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SITE SUITABILITY SPATIAL MODELLING USING GIS TECHNOLOGY FOR AFFORESTATION IN LOWER UMTREW BASIN, ASSAM

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ABSTRACT

Forest resources are vital repositories of biodiversity, providing essential ecosystem services that sustain life. This study emphasises on identifying potential sites for afforestation in the lower Umtrew basin of Assam, a region that has been experiencing severe degradation due to injudicious human activities, particularly the conversion of forested land into agricultural areas. The research employs Geographic Information System (GIS) techniques in preparing various thematic layers, viz. forest cover, agricultural land (both cropped and fallow), built-up areas, barren land, waterbodies, slope, transport, and drainage networks. These layers are prepared using IRS LISS III satellite imagery of 2016 following visual interpretation methods. A site suitability model is developed in the GIS platform. The final afforestation suitability map was generated using an intersect operation, with potential sites identified. The village layer was then overlaid on the map to assess village-wise distribution of suitable areas. Results revealed 22.5 km² of land as highly suitable for afforestation, with key areas found within the Aprikola reserve forest and the Marakdola Non-Cadastral (NC) village, where Maradola reserve forest is located. Other sites identified are Amsing NC, Bozra NC, Tamulikuchi NC, Niz Panbari No.2, and Chandrapur Bagicha. Thus, this study will serve as a baseline work for targeted afforestation and forest restoration efforts supporting ecosystem rehabilitation and sustainable land management practices.

Keywords: Forest, degradation, afforestation, site suitability, GIS, Umtrew Basin

INTRODUCTION:

Forest cover is the mirror of one area to understand its environment, prosperity, biodiversity, ecology, ecosystem and future development. Forest provides commercial goods worth nearly $590 while it provides environmental services worth nearly $196250 (Terrace and Hadly, 1994). Forests are crucial for the well-being of humanity. They provide the foundation for life on Earth through ecological functions by facilitating the climate, conserving soil and water and serving as

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habitats for millions of plants and animals. It also provides a wide range of essential goods such as timber, fuel, food, fodder, fibre and medicines, in addition to opportunities for recreation, spiritual renewal and other services. Considering the importance of forests, it is a general rule for all the countries of the world to have 33 per cent of their total area under rich forest cover (Sing, 1998). But because of the ever-increasing demands of the present economic man, the forests are under mounting pressure. Today, forests are under tremendous pressure due to over-expanding human domination, which frequently leads to the conversion of degradation of forests. The situation is no better in the case of Northeast India as well as in the lower Umtrew Basin. The human activities, including agricultural expansion, shifting cultivation, illegal felling of trees for timber, wood, medicine, etc., mainly deplete the lower Umtrew Basin's forest land, which turns into agricultural land over the course of time.

Until about a few years ago, there was a lack of comprehensive knowledge on the degradation of forest cover and the resultant consequences. During the last decade, however, rigorous efforts have been made to rehabilitate forest cover through the launch of afforestation programmes (Deka and Sharma, 2012). These programs can only be successfully implemented if the associated issues are thoroughly comprehended. Identifying regions where these programs can be implemented without negatively impacting the current land use pattern is one of their key components. This is especially important as agriculture is currently being practiced on the majority of the forest land that was previously encroached upon. These programs must be implemented on damaged forest lands or on grounds that are now sitting fallow and unusable. Thus, the initiative ought to be put into action in the regions with the highest concentration of scrub land and waste land. In addition to increasing the amount of forest land to satisfy the growing need for fuel wood, lumber, and other materials, this would also enhance the quality of the surrounding environment.

