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CASE STUDY

Rice suitability mapping using the analytic hierarchy process approach in a river catchment

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ABSTRACT

BACKGROUND AND OBJECTIVES: Land suitability analysis is a technique of attaining optimum utilization of natural available land resource. This study is the first attempt to map the potential rice suitability zone besides the existing rice cultivation zone in Imphal-Iril River catchment. The overriding objective of this study is to identify the land suitability potential zones for rice crop cultivation. The study was carried-out in Imphal-Iril River catchment, Manipur, India.
METHODS: The suitability analysis was carried-out based on soil, climate and topographic parameters as the input variable using integrated geographical information system and analytic hierarchy process, a multi criteria decision based approach. To compute criteria weight for various suitability classes, pairwise comparison matrix was applied using analytical hierarchy process and the resulting weights were used for assigning criteria ranking.
FINDINGS: The study result indicates that the major section of high and moderate potential suitability zones of rice is concentrated in the flatter valley regions of the catchment. The result also indicates that there is 79.15 km^2 of the area which can be potentially cultivated other than the existing agriculture cover. The major patches of such zones are found in the north-western portion of the valley region in the catchment.
CONCLUSION: This study clearly indicates, the potential zones lying in the foothills in the north-western which are still not under the agriculture cover have the potential to be cultivated as per the model result. The model result clearly indicates the potential of geographical information system integrated with analytical hierarchy process technique can be utilized to decide the weights of each individual parameter using experts' opinions which can serve as a versatile tool to carry-out such kind of analysis which can aid policy makers.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
35	7	6

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INTRODUCTION

Rice (Oryza Sativa) is the primary cereal food crop for more than 60 percent (%) of the world's population. Globally, rice is produced in many countries but Asia alone accounts for more than 90% of the world rice production and consumption (Naidu *et al.,* 2006) and they are grown successfully in tropical and sub-tropical regions (FAO, 2004). Rice is the major cereal crop in India having a total cultivable area of about 180 million hectares, even in North-East part of India it is the primary staple food crop. In Manipur state of North-East India, 90% gross crop area is under rice production (Singha and Mishra, 2015). Out of 95% of the entire state of Manipur's food grains production, 72% of the total cropland area is rice production (Santosh and Bera, 2017). Agriculture is the backbone of the state economy and majority of the people are involved in agriculture and allied sectors (Roy *et al.,* 2018). In Manipur, rice crop is cultivated predominantly in kharif season (June to November). In the valley region of Manipur, cultivable area have been decreasing day by day due to urbanization, construction and development activities, rendering an assessment of agricultural land suitability and mapping scope of sustainable agricultural development inevitable (Akpoti *et al.,* 2019). Optimum rice production is necessary through sustainable agriculture practice system. Sustainable agriculture concept involves producing good quality product, generally acceptable and economically efficient way by ensuring optimal utilization of natural available resources and target crops (Jules and Zareen 2014; Struik and Kuyper 2017). Sustainable agriculture requires growing the best suited crop for the specific region which further necessitates the analysis of land suitability (Kihoro *et al.,* 2013; NissarAhmed *et al.,* 2000). It is based on finding the requirements of crop and its corresponding land features class (Mugiyo *et al.,* 2021; Bock *et al.,* 2018). Thus, suitability analysis measures how well fit the qualities of land unit is with the requirements of a particular form of land used (Hamere and Teshome, 2018; FAO, 1976). Land suitability based on agriculture is an important assessment for future planning and development, and it also help to the decision makers and planners (Mohamed *et al.,* 2016). In the past decades Multi-Criteria Evaluation (MCE) integrated with Geographical Information System (GIS) has been used to assess the suitability potential (Anand *et al.,* 2021; Bandira *et al.,* 2021). GIS integrated with MCE is useful because various variables which impact the production is evaluated and are weighted as per their relative importance in optimal crop's growth condition (Perveen *et al.,* 2007). Multi-criteria decision method like analytical hierarchy process (AHP) has been integrated with GIS. Geospatial technology which includes remote sending, GIS and global positioning system (GPS) have been implemented in different parts of the world to assess the land suitability, to enhance the crop productivity and reduce environmental footprints and cost for input material (Dhami *et al.,* 2012). The main advantage of GIS based techniques over the other used techniques is the scale of application. Other techniques are limited to plot scale or a sub-regional scale and consume more human effort along with cost of equipments, whereas GIS based techniques are cost effective and can be applied over a vast land coverage using aerial or satellite datasets (Yalew *et al.,* 2016). Furthermore, the integration of AHP and GIS-based techniques in assessing land suitability has excellent prospects to enhance the efficiency and accuracy of findings. Using the AHP method of the MCDA technique with GIS is a valuable method for diversifying the crops and cropping systems for obtaining better output from agriculture-food systems (Jain *et al.,* 2020; Kihoro *et al.,* 2013). GIS allows the build-up of models using a new thematic map that can be developed from a set of thematic maps which is easier to visualize for the decision or policy makers. There have been only few studies carried out on rice productivity, socio-economic inter-relationship (Bidyapati and Kaushal, 2020), and trend analysis (Ria *et al.,* 2020). This study is the first attempt in Imphal-Iril catchment to identify the potential rice cultivation suitability zone other than the existing agricultural cover. The main objective of this study is to identify potential cultivation site of rice for optimum production, and compare the suitability zones with existing agricultural lands. The current study was carried out based on the datasets between the time periods 2000-2019 in Imphal-Iril catchment, India.

MATERIALS AND METHODS

Study area

Manipur is situated in the North-Eastern region of India and covering an area of 22,327 Square kilometer (km^2). It consists of 90% of hilly area and remaining 10% has the valley area. The valley has slope from north to south direction and having annual average rainfall of 1467 millimetre (mm)(DOE, 2013). Imphal-Iril River catchment is considered as the present study area and it is located in the North-Eastern portion of the state. Geographical location of the present study area is shown in Fig. 1. Agricultural land, vegetation, settlement, bare soil and water bodies are the different land use classes present in this catchment. In the study area the natural vegetation comprises of many diversities of plants including grasses, bamboos and numerous species of tree. Hill terrain is occupied by medium to thick tropical deciduous forest. Agriculture is the main state economy and therefore, more than 75% of the people living in this area are involved in agricultural activities and allied sectors and experiences the humid climate with seasonal water deficiency (Sen *et al.,* 2006). The Hydrochemical composition and quality of rivers and the river beds have always been influenced by natural and unnatural (Pollution) factors (Karbassi and Pazoki, 2015).

