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Bamboo livelihood development planning, monitoring and analysis through GIS and remote sensing

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Abstract—The North-Eastern region of India is endowed with rich bio-diversity. The total forest cover in the region is around 60% of the total geographical area. Bamboo accounts for approximately 7% percent of the total forest cover of the region [1]. Due to its inherent qualities and abundance in the region, it has become a part of the life of local communities. For sustainable micro-level development, scientific planning of bamboo resource is required. GIS and remote sensing are effectively used for bamboo resource management and planning in parts of two states of the region, i.e. Manipur and Tripura.

Key words: Livelihood development; GIS; remote sensing; satellite images; knowledge-based classification; soil erosion vulnerability; GPS; site suitability analysis and network analysis.

INTRODUCTION

Bamboo features predominantly in the lives of rural communities, particularly in Asia providing income, food and housing to over 2.2 billion people worldwide. Bamboo occupies an unparallel position in the plant kingdom in terms of its distribution, diversity, regeneration and uses in the tropics and sub-tropics. Governments in India, China and other south-east Asian countries have begun to focus attention on economic factors of bamboo production.

Due to its diversified use, bamboo has become a resource that can provide substantial support to the local economies. Its well-planned and substantial use will go a long way in improving the social and economic condition of the local communities.

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In order to do scientific planning, monitoring and proper channelisation of bamboo resource, Geographical Information System (GIS) proved to be an effective tool. With its unique capability of doing analysis and query the database, capability of GIS technology has been utilized for various kinds of analysis such as market scenario for bamboo products, condition of transportation network and cost, site suitability analysis for setting up various bamboo-based industries, etc.

SCOPE OF WORK

The objective is to focus on various aspects of bamboo that can be analysed using GIS environment for sustainable exploitation and also to find out ways to pass on the benefits to the local communities.

Using GIS and remote sensing

GIS has come a long way in providing solutions to planners and also in giving alternate solutions for sustainable exploitation of natural resources. The beauty of the system lies in analysing the complete scenario in a scientific manner.

Remote sensing is a technology where reflectance from earth objects are recorded in various multi-spectral bands through the sensors mounted on satellites. This gives a synoptic view of the earth surface with variation in the reflectance values from different land use land cover units. This variation in the reflectance value helps in identifying the surface properties that can be validated on the basis of the field-based GPS points collected as training sets. In order to map the natural resources remote sensing provides the most time and cost-effective solution.

STUDY AREA

The Tamenglong district of Manipur and two districts of Tripura state in the North-eastern part of India were the subject of this study. These are the areas where bamboo resources are available in abundance [1]. Bamboo is part of the daily life of local communities and it is used for channelling water from natural springs to their villages and also in construction of their houses.

METHODOLOGY

The methodology adopted for the study includes bamboo resource inventory using recent satellite images, natural resource mapping and creation of GIS database for market, financial institutions and socio-economic database creation at village level. The detailed methodology is given in Fig. 1.