Selection of potential sites is not an easy task for planners as it has to satisfy different parameters and conditions. Remote sensing, GIS and GPS have become effective tools for this kind of global and local studies (Rhoades, 1998). The site's suitability spatial modelling in GIS provides accurate and precise results that make the decision-making process easier. The hand-drawn overlay techniques employed by American landscape architects in the late 19th and early 20th centuries are the source of the GIS-based approaches to suitability analysis (Steinitz et al., 1976, Collins et al., 2001). Later on, many studies on site suitability involving remote sensing and GIS technology have been carried out at global scale (Dilek et al., 2008; Zomer et al., 2008; Elhag, 2010; Eslami et al., 2010). These studies revealed that GIS technology for identifying suitable sites for spatial planning can be an effective model because of its precise results. In this context, the present study aims to identify the potential site for afforestation using GIS techniques in the

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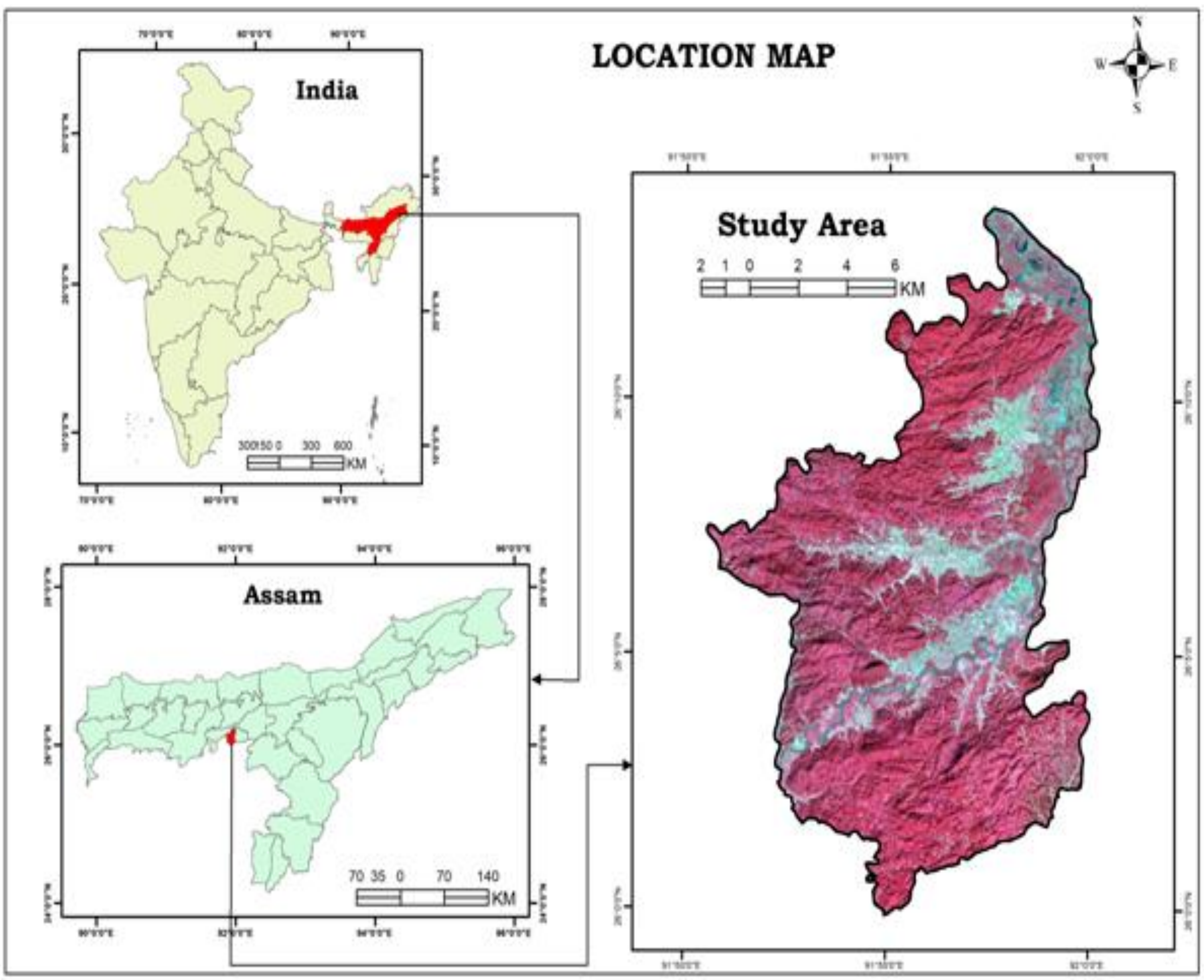
lower Umtrew basin, which has been severely degraded in the recent past due to human intervention.

