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Research Article

MAPPING OF POTENTIAL AREAS FOR RUBBER PLANTATION IN MIZORAM, INDIA USING GIS TECHNIQUES

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ABSTRACT
Rubber plantations in India are traditionally found in the hinterlands of the south west coast. This track is, however, reaching a stage of saturation for rubber cultivation and the scope for further expansion of the crop is limited. Thus, there is need for expansion of rubber plantation in non-traditional areas to increase its economic production. Several northeastern states of India have been identified to be fully or marginally suitable for rubber plantation, of which Mizoram is one of them. The agro-climatic conditions which represent tropical features in low altitudes, exposure to monsoon and other moderating influences are certain criteria that favor the potential of rubber plantation in Mizoram. To find out these specific potential areas, advance mapping techniques are required to enable accurate and quicker means of identifying untapped potential areas. In such context, this study highlights and extensively utilizes the capability of GIS techniques for mapping and identifying the potential areas for rubber plantation. The results of GIS analysis have shown that there is substantial potential area (29.08% of total geographical area) which can be utilized for rubber plantation. The present study also gives a comparative analysis of the district-wise potential areas that may serve as useful data for preparation of allied plantation schemes.

Keywords: *GIS, Mizoram, Potential Areas, Rubber*

INTRODUCTION
The rubber tree (*Hevea brasiliensis*) is a native of the Amazon basin and introduced to tropical countries of Asia and Africa during the 19th century. It is a quick growing, fairly sturdy, perennial tree of a height of 25 - 30 m and can be termed as the most far reaching and successful introductions in plant history resulting in plantations over 9.3 million hectares, across the globe in Asia (Rubber Board, 2002). The rubber tree may have a life span of 100 years or more, but its economic and commercial productivity is about 32 years including 7 years of immature phase. Commercial plantation of rubber in India started way back in 1902. India is now considered to be the third largest producer of natural rubber, next to Thailand and Indonesia. Large scale rubber plantations are found along the western coasts of India where Kerala is the largest producer, followed by Agartala. Commercial plantation of rubber in the northeast was introduced during the British colonial rule. Since then, rubber plantation has been taken up in few of the northeast states but not as extensively as in the southern part of India. As rubber plantation in traditional areas like Kerala are getting saturated, northeast India is becoming a focus area to increase the commercial production of rubber. It has been estimated that Northeast India can afford to plant rubber in 350,000 Ha., of land (Mithisnortheast, 2011). In Mizoram, rubber plantation had been initiated since the 1960s. However, due to unavailability of good saplings, lack of technical know-how and poor package of practices, the plantations were taken up in small patches by very few individuals. Previously, it has been found that Mizoram has about 5,75,000 Ha for rubber plantation out of which initiatives are being taken up in 50 Ha., of land by Soil and Water Conservation department. Under, the present State Government's flagship programme of NLUP (New Land Use Policy) about 1,117 Ha., was estimated to be covered for rubber plantation under Phase I and II of NLUP. The State's Soil and Water Conservation department had begun to setup budwood nursery and seedling nursery at 6 different places since 2010 under NLUP to bring self-sufficiency in rubber seedlings. A number of families taking up rubber plantation under NLUP are expected to be successful, as high quality rubber seedlings - RRIM have been given to them (Manipur Mail, 2013).