Dataused

Important parameters used in this suitability analysis are climate data (temperature, rainfall), soil data (texture, depth, drainage, soil pH) and topography. These parameters were carefully selected based on local expert knowledge, data availability, literatures review and researcher. Climate Data: crop growth, developments and productivity of rice is very much depending on various climatic factors. From these various factors, rainfall and temperature were selected in this suitability analysis. Rice is normally grown in tropical and sub-tropical region at a temperature between 20 °C to 40 °C with an annual average rainfall greater than 1250mm. Twenty years tropical rainfall measuring mission (TRMM) daily rainfall and moderate resolution imaging spectrometer (MODIS) (MOD11A1) surface temperature data were used in this study. The detail information regarding the data is described in Table 1.

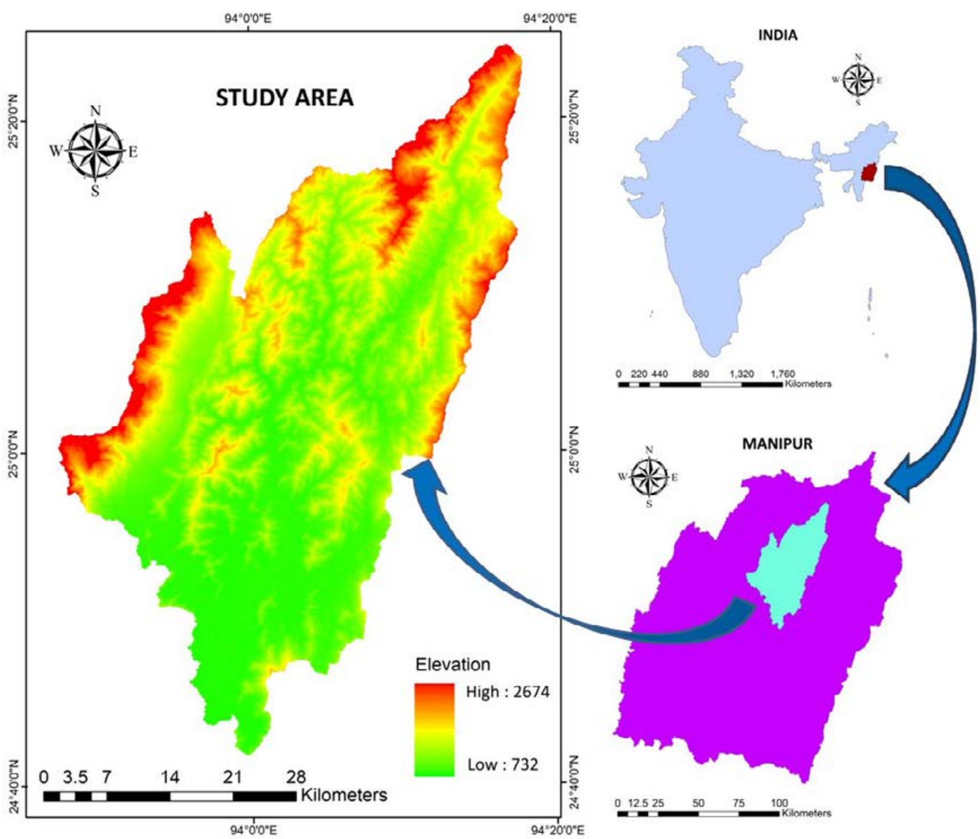


Fig. 1: Geographic location of the study area in the land suitability potential zones for rice crop cultivation along with land use/ land cover in the Imphal-IrilRiver catchment, Manipur, India

Soil data

Soil is one of the basic components for agriculture environment as it provides structure support and nutrient to the plant's growth. Good knowledge of chemical and physical properties of soil is required for land suitability analysis. Some important soil parameters used in this study are soil texture, soil drainage, soil depth, and soil pH (Karbassi and Heidari, 2015). These soil information data were obtained from national bureau of soil survey and land use planning and Indian council for agricultural research (NBSS and LUP and ICAR) (Sen*et al.,* 2006).

Topography

The important topographic element for the application for land suitability analysis is slope and it can be assisted in site and suitability analysis. Slope is generally computed from digital elevation model (DEM). The shuttle radar topography mission (SRTM) DEM having spatial resolution of 30 metre (m) was used to compute elevation using spatial analyst tools in ArcGIS 10.3. Steeper terrain is observed when the slope value is high, whereas flat surface terrain is observed when the slope value is low. The terrain having smooth surface are more suitable for rice production since water can be distributed uniformly in all directions.

Multispectral data

The multispectral remote sensing images of Landsat-8 (OLI+TIRS) of the study area were collected from United States Geological Survey (USGS) Earth Explorer. Landsat-8 imagery data has a temporal resolution of 16 days having a spatial resolution of 30 m. The present LULC map of Imphal-Iril catchment was generated using the Landsat-8 imagery data in ArcGIS 10.3 with maximum likelihood classifier tool. The parameters used in this study are described in Table 1.

The requirement of rice suitability was obtained from NBSS and LUP (Naidu *et al.,* 2006). All the parameters are developed in raster data format to run the suitability model in ArcGIS 10.3. Raster datasets were converted into Universal Transverse Mercator (UTM) coordinate system having zone 46N and resample into a spatial resolution of 30 m. The input

Table 1: Description of input parameters

Parameter/satellite	Description	Resolution
Rainfall	20 years(2000-2019)	25 km
Temperature	20 years(2000-2019)	1 km
soil data	Texture, Depth, Drainage, pH	-
Slope	Year-2019	30 m
Multispectral data	Year-2019	30 m

Table 2: Suitability criteria for rice (NBSS and LUP) (Naidu *et al.,* 2006)

Parameter	Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Rainfall	mm	1110 - 1250	900 – 1110	750 - 900	< 750
Temperature	Celsius	30 - 34	21-29 & 35-38	15-20 & 39-40	< 15 &> 40
Soil Texture	Class	C, SIC, CL, SICL,SC	SCL, SIL, L	SL, LS	S
Soil Depth	cm	>75	51 – 75	25 - 50	< 25
Soil Drainage	Class	Imperfectly drained	Moderately drained	Well drained	Excessively drained
Soil pH	1:2.5	5.5 - 6.5	4.5 - 5.4	7.6 - 8.5	> 8.5
Slope	%	0 - 2	1 – 2	3 - 5	> 5