STUDY AREA:

The lower Umtrew River Basin of Assam lies in between 25° 30' 15" N to 26° 14' 18" N latitude and 91° 34' 15" E to 92° 0'15" E longitude (Fig.1). The total area of the lower Umtrew basin is 217.3 Km^2. The origin of the Umtru River is in the Khasi Hills District of Meghalaya. The river rises at an elevation of 1067 m above Mean Sea Level (MSL) south of the village Raitong ($92^0$02' E / $25^0$45' N). The upper part of the river course lies in Ri-Bhoi District of Meghalaya.

Fig1: Location Map of Lower Umtrew Basin



METHODOLOGY:

The study is based on the overlay operation of GIS using various thematic layers. The Study necessitates thematic layers like forest cover, built-up land, transport network, drainage network, barren land, agricultural land (Crop and fallow), waterbody and slope. The layer has been prepared using IRS LISS III satellite image of 2016. Visual interpretation techniques have been mostly used in the preparation of thematic maps. After the preparation of the thematic layers, it has been processed as per certain parameters using different tools under GIS environment. The tools like buffer, clip, select, erase and unions were used extensively. Finally, the site suitability model has been constructed in the model builder menu of Arc GIS software. The model has been run after overlaying all the thematic layers using the intersecting tool, and accordingly, the final potential site suitability map has been generated. The final map has been again overlaid above the village layer of the study area to check the village-wise spatial distribution of potential sites for afforestation.

RESULTS AND DISCUSSION:

Changing Pattern of Forest

The forest maps (Fig. 2 and 3) of 1999 and 2016 clearly depict the picture of the changing nature of forest cover in the lower Umtrew basin. It has been observed that most of the forest changes have taken place where a number of reserve forests are present. In 1999, the area under dense forest was 130.80 km2 (60.25 % of the total area of the basin), which was significantly reduced to 44.1 km2 (20.27 %) in 2016. In contrast, the area under the open forest category has increased from 11.9 km2 (5.48 %) in 1999 to 31.8 km2 (14.62 %) in 2016. Similarly, the scrub forest, i.e. the degraded forest, has sharply increased from 2.1 km2 (0.97 %) in 1999 to 51.27 km2 (23.57 %) in 2016. It indicates that during the last 17 years, the dense forest has been converted to open and scrub forest in the study area. The plain state of this area, coupled with the incredible rate of population expansion over time, led to a great deal of developmental activities, which have a significant impact on the ecosystem. The field investigation additionally revealed that forest outside the reserve forest had been cleared for the establishment of orchards, areca nut, betel leaf, bamboo plantation, and homestead tea gardens, despite reports from local sources of illegal big-tree cutting for dwelling houses and other developmental activities. It is well established from the study that the degradation of forest land mainly takes place in the hilly areas of the study area. So, based on the forest maps and related statistics, there could be some ideal and potential locations and sites in the study area where the river itself might be an important component for forest area development. It is vital to say that a big afforestation plan was undertaken under the Meghalaya government in the 1980s for which a large area got under forest in the upstream of

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Umtrew Basin. This indicates that, with careful planning, this land has the inherent capacity to grow forest cover. As per the thematic maps, the area under open forest and scrub forest were previously covered by dense forest, indicating that these areas have high potential forest growth with scientific planning and management.