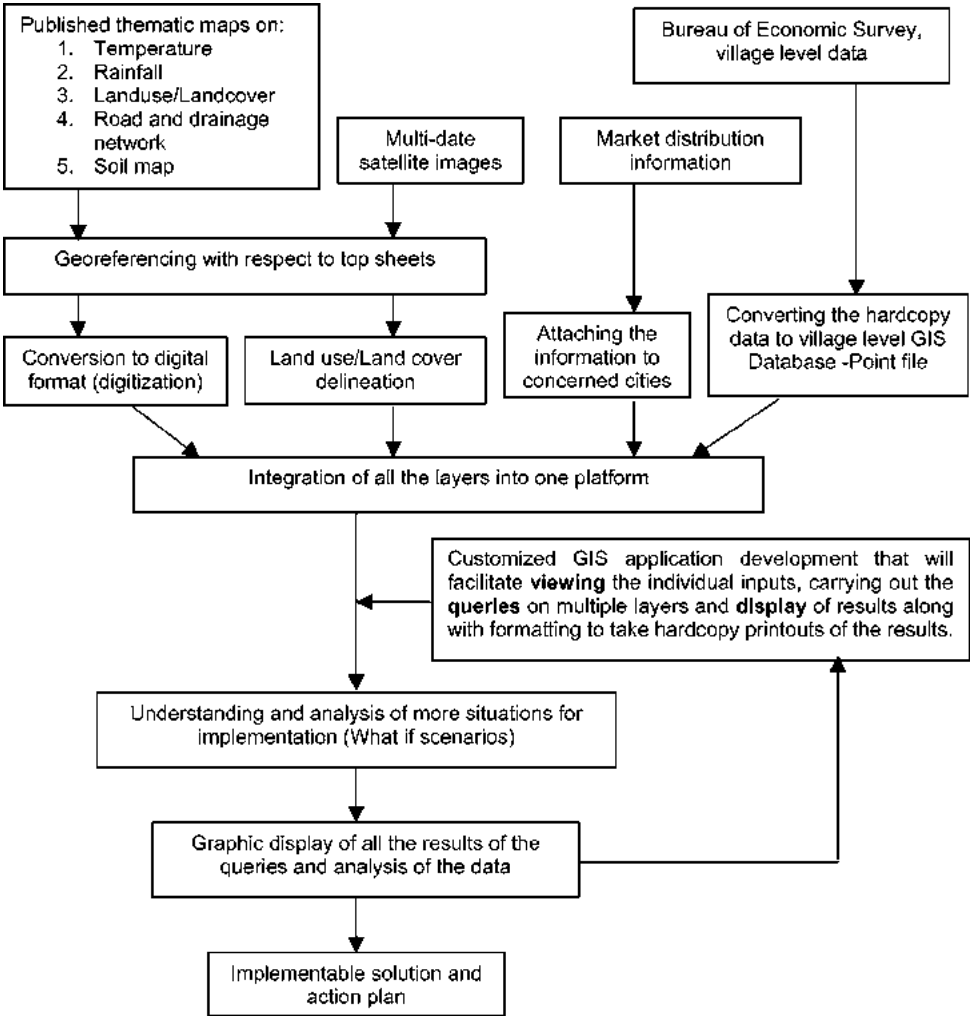

Figure 1. Flow chart of methodology.

Remote sensing for bamboo resource inventory

As bamboo resource is the most important part of the project, for mapping and inventory of bamboo recent remote sensing satellite images were used. IRS 1D LISS III images of recent dates are analysed and classified using supervised classification technique based on the training set consisting of representation from different type of forest tree type [2]. IRS stands for Indian Remote sensing Satellite and IRS 1D is one of the satellites out of IRS series. LISS III stands for Linear Imaging Self Scanner and it is the third generation sensor onboard IRS 1D satellite. This sensor is capable of taking images in 4 spectral bands with 23.5 m spatial resolution. Spatial resolution means any object greater than 23.5 $\times$ 23.5 m in size can be identified on satellite image.