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With the demand of natural rubber getting higher, there is a need for identification of potential sites outside the traditional rubber growing areas so that the production of rubber can meet the demands in the market. The use of advanced mapping technologies has been suggested by various researchers and some of which have been done on a research basis. Mapping of rubber distribution areas and development of rubber information system using remote sensing and GIS have been taken up to generate a database which would form the basis in rubber plantation related decision-making (Rao *et al.*,2003). The Rubber board, Govt. of India collects data on area under rubber plantation through sample survey technique which is costly, time consuming and not feasible to monitor spatial and temporal changes (Shankar *et al.*, 2008). Therefore, the use of modern technologies is recommended to pace up the process involved in mapping of rubber plantation areas as well. The feasibility of such mapping exercise using remote sensing and GIS techniques have been reported earlier (Menon, 1991; Menon and Ranganatha, 1992; Rao *et al.*, 2001; Rao *et al.*, 2003; NRSC and RRII, 2012). Extending these feasibilities, there has also been research works for selection of suitable areas for rubber tree plantation using GIS as well as to model sustainable land use management (Kokmila *et al.*, 2011). The efficiency of GIS has also been realized in rubber replanting programme in other countries like Malaysia (Clarice, 2011). In Mizoram, the effectiveness of using GIS in planning and proposing various improved landuse systems (Agriculture and Horticulture systems, agroforestry systems, etc) for crop productivity has been studied (Lallianthanga and Robert, 2013; Lallianthanga *et al.*, 2014). These techniques could be replicated for identification and proposing potential sites for rubber plantation in the state. This is where GIS offers its flexibility in allowing the creation of models with different sets of criteria. Keeping this in view, the present study has made use of the spatial integration and modeling aspect of GIS to find out potential areas for rubber plantation in Mizoram.

MATERIALS and METHODS

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′ and 24^{o} 35′ N Latitude, and 92^{o} 15′ and 93^{o} 20′ E Longitude (Fig. 1), with the tropic of cancer passing through the State at 23^{o} 26′ N latitude.

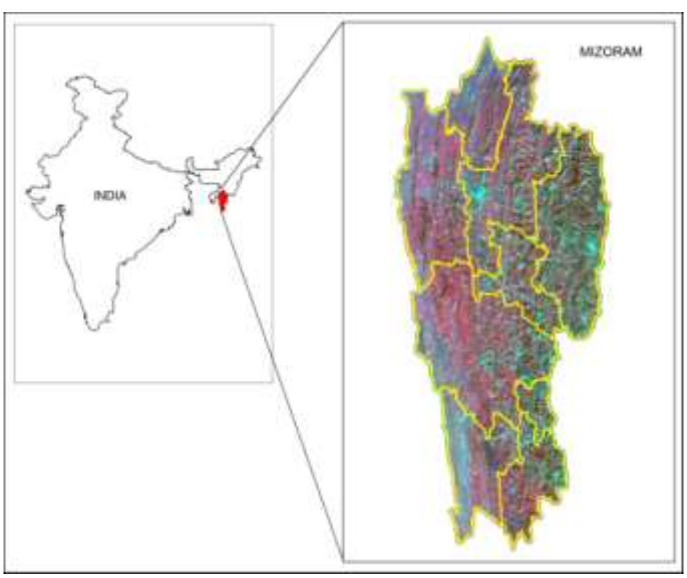

Figure 1: Location map of study area

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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 and 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 and Robert, 2012).

Data Used

The required GIS layers (land use, slope, reserve forest, elevation, road, etc) for identifying and extracting rubber potential areas was collected from the Centre's geospatial data repository. Ancillary data like Survey of India Toposheets, reports and other relevant data pertaining to rubber plantation in the state were referred during preparation of base maps.

Methodology

The mapping and identification of potential areas of rubber plantation involves extensive utilization of geospatial techniques from the initial stages of data processing and extraction, to map generation and statistical outputs. The vector GIS data from various thematic layers were integrated to enable further analysis in a GIS environment. These layers include slope, land use / land cover (MIRSAC, 2013), reserve/protected forests and elevation. The basic criteria for rubber plantation required the extraction of elevation layer upto 450 m MSL. This was considered to be the maximum elevation extent that is suitable for rubber plantation. The slope layer included two broad classes of slope in percent, i.e, 0-30% and 30-70%, which were classified as Very good (Class I) and moderate (Class II) category for rubber plantation. Areas falling in these slope percent categories are extracted from the slope layer. More or less similar specifications have been found in studies carried out in some southeast Asian countries, where rubber plantation is concentrated on slopes upto 25 ^{o} (~ 46% slope) and rarely distributed on slopes above 35^o (~ 70% slope) (Lui *et al.,* 2013).