Fig. 2: Forest Map, 1999

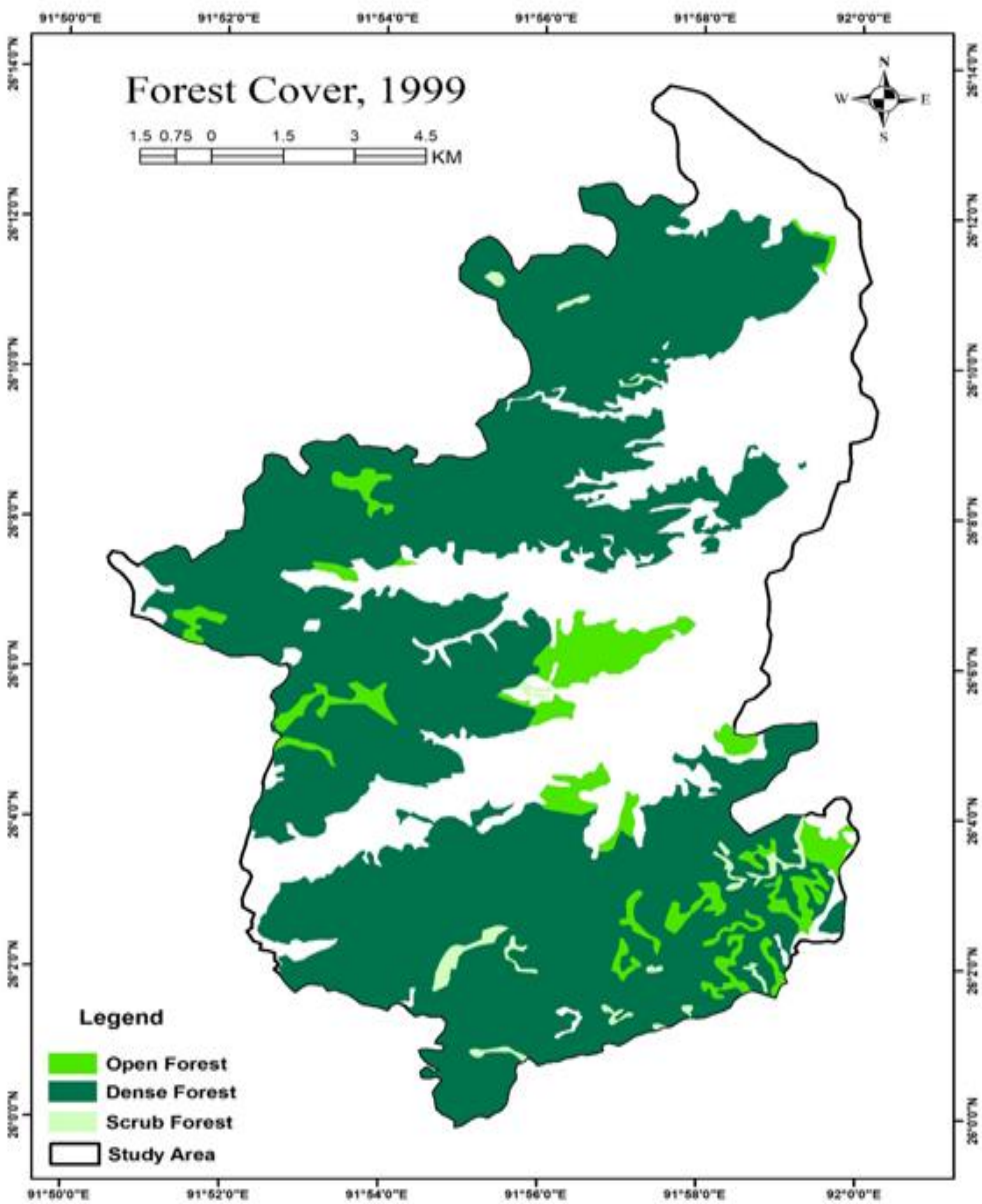

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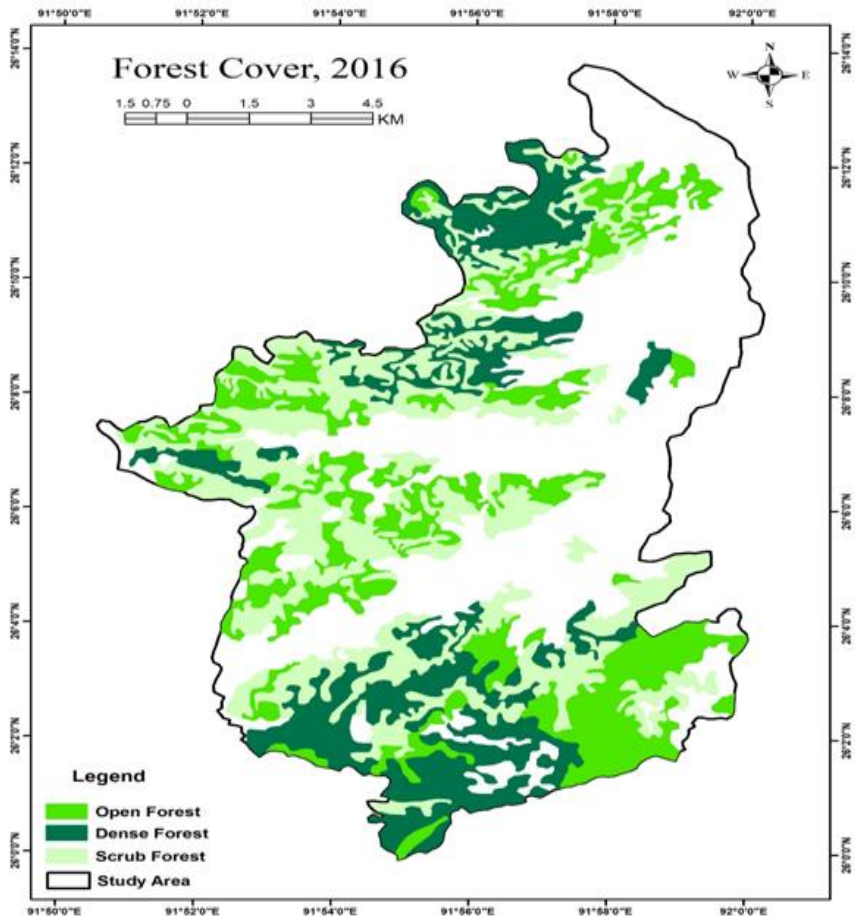
Fig. 3: Forest Map, 2016



Preparation of Dataset:

The dataset needed for the purpose has been prepared for the study area in GIS environment using different tools. Layers of dense forest, open forest, scrub forest, drainage, road, slope, barren land, water body, etc. have been clearly identified to make the outcome precise. There is a certain conditions given by the Ministry of Environment and Forest for the afforestation programme. That has been followed properly. The parameters that have been chosen for the identification of potential site for afforestation are as follows-