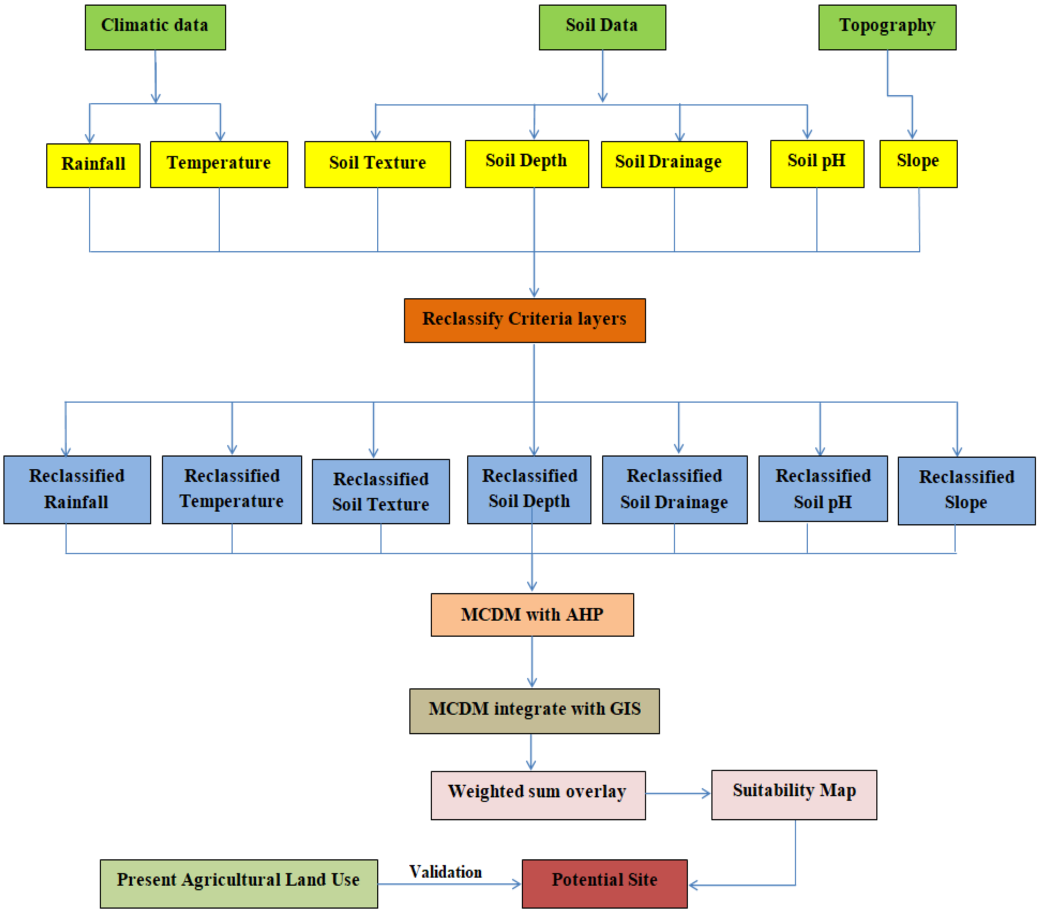


Fig. 2: Methodological approach for rice suitability mapping

datasets were reclassified into different suitability classes based on NBSS and LUP and ICAR classification using spatial analyst tool in ArcGIS. These classified layers rating are shown in Table 2. Based on Food and Agriculture Organisation (FAO, 1976) land suitability classification, suitability class for the parameters used in this study were ranked as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N). The overall methodological approach for rice suitability analysis is shown in Fig. 2.

Analytical hierarchy process and assigning criteria weight

AHP is a multi-criteria decision making method and it is extensively used by many researchers for various studies (Saaty, 1980). This method can be integrated with GIS for various suitability modelling (Marinoni, 2004). In this method one of the crucial steps is to assign weight to the input data with high degree of precision. It is necessary to determine the rate or relative importance for each criterion present in the decision making problem (Saaty, 1980). Pairwise comparison matrix proposed by Saaty (1980) has been applied for decision making method in this study. Simultaneously, factor weights were determined through comparison of the two factors by using pairwise comparison matrix. In this comparison matrix a scale having the value range from 9 to 1/9 was applied as per scale provided by Saaty (1980). A score of 9 in the rating value indicates the row factor is extremely important than the column factor. Subsequently, a score of 1/9 in the rating scale indicates the column is more important over row factor. Furthermore, a score of 1 in the rating

Table 3: Pairwise comparison matrix

Parameter	Temperature	Rainfall	Soil texture	Slope	Soil pH	Soil depth	Drainage
Temperature	1	1/3	1/5	1/3	3	5	3
Rainfall	3	1	1/3	3	7	5	5
SoilTexture	5	3	1	3	7	5	5
Slope	3	1/3	1/3	1	7	7	3
Soil pH	1/3	1/7	1/7	1/7	1	1	1/5
Soil Depth	1/5	1/5	1/5	1/7	1	1	1/3
Drainage	1/3	1/5	1/5	1/3	5	3	1

Table 4: Normalized comparison matrix

Parameter	Temperature	Rainfall	Soil texture	Slope	Soil pH	Soil Depth	Drainage	Weight	Ranking
Temperature	0.08	0.06	0.08	0.04	0.10	0.19	0.17	0.10	4
Rainfall	0.23	0.19	0.14	0.38	0.23	0.19	0.29	0.24	2
Soil Texture	0.39	0.58	0.42	0.38	0.23	0.19	0.29	0.35	1
Slope	0.23	0.06	0.14	0.13	0.23	0.26	0.17	0.17	3
Soil pH	0.03	0.03	0.06	0.02	0.03	0.04	0.01	0.03	7
Soil Depth	0.02	0.04	0.08	0.02	0.03	0.04	0.02	0.04	6
Drainage	0.03	0.04	0.08	0.04	0.16	0.11	0.06	0.07	5
CR=0.06			Eigen value = 7.48					∑ = 1	

Table 5: Random index (RI)