To avoid any misinterpretation of potential areas, this extracted layer is cross-referenced with topographical layers (contours digitized from toposheets) to ensure that layer integrity is maintained and to remove excess feature polygons that fall outside the elevation limits i.e, 450 m (MSL) . Any potential areas falling within settlements, dense forests, reserved/protected forests, existing wet rice cultivation, agricultural/horticultural plantations and forest plantations were eliminated to avoid overlapping of rubber potential areas with existing developed and conserved areas. GIS provides a suitable platform for carrying out these processes through various modules and tools for analysis. All the GIS layers required for indentifying the final potential areas for rubber plantation are integrated and a final output layer was generated. Other ancillary information regarding rubber plantation areas were also incorporated during final stages of mapping and were used to assess and estimate the potential areas for rubber plantation.

RESULTS AND DISCUSSION

The mapping for identifying potential areas for rubber plantation in Mizoram has extensively utilized the capabilities of GIS techniques. The process adopted in this study using GIS has incorporated various spatial and non-spatial information that would give a practical figure for the scope in extending rubber plantation in Mizoram. Various parameters and layers used in the present study has incorporated the suggestions and established findings of concerned departments and researchers dealing with rubber plantations. The end analysis for mapping of rubber plantation potential areas has resulted in an identified area of 6129.78 sqkm which is 29.08% of the total geographical area of the state (Figure No. 2). The mapping has shown that majority of the potential areas are located along the western flank and to the northern part of the state, as such areas have lower elevations and gentle slopes. Further, a larger percentage (18.11%) of these potential areas fall under Class I, which is considered to be areas having good potential for rubber plantation. This indicates that, rubber plantation has a good scope for introduction in the state. The Class II category of potential areas also signifies that the plantation could be carried out in a relatively large area, which constitutes 10.97%. The district-wise distribution of potential areas (Table 1) shows that Lunglei district has the largest potential area (1673.62 sqkm). However, when compared to individual district areas, Kolasib district has the highest percentage with 65.60% of its total district area having potential for rubber plantation.

