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Research Article

IDENTIFICATION OF POTENTIAL WET RICE CULTIVATION AREAS IN MIZORAM, INDIA: A REMOTE SENSING AND GIS APPROACH

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ABSTRACT
Food grain production in Mizoram generally refers to agricultural activities and its allied fields where rice is the main component and staple crop. Cultivation of paddy/rice is taken up either in the form of wet rice cultivation in valley plains or as upland rice cultivation on hill slopes. The latter type of cultivation is practiced on jhum lands where traditional knowledge of cultivation practices is still followed and the productivity is generally low. Wet rice cultivation (WRC) is more or less an evolved system for rice production in the state, practiced in a systematic manner with better productivity. Due to the hilly undulating terrain of the state, the existing WRC areas are confined to only a few places, usually close to river banks and valley plains. The present study has been taken up to identify the additional potential areas for wet rice cultivation besides the existing areas, and to investigate on the practical feasibility of locating potential WRC areas based on slope, water resource availability, land use pattern and environmental aspects of the state. This study also highlights and extensively utilizes the capability of remote sensing and GIS techniques for mapping and identifying the potential WRC areas. The results of GIS analysis have shown that there is substantial potential area (3.54% of total geographical area) which can be utilized for wet rice cultivation. The present study also gives a comparative analysis of the district-wise WRC potential areas that may serve as useful data for preparation of Agriculture and allied schemes.

Key Words: *GIS, Food Grain, Mizoram, Potential Areas, Remote Sensing, WRC*

INTRODUCTION
Rice is the main staple food crop and one of the important food grain components in Mizoram. Since the consumption of rice is high in terms of food grains, the WRC area has to meet the demands for higher production of this food grain. The present scenario shows that much of this demand is still not met from existing wet rice cultivation areas and a larger percentage of the demand is filled up by importing from other states of the country. The state government through its concerned Agriculture department has been taking up measure and steps to increase the production of rice in the state by way of introducing better package of practices and mechanisation of farms. As a result, the areas of wet rice cultivation were increased by 28.4% during 2011 and an overall 10% increase in food grain production was achieved during the past year (Zodinsanga, 2013). However, the state's rice production was hardly 30% of its consumption, indicating that there is still more to be achieved to meet the consumption demands of the state. With over 60% of the total agricultural work force engaged either directly or indirectly in agriculture (Agriculture Dept., 2013), shifting cultivation still predominates the form of farming which is also still under-developed and primitive, not to mention its low production and productivity. Rice is cultivated in these jhum lands where slope percent is usually high. Generally, local upland varieties ('tai' & 'buhpui') are cultivated in monoculture or mixed with other crops (Tawnenga *et al.*, 1996) on these sloping lands under traditional package of practices. Productivity from shifting cultivation is not high and can barely sustain the food requirements of the locals, as soil fertility declines even at the first and second year of cropping, with the decrease more pronounced during the second year of cropping (Tawnenga *et. al.*, 1997). This also applies to upland paddy/rice cultivation as its cultivation is declining in jhum lands under force of declining productivity (MART, 2011).

Space technology has been utilized to map land features and locate potential areas from different kind of land uses. Visual interpretation techniques of remotely sensed images have been used for identifying and classifying broad land use classes in Aizawl district (Lallianthanga *et al.*, 1999). The existing wet rice cultivation areas are often demarcated during the process of land use / land cover mapping and represents a constituent land use class in the classification of land features in the state. These cultivation areas are identified from remotely sensed multi-temporal satellite data (MIRSAC, 2009a) as large cropped areas or small and linear patches along river banks. The current scenario depicts the general reliance on flat river valley plains for wet rice cultivation, resulting in few areas being implemented for productive rice cultivation. This limited scope could be extended if potential areas are identified using other terrain factors like slope and associating it during the process of GIS analysis. Identification of most of the rice cultivation areas using Remote sensing data alone is not an easy task because of the tiny field sizes and partly jhum cultivation practices where agriculture if mixed with shrubs (Shirish Ravan *et al.,* 2004). Besides being associated with river valleys, the WRC areas have potential implementation on gentle slopes ranging from 0-25% (MIRSAC, 2008). The present study utilizes remote sensing and GIS techniques to locate and identify potential wet rice cultivation areas in Mizoram.