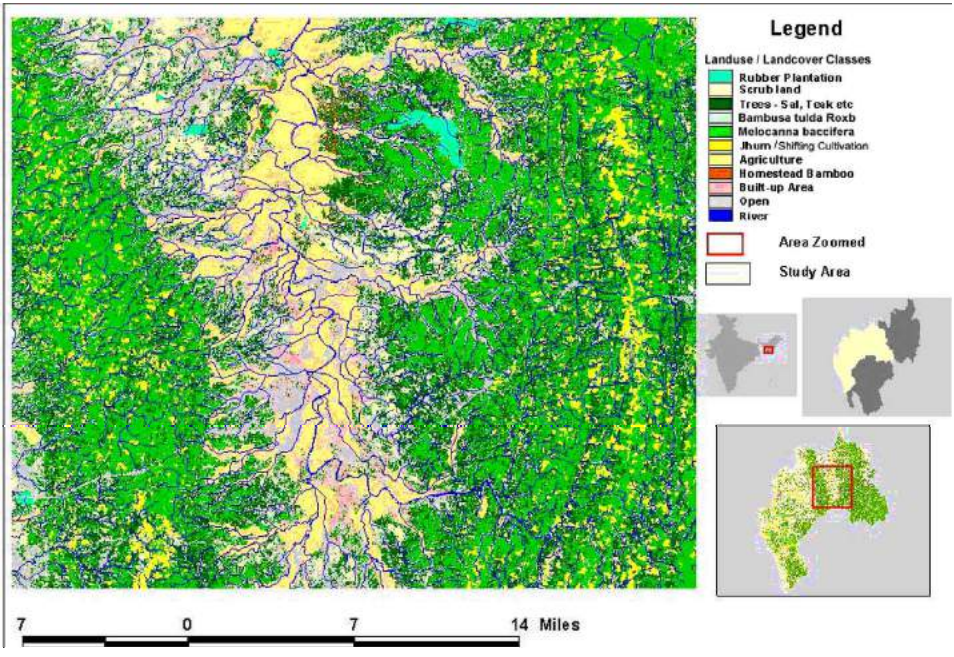

Figure 2. Landuse/Landcover map (with bamboo species distribution). This figure is published in colour on http://www.ingenta.com

As various bamboo species have their own economic value; therefore, in order to do bamboo species level classification, the knowledge-based classification technique is effectively used. In knowledge-based classification various physical parameters such as DEM, slope, drainage and bamboo resource are considered. DEM stands for Digital Elevation Model. This is a 3-dimensional model where a surface can be represented in x, y and z. x and y ares for locating a point on the surface of the earth and z is for height. DEM is created using contour data captured from topographical maps. Information gathered from field is compiled together to find out the correlation between the distributions of various species of bamboo with physical attributes. The correlation thus acted as the guiding line for classification of bamboo species out of total bamboo covered areas (Fig. 2).

The accuracy estimation has been done by randomly selecting GPS location sites. The results were very encouraging and accuracy was up to 85%.

GIS for natural resource analysis

The local conditions, defined in terms of elevation, slope, drainage, rainfall, land use/land cover, etc. (Fig. 3), determine suitable conditions for the growth of particular type of bamboo species. Mapping of these natural resources not only helps in identifying suitable locations for bamboo plantation but also in number of analysis.

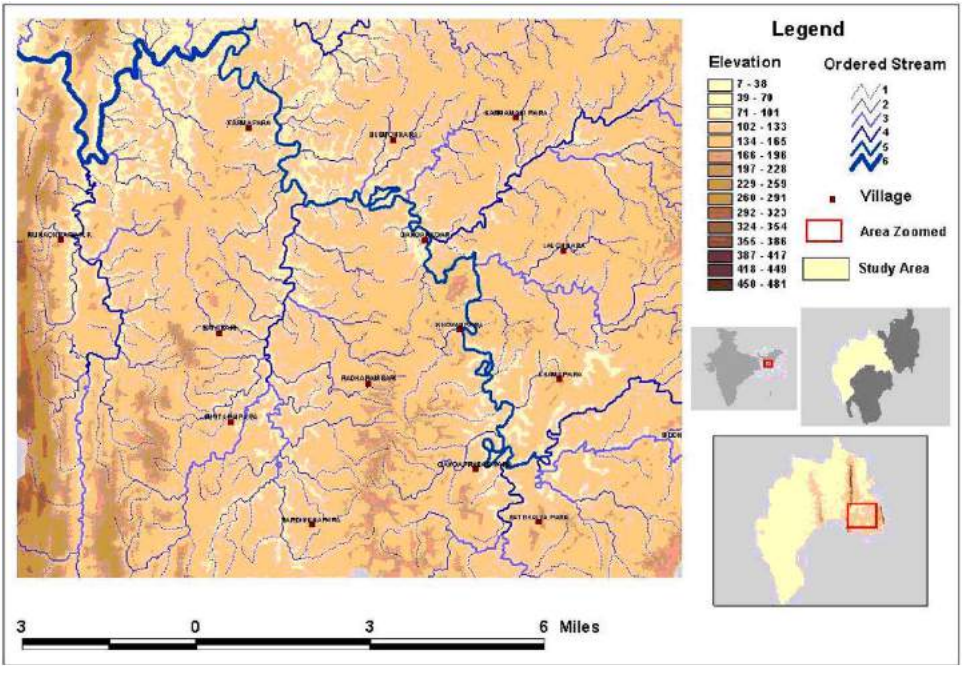

Figure 3. Digital elevation model and drainage. This figure is published in colour on http://www.ingenta.com

Some of the analysis that has been done is listed below:

- Soil erosion vulnerability zoning (Figs 1 and 4)
- Network analysis for estimation of bamboo transportation cost from source to product development to market.