1. The site should be within 1.5 km of the transportable roads so that transport and communication for proper planning and management of the afforestation site can be maintained. Afforestation in remote areas can never be looked after once the programme has been implemented.

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2. The site should be 1km away from the built up area. It has been observed that there is growing tendency of cutting the forest for agricultural purpose and dwelling houses. That is why the areas nearer to the built up areas are prone to this condition then the areas located far from the human habitation.

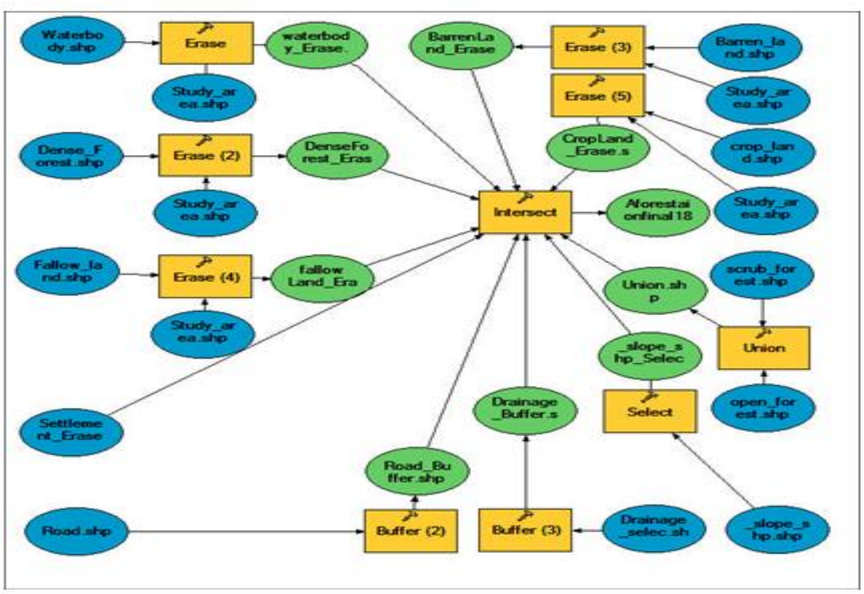
3. The site should be within 500 meter from the major drainage. It is well known to all that availability of ground water and surface water is mostly needed for the healthy forest growth. So the areas near the major drainage have maximum availability of ground water which is necessary for success of the afforestation programme.