Order Matrix(n)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0.0	0.0	0.58	0.90	0.12	1.24	1.32	1.41	1.45	1.49

value indicates its equal importance (Saaty, 1977). A value of unity is assigned to diagonal elements once a criteria factor is compared with itself. Pairwise comparison matrix and normalized comparison matrix developed for this study are shown in Tables 3 and 4 respectively. In this method, only triangular half portion of matrix needs to fill since the matrix is symmetrical. The weights of individual parameters to construct the pairwise comparison matrix were allocated based on literature survey and through questionnaires with the experts of agricultural domain. Thus, the remaining elements are simply reciprocal of another half portion. For example, if the rating of rainfall with respect to temperature is 3, than rating of temperature with respect to rainfall is 1/3. In order to generate the normalized comparison matrix, the individual components of the matrix were divided with its corresponding sum of the column. Later, based on the sum of the rows of normalized comparison matrix was divided with the number of parameters to generate the weights of individual parameters. It is necessary to check the pairwise comparison matrix is consistent or not. As per the AHP model, pairwise comparison matrix should be consistent. The resultant consistency Index (CI) for the matrix is calculated using the Eq. 1 (Saaty 1977).

$$CI = (\lambda max-n)/(n-1) \quad (1)$$

Where, λmax is maximum the Eigen value and n is the number of criteria of the comparison matrix.

Then, the Consistency Ratio (CR) is calculated for the corresponding n value of random index (RI) using the following Eq. 2 (Saaty 1977). The value of RI is obtained from Table 5.

$$CR = \frac{CI}{RI} \quad (2)$$

If the CR value is less than 0.1, it indicates that the comparison matrix is significant and the judgement is correct (Saaty 1977; Park *et al.,* 2011). For this comparison matrix, the CR value of 0.06 was

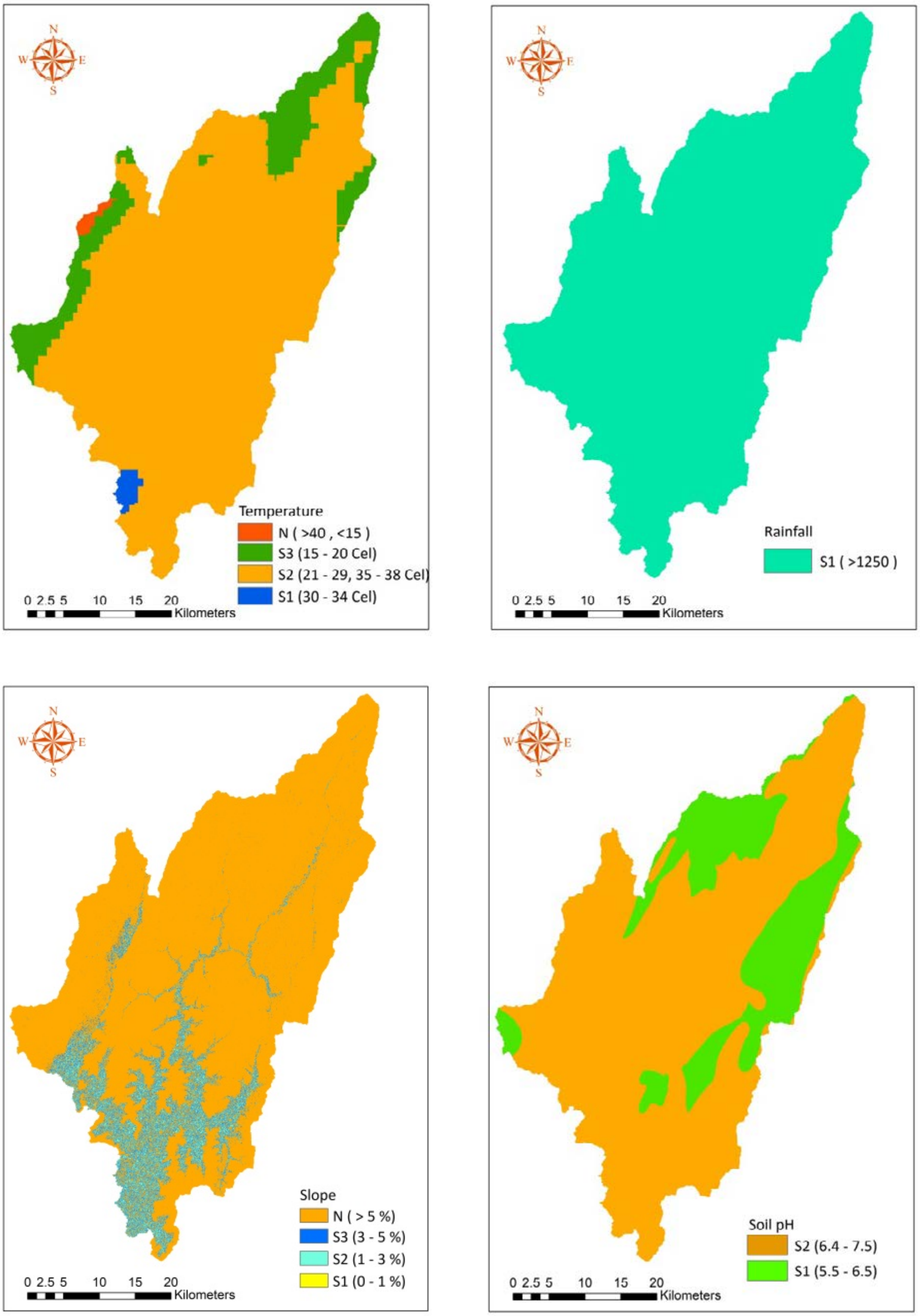
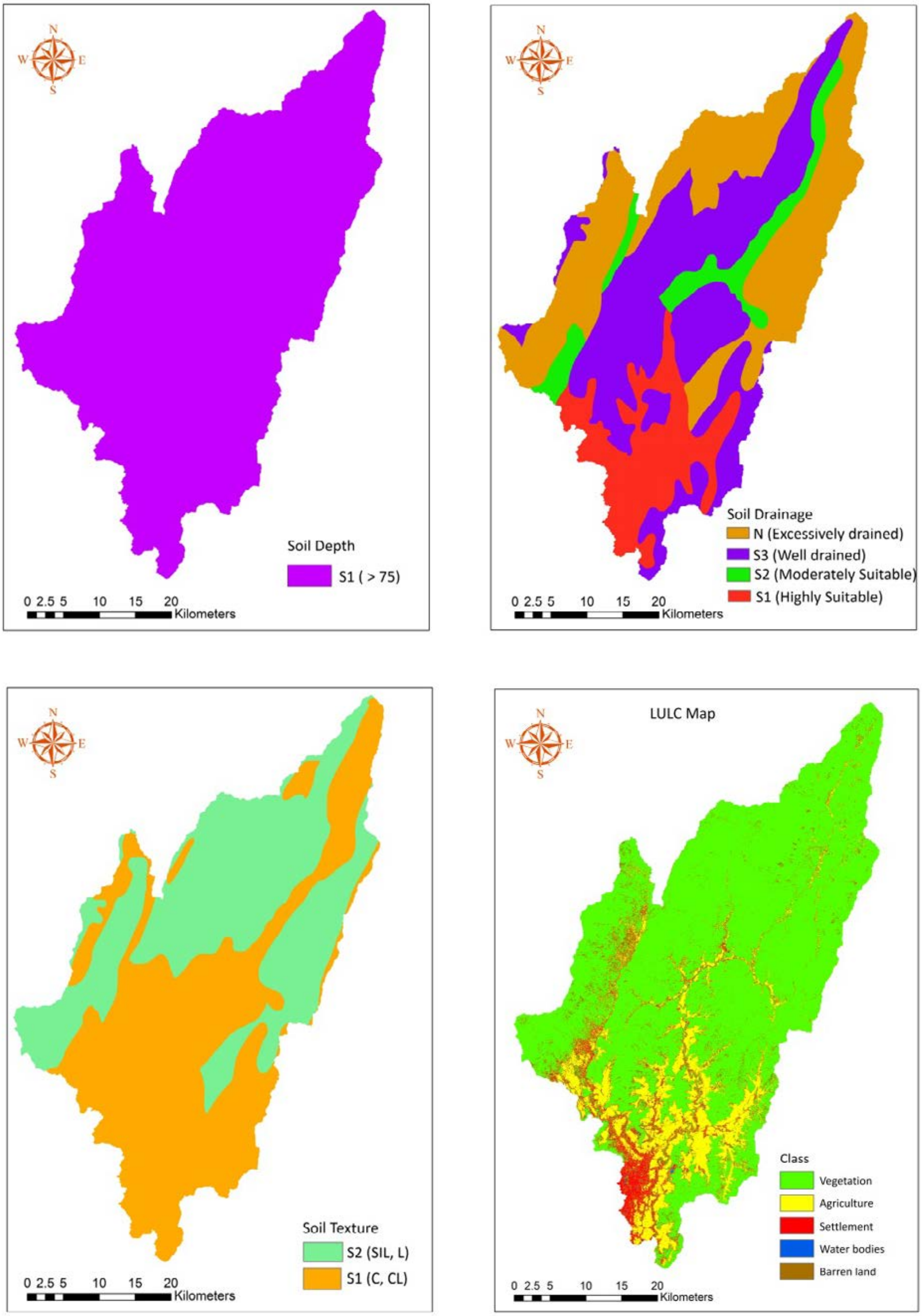