MATERIALS AND METHODS

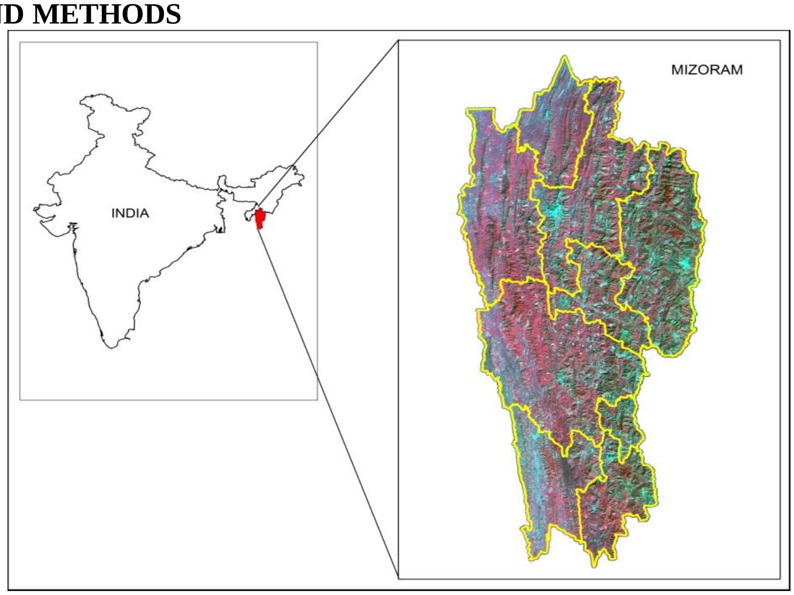

Figure 1: Location map of study area, Mizoram

Study Area

The study area covers the entire state of Mizoram, located in the north eastern part of India. The state shares national borders with Assam, Tripura and Manipur. It occupies an important strategic location in north east India as it shares a long international boundary with Myanmar (to the east) and Bangladesh (to the west). It is also known for its rugged hilly terrains, winding rivers with sparse to dense forest throughout. The State has a geographical area of 21,081 sq.km and lies between the coordinates of 21^{o} 58′ & 24^{o} 35′ N Latitude, and 92^{o} 15′ & 93^{o} 20′ E Longitude (Figure 1), with the tropic of cancer passing through the State at 23^{o} 26′ N latitude. The State has a climate ranging from moist tropical to moist sub-tropical. During winter, the temperature varies from 9.4^{o}C to 25.5^{o}C and in summer, it varies between 14^{o}C to 33.1^{o}C (MIRSAC, 2012). The state is under the direct influence of south west monsoon, with average annual rainfall of 2693.4 mm (MIRSAC, 2012).The physiography of Mizoram can be broadly divided into hills and valleys. The physical set-up is composed predominantly of mountainous terrain of tertiary rocks. The hilly terrains (High hills) are undulating with average altitude above 1300 m (msl), Medium hills with altitudes ranging between 500 m and 1300 m and Low hills with altitudes below 500 m above msl with the maximum reaching 2,157 m in Phawngpui (Blue Mountain) (MIRSAC, 2009). On the basis of Champion & Seth classification system (1968), the forests of Mizoram have been broadly divided into 4 (four) forest type groups, viz., Tropical Semi-evergreen forest, Tropical Moist Deciduous forest, Sub-tropical Broad-leaved Hill forest and Sub-tropical Pine forest (FSI, 2011). Bamboo forest constitutes a majority of understory species of Tropical Moist Deciduous forest type (Lallianthanga & Robert, 2012).

Data Used

Multi date satellite imagery (LISS III) of IRS-1D and Cartosat-I was acquired from National Remote Sensing Centre (NRSC), Hyderabad. Other ancillary data like Survey of India Toposheets, existing land use/ land cover, slope, soil, contour, roads and settlements were used for preparation of base maps and for planning ground surveys to locate existing wet rice cultivation areas. Ground data collected for verification of doubtful areas arising during the pre-classification stage were used for correction of interpreted layers.

Methodology

The mapping and identification of potential areas of wet rice cultivation involves extensive utilization of geospatial techniques from the initial stages of data processing and extraction to map generation and statistical outputs. The multi-date satellite imagery was subjected to geometric corrections to give the integrity during mapping, to correct distortions and to enable cross-referencing of images with other ancillary geographic databases. Geo-referencing was also done using digital topographic maps of the study area in the scale of 1:50,000. Digital elevation model prepared from Cartosat-I data was further used in preparing slope layer in a GIS environment. Areas already used for wet rice cultivation was extracted from existing land use / land cover data prepared during previous mapping exercises. This was again checked for layer integrity with the multi-date IRS LISS III imagery using color, tone, texture, shape, size and association as basic key elements of interpretation. Flat fields with smooth surfaces are better for rice cultivation as it facilitates even and equal distribution of water (Sailesh *et al.*, 2011).