4. The site should be either in open forest or scrub forest. There has always been a tendency to transform dense forest areas into open forest and then scrub forest. This means that these areas have the potential for forest growth, or earlier, they were covered with dense forest. So selecting these areas for aforestation with proper care will definitely make the programme a big success.

5. The site should not be in dense forest, fallow land, barren land, water bodies, or crop land. These areas must be ignored because they are not ideal for forest plantation.

6. The slope angle should be less than 25° for the potential site because more sloping land is susceptible to erosion.

Fig.4: Model builder showing the overlay in GIS environment



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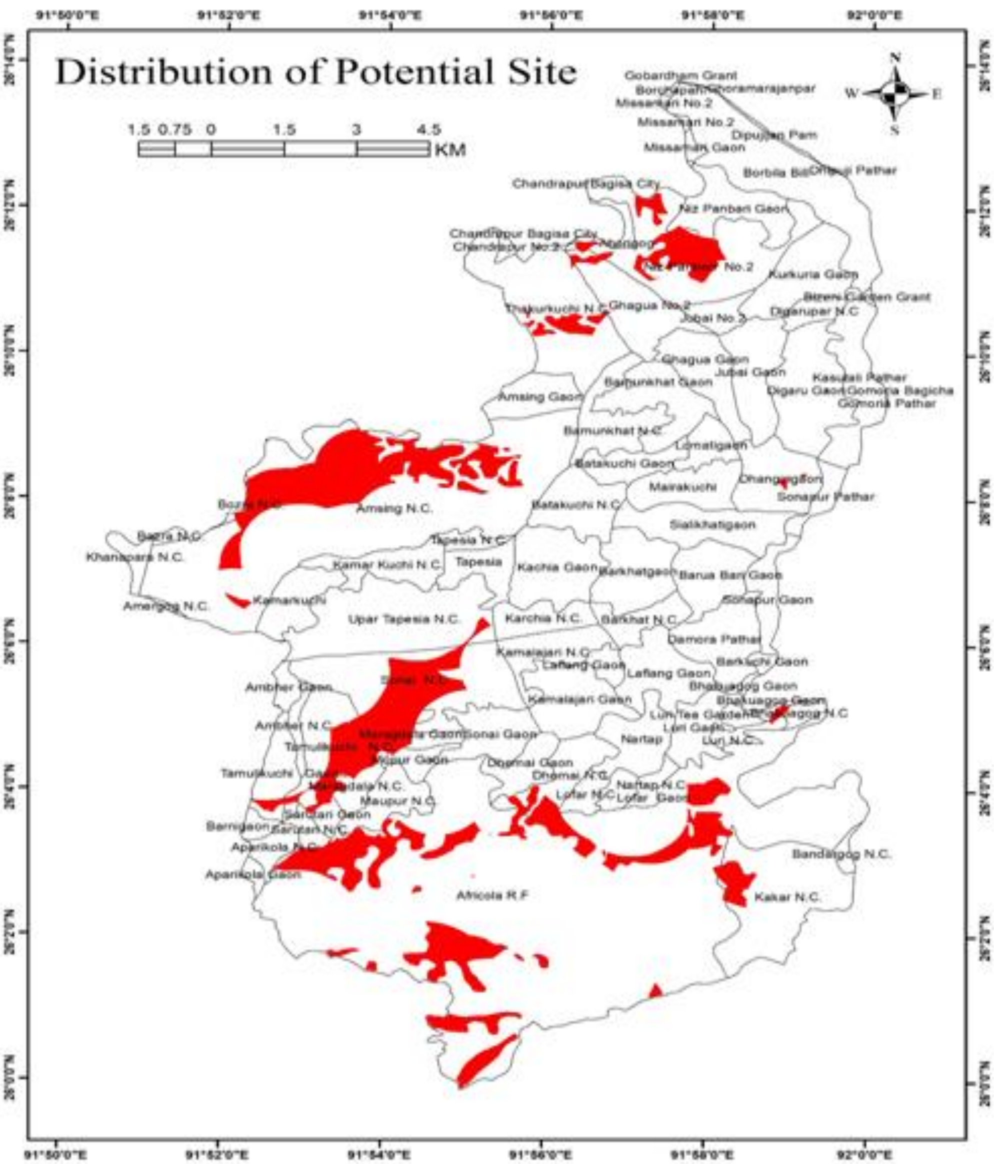
With this condition and prepared layers, the model has been build and verified in GIS environment. (Fig 4) After intersecting all the layers of different parameters the model has been run and the final site suitability map has been prepared. (Fig 5)