Fig. 3: Suitability level for selected parameters: temperature, rainfall, soil texture,slope,pH, soil depth, soil drainage and land use land cover (LULC)



Continued Fig. 3: Suitability level for selected parameters: temperature, rainfall, soil texture,slope,pH, soil depth, soil drainage and land use land cover (LULC)

Table 6: Parameters with its assigned rates and their corresponding weights

Parameters	Range	Rating	Weight
Rainfall	>1100 mm	4	0.24
	900-1100 mm	3	
	750-900 mm	2	
	<750 mm	1	
Temperature	>29 ºC	4	0.10
	21-29 ºC	3	
	15-21 ºC	2	
	<15 ºC	1	
Soil Texture	Clayey, clay loam	4	0.35
	Silty loam, loam	3	
Soil Depth	>75 cm	4	0.04
Soil drainage	Imperfectly drained	4	0.07
	Moderately drained	3	
	Well drained	2	
	Excessively drained	1	
Soil pH	5.5-6.5	4	0.03
	4.5-5.4	3	
Slope	0-1 %	4	0.17
	1-3 %	3	
	3-5 %	2	
	>5 %	1	

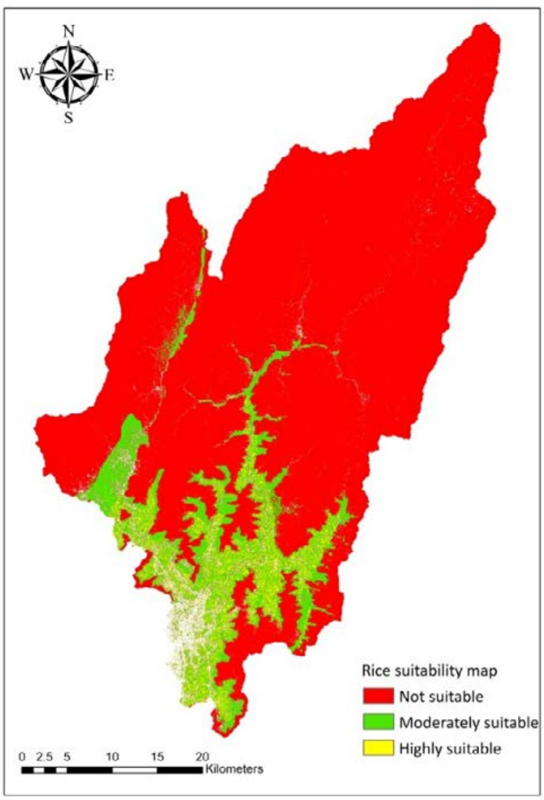


Fig. 4: Suitability map for rice crop

obtained. The result shows that the comparisons of these parameters are consistent and matrix is highly significant.

In this suitability analysis the input parameters were standardized to a scale from 1 to 4 since parameters were collected from different sources (Ahmad *et al.,* 2021). Thus, all criteria were classified into 4 classes that ranges from a score of 1 to 4 based on its different land suitability class. The highest suitability is indicated by the score value 4 and the least suitability is indicated by the score value of 1. The map of suitability levels for seven parameters use in this study are shown in Fig. 3.