In this study, slope percent ranging from 0-25 and soil type of clayey, aquic dystrochrepts and clayey, fluventic dystrochrepts (USDA, 1988) is considered potential for wet rice cultivation. Hence, areas falling in this slope percent category are extracted from the slope layer. To avoid any misinterpretation of potential areas, this extracted layer is cross-referenced with topographical layers (contours digitized from toposheets) to remove any areas that lie on hill tops and those that are far away from water source (drainage). GIS provides a suitable platform for carrying out these processes through various modules and tools for analysis. The existing wet rice cultivation areas extracted previously is overlaid on the derived layer for potential areas to ascertain the extent of land which is still available for extensive wet rice cultivation. Ground surveys are conducted to check that the maps prepared are accurate and also to clarify doubts that were recorded during the process of interpretation and analysis of wet rice potential areas in the state. Other ancillary information regarding wet rice cultivation was also incorporated during final stages of mapping and was used to assess and estimate the area of potential wet rice cultivation.

RESULTS AND DISCUSSION

GIS analysis and mapping for potential areas of wet rice cultivation was done for the entire state of Mizoram and the process has extensively incorporated various spatial and non-spatial information that would give a practical figure for extending wet rice cultivation in addition to the existing areas. The end analysis for wet rice potential areas has resulted in an identified area of 746.44 Sqkm which is 3.54% of the total geographical area of the state. To elaborate more on the identified potential areas, a district-wise analysis is further carried out which highlights specific areas where implementation of wet rice cultivation would be practical. The district-wise distribution of potential wet rice cultivation areas is discussed below along with corresponding WRC potential map of the state and statistics (Figure 2 & Table 1).

Figure 1: Ground photo of WRC potential area along banks of R.Mat, Serchhip

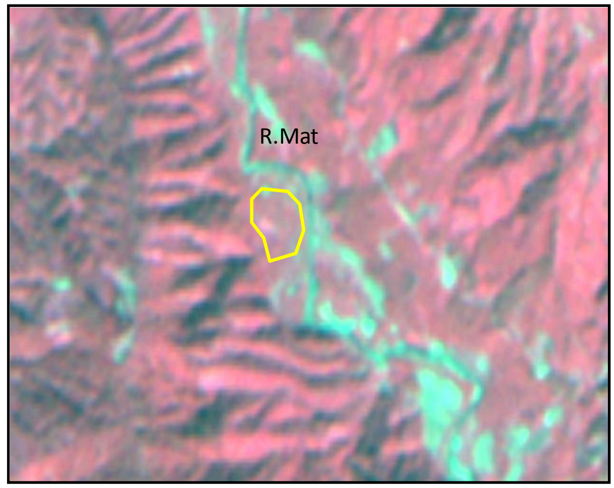

Figure 2: IRS LISS III showing WRC potential area along banks of R.Mat,

Table 1: District-wise statistics of WRC potential areas in Mizoram

Sl No.	Name of District	Area of District (Sq Km)	WRC Potential Area (SqKm)	% WRC Potential area
1	Mamit	3025.00	201.82	6.67
2	Kolasib	1382.00	94.29	6.82
3	Aizawl	3576.00	41.40	1.16
4	Champhai	3185.00	86.97	2.73
5	Serchhip	1421.00	37.10	2.61
6	Lunglei	4536.00	127.97	2.82
7	Lawngtlai	2557.00	114.05	4.46
8	Saiha	1399.00	42.84	3.06
	Total	21081.00	746.44	3.54

Mamit District

The total geographical area covered by the district is 3025 sq. km. Out of this 6.67 % of the district area is WRC potential areas, i.e. as large as 201.82 sq km. Many of these areas are forested areas and in few of these places the natural resources are not being tapped as they are inaccessible. Within this district the Teirei river valley is the most prominent WRC potential area and the area around Darlak village, which is the middle parts of the Teirei watershed, has been quite developed with irrigation facilities. Further downstream, there are several underdeveloped potential areas. Next to Teirei river valley is the Langkaih river valley in the western part of the district and together they accounted for maximum flat land available for WRC area. There are several WRC potential areas along Langkaih river and its tributaries especially between Zawlnuam and Kanhmun villages. But the river water level in this region is low and hence lift irrigation may be applicable in the region.