Fig 5: Site Suitability Map for Afforestation



It has been estimated that 22.5 km^2 areas have been identified as potential suitable site which fulfils the condition of forest plantation. A major portion of the suitable locations are found to be inside of Aprikola reserve forest which had a high natural forest cover in 1990s. Similarly, an

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elongated strip of suitable site has also been found in the Marakdola Non Cadastral (NC) village where Maradola reserve forest is located. Villages like Amsing NC, Bozra NC, Tamulikuchi NC, Niz Panbari No.2, and Chandrapur Bagicha also have potential sites for afforestation. Though these areas are free from official human settlement but illegal construction of houses and illegal agricultural activities are performed extensively. Planting trees, particularly ones with economic and medicinal significance, would increase the productivity of these land regions, prevent further deterioration, and restore ecological balance, preserving the potential for agriculture in the surrounding territories. But stakeholders' participation in such a programme is essential, implying a systematic local autonomy in which the community manages its own development. Increased public involvement and awareness-raising, along with government actions, might undoubtedly aid in expediting the restoration of the natural environment and bolstering human economic support. For the programs to be successful, the afforested land must be continuously monitored. The tree planting program is typically completed adequately, but the tree survival rates—which are crucial to the real success of these programs are typically depressing. Usually, this is overlooked while calculating the statistics. Thus, it is advised that temporal assessment of woodland regions should be done in addition to monitoring afforested areas. In addition to this, horticultural practices and agroforestry should be encouraged instead of unsustainable shifting cultivation, which is also responsible for the loss of biodiversity. Excessive jhooming should be stopped; rules and regulations should be formulated in using the government land. The government should take the initiative in developing community forests in each village, and funding and subsidies should be provided for constructing shelf-help groups to promote animal rearing and do necessary training for the skill development of the youth.

CONCLUSION:

The present study delves into identifying potential sites for afforestation using spatial modelling supported by GIS techniques in the Lower Umtrew Basin of Assam. Various derived thematic layers such as forest cover for 1999 and 2016, drainage, transport network, agricultural land (crop and fallow), barren land, waterbody etc. have been prepared and incorporated in the model to generate the potential site map. Parameters or conditions have been formulated based on available Ministry of Environment and Forest guidelines and local knowledge. The results show that approximately 22.5 km^2 area of the study area has been found to be suitable for afforestation. In conclusion, analyses using spatial model and Spatial Decision Support System are able to assess the suitability with higher accuracy. Further attention should be given in implementing the plan and policy for further management. Community participation, stakeholder involvement and continuous monitoring should be focused on while doing the afforestation programme in the study area.

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