Weighted sum overlay technique has been applied to compute rice suitability mapping through spatial analyst tools in ArcGIS 10.3. It is a technique to create an integrated analysis by applying a common scale of value for different input data (Kuria *et al.,* 2011). Different raster layers with their corresponding criteria weights were assigned as per to AHP procedure. The rating and assigned weight of each parameter is shown in Table 6. Then the selected land suitability criteria weights are multiplied by assigned rating score of suitability class (Raster layers). The final suitability map was computed by adding the resulting the cell values as shown in Fig. 4 and the resulting suitability map was classified as highly suitable, moderately suitable, marginally suitable and not suitable. Thus, we obtained the spatial distribution for different suitability classes for rice cultivation in the catchment.

RESULTS AND DISCUSSION

Suitability assessment of rice in the catchment

The land suitability analysis for rice production was carried out for the whole Imphal-Iril sub-catchment which includes both valley and hilly terrain region. Later, the land suitability for rice was extracted particularly for the valley and foot hills region of the catchment with gentle slope as the hilly regions especially in the mid and upper reaches is covered mostly by evergreen and deciduous forest. The rice suitability map identified by weighted overlay method embedded in tool box of ArcGIS is shown in Fig. 4. From the rice suitability map in Imphal-Iril sub-catchment it can be observed that, highly suitable class covers an area of about 60 km^2 which is characterized by slope value range of 0 - 1%, soil pH value of 5.5 – 6.5, soil depth of greater than 75 centimetre (cm), soil texture class-clay, silty-clay, clay-loam, sandy-clay, annual average rainfall ranges between 1110-1250 mm, soil drainage-imperfectly drained and temperature between 30-34 °C. From the analysis it was observed that the highly suitable zones are mostly located in the flatter valley regions of the current existing agricultural land of the catchment. Moderately suitable area for rice production was spread over an area of 211.6 km^2. This class were characterised by slope value range of 1- 3%, pH level between 6.4-7.5 and 4.5-5.4, soil drainage -moderately well drained, soil texture-sandy clay loam, silt loam and loam, temperature between 35 °C– 38 °C and rainfall in between 900 and 1110 mm. From the land suitability map it can be observed that the moderately suitable zones were mainly concentrated in the valley and the foot hill regions of the catchment with the milder sloping topography. From the model output result it was found that marginally suitable and not suitable class were found only in the higher hilly reaches. Large considerable amount of area was found under not suitable and marginally suitable class as compared to other suitability classes. It is because due to the presence of large hilly regions, natural wildlife habitat area and protected reserved forest area. Primarily, hilly regions having high slope profile are not suitable for agricultural activities particularly for rice crop and secondarily, those regions are covered with dense evergreen and deciduous forest which cannot be slashed due to this, not suitable and marginally suitable class were merged together. The results indicate that highly and moderately suitable zones are significantly located in the lower flatter regions of the catchment. To further extract the potential suitability region and existing agricultural region the study was carried focusing particularly the flatter valley region of the sub-catchment.

Potential area for rice cultivation in the valley region of the catchment

The land suitable for the rice cultivation was extracted from the valley region of the catchment using Structured Query Language (SQL). In the valley region of the catchment only two suitability class were observed, that is, highly suitable class and moderately suitable class. From the suitability result at the valley level it was observed that the area coverage under highly and moderately suitable class was found to be