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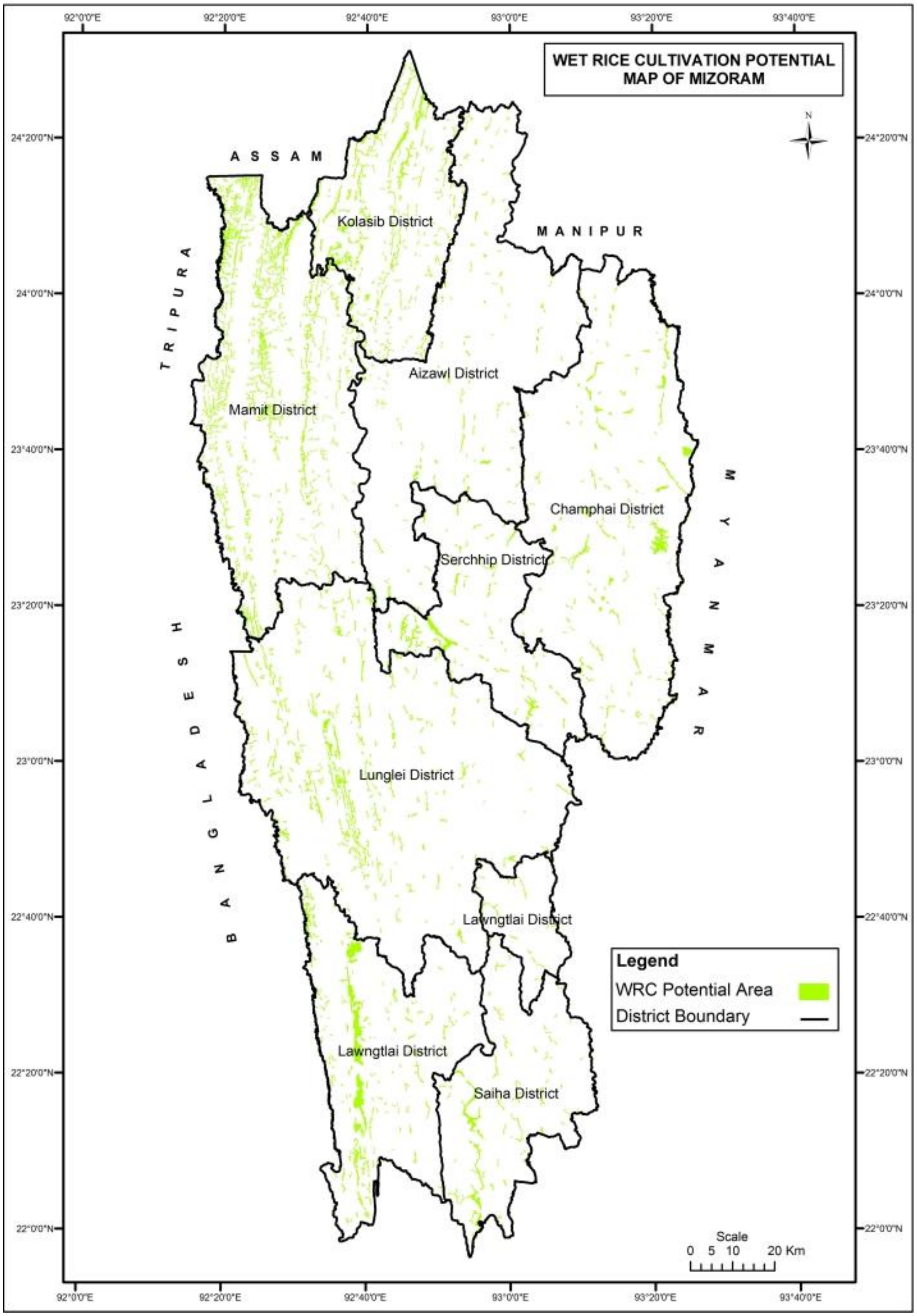

Figure 2: Wet Rice Potential areas in Mizoram

Kolasib District

Kolasib district is the smallest district of the state and the total geographical area covered by the district is 1382 Sq.km. Out of this 6.82 % of the district area has WRC potential areas, i.e. as large as 94.29 Sq km. Within this district, Serlui and Chemlui river valleys in the eastern part are the most prominent ones and they accounted for maximum flat land available within the district. Apart from these two river valleys, Chhimluang and Tuichhuahen Rivers have produced fairly extensive fluvial plains along their courses in the western part of the district. Some potential areas are also found along Tlawng river valley near Hortoki village.