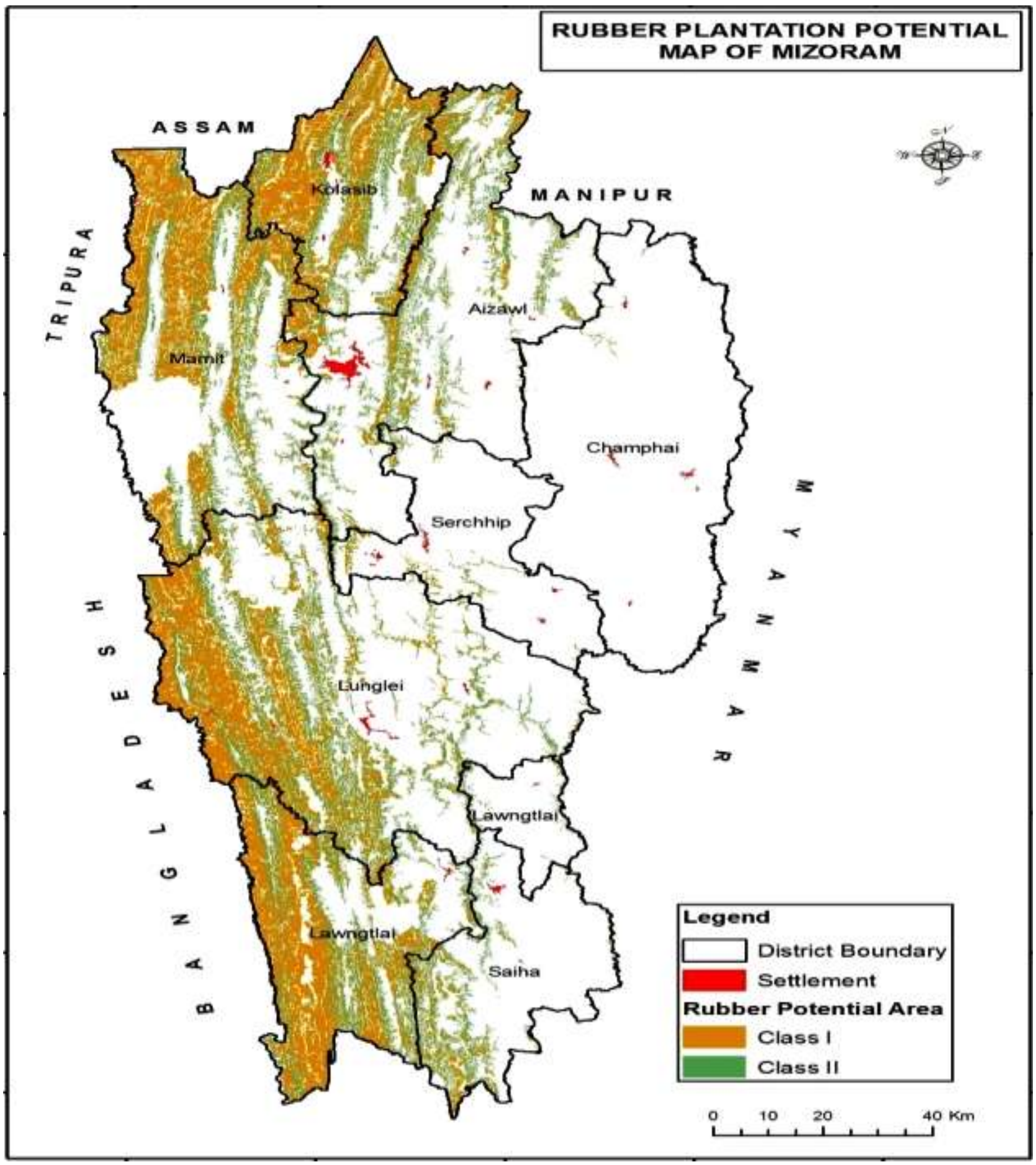

Figure 2: Rubber Plantation Potential areas in Mizoram

Table 1: District-wise statistics of Rubber Plantation Potential areas in Mizoram

Name of District	District Area (SqKm)	Potential area (SqKm)			Potential area (%)		
		Class-I	Class-II	Total	Class-I	Class-II	Total
Kolasib	1382	614.74	291.92	906.66	44.48	21.12	65.60
Mamit	3025	911.94	392.97	1304.91	30.15	12.99	43.14
Aizawl	3576	299.50	394.51	694.01	8.38	11.03	19.41
Champhai	3185	5.40	16.88	22.28	0.17	0.53	0.70
Serchhip	1421	30.81	43.62	74.43	2.17	3.07	5.24
Lunglei	4536	1033.23	640.39	1673.62	22.78	14.12	36.90
Saiha	1399	97.94	158.30	256.24	7.00	11.32	18.32
Lawngtlai	2557	823.52	374.11	1197.63	32.21	14.63	46.84
Mizoram	**21081**	**3817.08**	**2312.70**	**6129.78**	**18.11**	**10.97**	**29.08**

Conclusion

Rubber plantation is considered to be one of the most valuable and high revenue-earning form of plantation in the world. Its economic importance and implications on industrial needs have been acknowledged as well. Increasing rubber production is an inevitable policy to meet the increasing demands for natural rubber, with expansion of plantation areas being the likely option. Expansion policies should balance production targets with maintenance of ecosystem services. With Northeast India possibly being the next major destination for rubber plantation in India, there is need for identification of areas which are suitable for taking up this plantation. Mizoram is one such state where the focus has been given for expansion of rubber plantation and it has also been introduced as one of the trade schemes under the NLUP programme. Areas for plantation of rubber require various aspects of socio-economic and bio-physical evaluation for its successful implementation at the grass-root level. The conventional means of identifying such potential areas would have been a huge task considering the uneven and mostly inaccessible terrain of the state. The present study has thus highlighted the capability of advanced technology like GIS to locate potential areas for rubber plantation and also to find out priority areas for taking up this plantation. The study has shown that there are vast potential for rubber plantation along the western flank and northern part of the state. Cultivable wastelands could be extensively utilized for these plantations and in most parts, an alternative to shifting cultivation. The existing plantations could able be improved by restocking or replanting to increase the overall productive output of the land.

The use of advanced technology like GIS in the study can help in a reliable and cost-effective identification of land for plantation and also for carrying out further user-specific analysis. The techniques could also be replicated for other plantation crops with additional parameters incorporated during the preparation of GIS model.

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