXiao., Chandrashekhar M.Biradar., JinweiDong., YuanweiQin., Michael A.Menarguez., YutingZhou., YaoZhang., CuiJin., JieWang., Russell B.Doughty., Mingjun Ding., Berrien MooreIII Spatiotemporal patterns of paddy rice croplands in China and India from 2000 to 2015. *Science of The Total Environment.* 579 (1). February 2017, Pages 82-92
6. Ray, Shibendu., Neetu., Mamatha, S., Gupta, Sanjeev. (2014). Use of Remote Sensing in Crop Forecasting and Assessment of Impact of Natural Disasters: Operational Approaches in India. Conference: FAO Expert Meeting on Crop Monitoring for Improved Food Security, At Vientiane, Lao PDR
7. Christos G. Karydas, Panos Panagos & Ioannis Z. Gitas (2014): A classification of water erosion models according to their geospatial characteristics, *International Journal of Digital Earth*, 7(3): 229-250 (DOI:10.1080/17538947.2012.671380)
8. www.megagriculture.gov.in

FIELD PHOTOGRAPHS



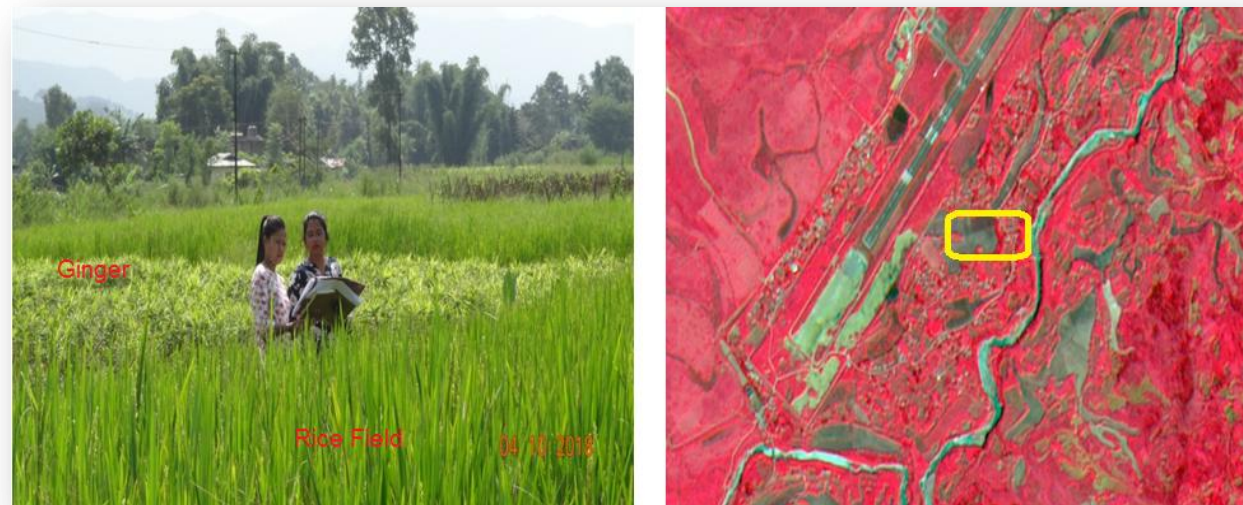


2

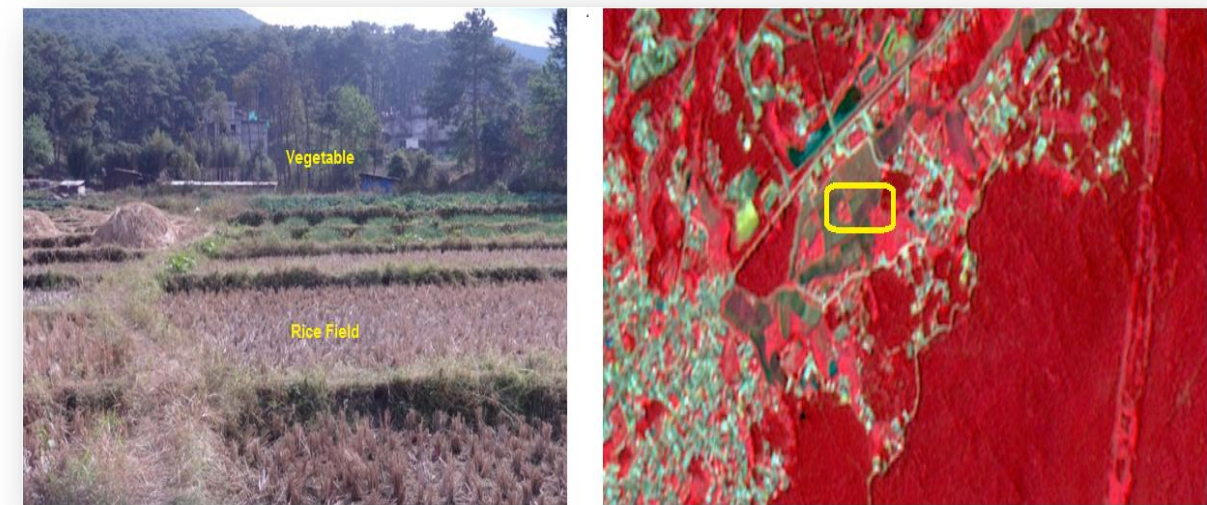




Annexure - I



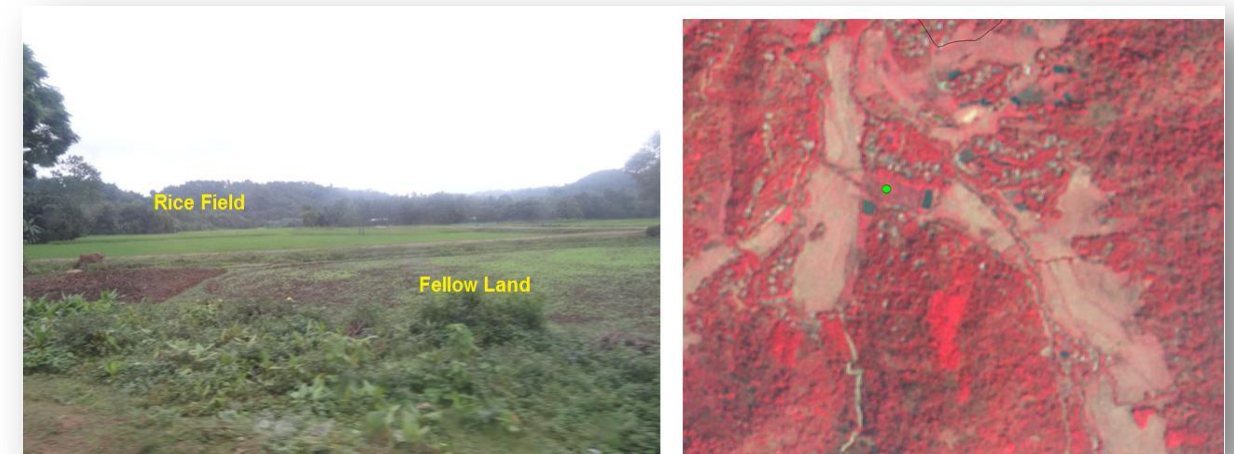
Rice field mixed with zinger cultivation near Umroi airport



Rice field with vegetables in Mawkyntroh, East Khasi Hills



Fallow land near rice field Klaicharpara, South West Garo Hills



Fallow land near rice field Manikganj North Garo Hills

STATE MAPS