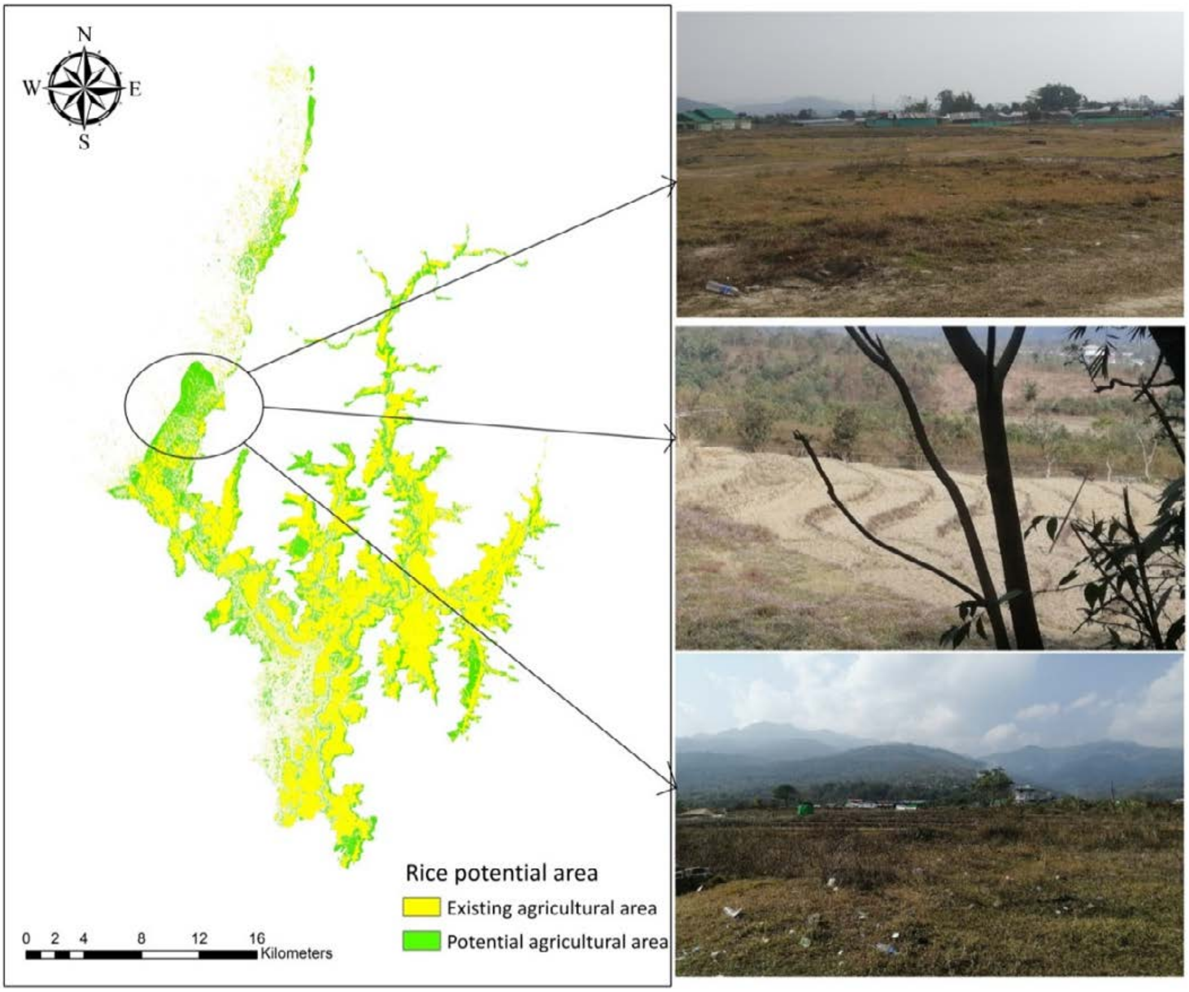


Fig. 5: Potential area for rice cultivation along with the field photographs

60.01 km^2 and 211.63 km^2. Highly suitable zones were mainly concentrated in the central part of the valley with milder slope, whereas the moderately suitable zones were mainly concentrated near the foot hills with mild/gentle slope. Out of the total area of 271.64 km^2 covered under moderate and highly suitable class, it was observed that the 192.49 km^2 of the area is already under existing agriculture cover. The existing LULC of the catchment covering agriculture class is shown in the Fig. 3. It can be clearly noted that the 79.15 km^2 of the area still has the potential for rice to be cultivated in such zones in the valley. Interestingly it can be noted that the zones with higher suitability is already covered with the existing agriculture cover, whereas the area near the foothills which falls under moderately suitable class still has the potential to be cultivated since it is not covered under existing agriculture cover. The area under existing agriculture cover and the areas which still have the potential to be cultivated is shown in Fig. 5. There were some major stretches of the land were identified as: 1) near to Kanglatombi, Keithelmanbi, and Kangpokpi and 2) Chanam Sandrok, Langdum. In order to field validate the model result a field survey was carried-out in the Kanglatombi, Keithelmanbi region using handheld Global Positioning System (GPS). From the field survey it was observed that the few stretches of land are being cultivated but the majority portion of the land is still not under the agriculture cover which still has the potential to be cultivated as indicated by

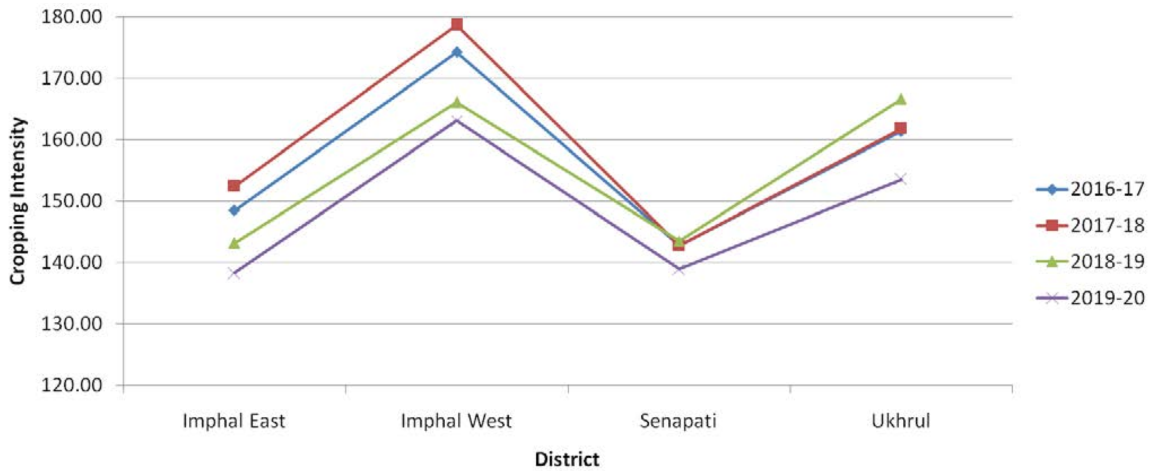


Fig. 6: Cropping intensity of each district lying under Imphal-Iril River catchment (DOA, 2022)

the model result. The potential area which can be cultivated along with the field photographs indicating the small patches of land which is being cultivated and majority of those still left barren is shown in Fig. 5. In this study, the criteria for evaluation were opted by considering the crop requirements based on the local conditions. Factors were selected according to the share knowledge of local experts in agronomist and available relevant literature review. The result of this study provides vital information on the importance of parameters relatively and could be beneficial for the future reference on rice and other crops. This study will further serves as general spatial guideline to the local farmers of the region for their strategy of land use management and crop.

The cropping intensity data was obtained from Directorate of Agriculture (DOA), Govt. Of Manipur at district level for four district namely Senapati, Ukhrul, Imphal West, and Imphal East which intersects the Imphal-Iril River catchment. The trend of cropping intensity between the time periods 2016-2020 is shown in Fig. 6. Since the Senapati and Ukhrul district are under restricted forest belt, the model result was validated by using the datasets of Imphal East and Imphal West districts which covers nearly 95% of the area under rice cultivation in the catchment. The result was validated based on agriculture coverage intensity expressed in terms of percentage. The agriculture area intersected by Imphal East and Imphal West district under Imphal-Iril River catchment was taken into consideration. The agriculture coverage intensity was computed based on the ratio of total geographical area and the gross cultivable area. The agriculture coverage intensity of Imphal East and Imphal West was computed based on the data obtained from DOA at district level. The computed agricultural coverage intensity was compared with the agriculture coverage intensity simulated by the model under the intersecting zone of Imphal East and Imphal West district. Agriculture area intercepted by Imphal East and Imphal West district under Imphal-Iril River catchment is shown in Fig. 7. The agriculture coverage intensity computed from the field based data obtained from DOA were found to be 71.91% and 84.83% for Imphal East and Imphal West district whereas, the agriculture coverage intensity computed from simuated result of the model for Imphal East and Imphal West under the intersecting zone of Imphal-Iril River catchment were found to be 79.97% and 78.31%, respectively.