Aizawl District

The district is situated between Tlawng River in the west and Tuirial River in the East. The total geographical area covered by the district is 3576 sq. km. Out of this only 1.16 % of the district area has potential for WRC, i.e. 41.49 Sq km. Within this district, the Tuirini river valleys in the eastern part of the district possess narrow fluvial plains located along its courses. Besides this, there are some valley plains along Lau River, Buallawn River etc in the southern part of the district but in small patches. Among the eight districts of Mizoram, Aizawl district possesses the least area for WRC potential areas.

Champhai District

Champhai district lies to the eastern most part of the state is bordered by Myanmar. The total geographical area covered by the district is 3185 sq. km. Out of this 2.73% of the district area has WRC potential areas, which totals to 86.97 Sq km. In the up-stream part of Tuipui river lays one of the widest fluvial flood plain of the state, named "Champhai zawl". Fluvial plains mainly exist along the river and other such WRC potential areas are Tiau river valley, Phaisen river valley, Tuithoh river valley and Tuilak river valley.

Serchhip District

Serchhip district is geographically situated at the central part of Mizoram and it is the second smallest district in terms of geographical area occupying an area of 1421 sq. km. Potential areas identified for WRC in the district constitutes 2.61 % of the district area which is 37.10 Sq km. Mat river has created the widest plain area in the district. Besides this, there are some small patches along other rivers like Tuikum and Tlawng River etc.

Lunglei District

Lunglei district is located at the south central part of Mizoram bordering Bangladesh in the west. It is the largest district of the state with an area of 4536 sq. km. River Kau and Phairuang have contributed quite vast areas for WRC potential areas along their courses. Besides these, there are some fluvial plains along De and Tuichawng rivers and also at the upper parts of the streams at various locations. The total WRC potential areas identified is 127.97 sq. km which is 2.28% of the total district area.

Lawngtlai District

Lawngtlai district is the southernmost district of Mizoram having international borders with Bangladesh in the west and south, and Myanmar in the east. Within the district there are two Autonomous District Councils namely the Lai Autonomous District Council (LADC) and the Chakma Autonomous District Council (CADC). The total geographical area covered by the district is 2557.10 sq. km. The WRC potential area occupies 4.46 % of the district area, which is 114.05 Sq km. The fluvial plain along Tuichawng River has prominent vast area which is potential for WRC. The Chamdur area along this river has tremendous capacity to be developed for Wet Rice Cultivation. Other fluvial plains potential for WRC are found along Kawrpui lui in the west.

Saiha District

Saiha district is situated on the south-eastern fringe of the State and is surrounded by Myanmar to the east as well as to the south. It is the second smallest district in Mizoram in terms of geographical area occupying a total area of 1399 sq. km. Out of the total district area, 3.06 % has potential for WRC, i.e. 42.84 Sq km. The plain areas along Palak River and Sala River can contributed a vast potential area for

WRC. The valley plains along Chhimtuipui River in the eastern part and Tuisih River in the middle part also have been identified as WRC potential areas.

Conclusion

The increase in population has put tremendous pressure on land for production of food. With a decadal population growth of 22.78% in Mizoram (Census, 2011), this demand for food, especially food grains like rice will continue to grow. The present stock has to be increased by exploring all available options to meet the demand of rice as it is the main staple food crop of the state. The initiatives taken up by the Government in terms of providing better and high yield varieties and better farming practices is a good step in increasing the production of rice. Yet, this production can also be increased by identification and utilization of potential lands for cultivation of rice, which is otherwise not explored to its full capacity. Remote sensing and GIS technology has proven to be important tools in this aspect and has been highlighted in this study. In-depth research on other aspects of rice production could be explored wherein the tools and models available in GIS can make the researchers' task become easier (Serge, 2010). The ability of spatially integrating constituent important layers in a GIS system to find out potential areas for wet rice cultivation has explored the flexibility of this system. Similar techniques can also be utilized for locating potential areas for other food grains as well.

Increasing rice production is an inevitable policy for the government, with expansion of cultivation areas being the likely option. Policies to increase productivity may require the procurement of new lands where the risk of deforestation is high. While lowland areas in the state are now more suitable for conversions to rice production, research into drought-resistant strains of rice will allow expansion within the marginal lands, opening up new areas which were previously unsuitable for cultivation. Expansion policies should balance production targets with maintenance of ecosystem services. This will require an intensive evaluation of current lands, significant landscape planning and a holistic approach (UNDP, 2010).

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