CONCLUSIONS

The rice suitability analysis carried out in this research study clearly indicates the capability of AHP in predicting the suitable zones of rice cultivation when integrated with GIS. The model performance was found to be satisfactory when validation with field based data with model uncertainty lying within

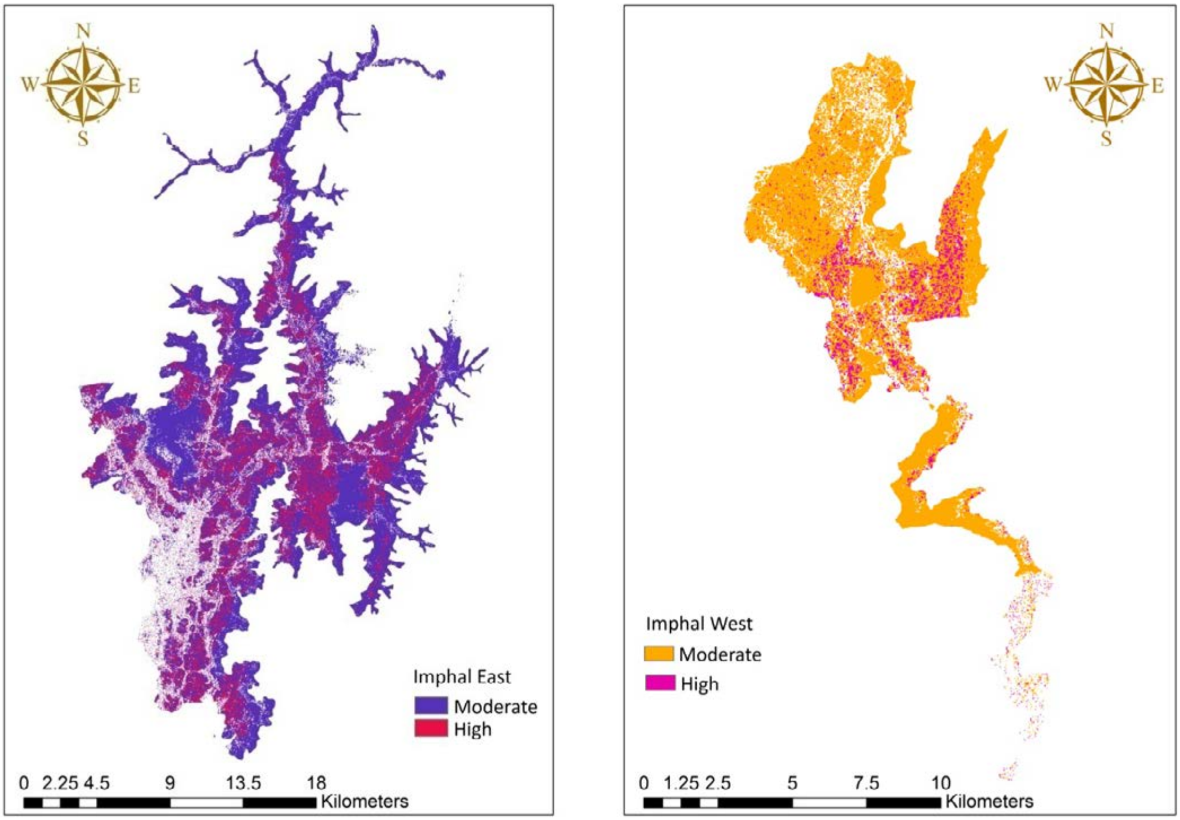


Fig. 7: Agriculture area intercepted by Imphal East and Imphal West district under Imphal-Iril River catchment

10% limit when agriculture coverage intensity of field was compared with the simulated result of Imphal East and Imphal West intersecting within the catchment boundary. The results of this study demonstrate the potential use of Geographical Information System and spatial analyst tools using AHP in identification of potential zones for rice cultivation. It could aid in developing a guide map and suitable database for policy makers which will help in achieving high production of rice in the region. AHP integrated with GIS enables the user to induces the expert based knowledge while carrying out the suitability modelling whereas, the integration with GIS provides the interface to indentifies the zones or its spatial variability since the datas are geotagged. As per the model result of Imphal-Iril River catchment, high and moderate suitability zones were located in the valley region whereas, the marginally suitable to not suitable zones were located in the hilly region. Though the model performance indicates there are few patches of land were in moderately suitable zone, but practically they cannot be cultivated because of dense deciduous forest cover. In particular, this study clearly indicates the potential zones lying in the foothills which are still not under the agriculture cover. 271.64 km^2 in the valley lies under moderate and highly suitable class of which 70.86% is under agriculture cover, whereas 29.14% of the area lying under moderate suitability class still has the potential to be cultivated. The major section of such potential region can be found in the north-western part of the valley as per the model result. For the purpose of crop management diversification, this study clearly presents the spatial distribution of rice drawn by digitized datasets along with the evaluation of topographic, climatic and soil parameters. The results of this study can provide vital information to the local farmers to select their pattern of cropping. This study results is based on the past climate datasets, and there is a future potential of study which can be done using future projected General Circulation Model (GCM) datasets to provide the suitability potential of rice in the Imphal-Iril River catchment for the future. As this study is based on soil, topographic and climate parameters, this study paves a way for further study which can be done by incorporating socio-economic factors and irrigation facilities available at regional level which drives the sustainable use of land resources.

AUTHOR CONTRIBUTIONS

N. Robertson performed the literature review, framework of this study, data analysis and interpretation; prepare the manuscript text and manuscript edition. B. Oinam performed the literature review, model configuration and critical revision of manuscript and supervision.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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ABBREVIATIONS

%	Percentage
AHP	Analytical hierarchy process
°C	Degree Celsius
C	Clay
CI	Consistency index
CL	Clay loam
cm	centimetre
CR	Consistency ratio
DEM	Digital elevation model
DOA	Directorate of Agriculture
Eq	Equation
FAO	Food and Agriculture Organization
GCM	General circulation model
GIS	Geographical information system
GoM	Government of Manipur
GPS	Global positioning system
ICAR	Indian council for agricultural research
Km^2	Square kilometre
L	Loam
LS	Loamy sand
LULC	Land use land cover
MCE	Multi criteria Evaluation
mm	Millimetre
MODIS	Moderate resolution imaging spectrometer
n	Number of criteria in pairwise comparison matrix
N	Not suitable
NBSS and LUP	National Bureau of Soil Survey and Land Used Planning
OLI	Operational land imager
RI	Random index
S	Sandy
SIL	Silt loam
SL	Sandy loam

S1	Highly suitable
S2	Moderately suitable
S3	Marginally suitable
SCL	Sandy clay loam
SIC	Silt clay
SQL	Structured query language
SRTM	Shuttle radar topography mission
TIRS	Thermal Infra-Red Scanner
TRMM	Tropical rainfall measuring mission
UTM	Universal transverse Mercator
USGS	United States Geological Survey

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