Soil erosion is a major problem faced in these areas of high rainfall. Identification of extremely vulnerable areas will go a long way in taking remedial measures and these areas will also act as probable sites for plantation of bamboo species. As bamboo is very light in weight therefore it not only holds soil together but also does not put a lot of weight on the fragile surface.

River bank erosion is another aspect that is quite severe, especially in case of Tripura. Identification of probable fragile riverbanks through overlay analysis in GIS environment enables to take quick remedial measures. In such locations the best possible method to check riverbank cutting and erosion is to plant lightweight plants/trees and bamboo is found to be the appropriate solution. Bamboo grows at a much faster rate as compared to any other tree specie. It takes 2–3 years of time to reach its maturity. Bamboo roots help in holding the soil particles together, even after cutting down the clumps. They also put less weight on the soil as compared to other trees, thereby avoiding any type of soil slump or creep.

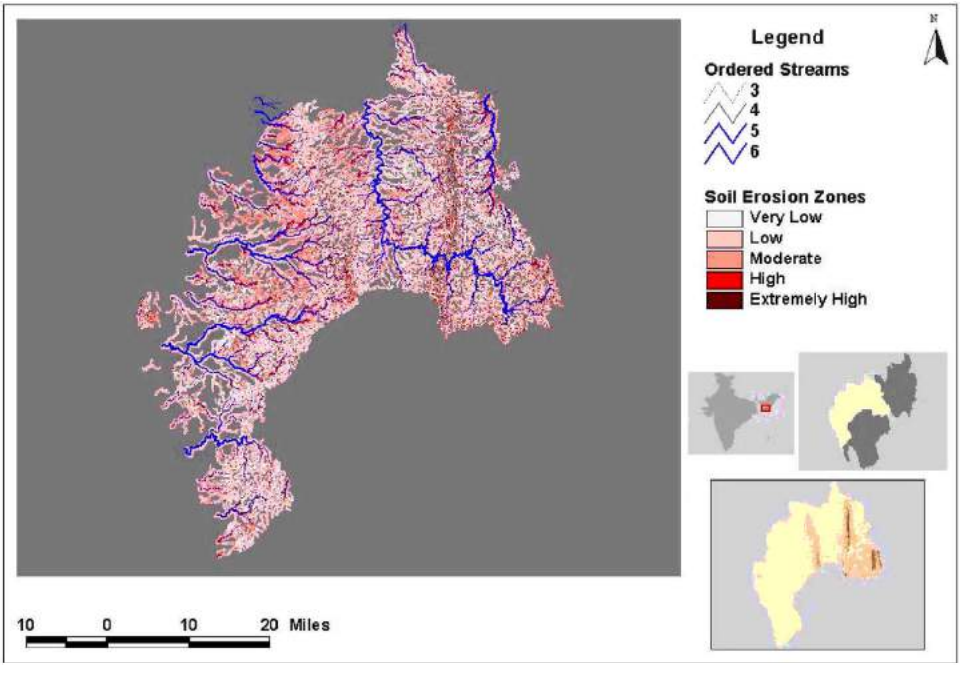

Figure 4. Soil erosion vulnerability zone. This figure is published in colour on http://www.ingenta.com

GIS for planning

For bamboo and bamboo-based products, understanding of the local market scenario, various financial institutions functioning in the area and skill set of the local communities play a significant role in planning the resources. Some of the analyses that have been done are listed below:

- Site suitability analysis for setting up various bamboo based industries, such as gasifier plant (Fig. 5), bamboo based charcoal making enterprises, bamboo oil curing industries, matchstick enterprise, nurseries for bamboo and rattan etc.
- Bamboo-based market scenario
- Financial institution functioning in the area and developmental support provided by them.
- Skill-sets of the local people.

Identification and development of the industrial sector based on locally available resources is the key for sustainable micro level development. As various species of bamboo inherit specialized characteristics for particular use therefore identification of suitable bamboo based industries becomes imperative for such developmental activity. From sustainability point of view any industry needs proximity of resources, good transportation network and market. Site suitability analysis using GIS environment takes care of all such conditional parameters and gives the result

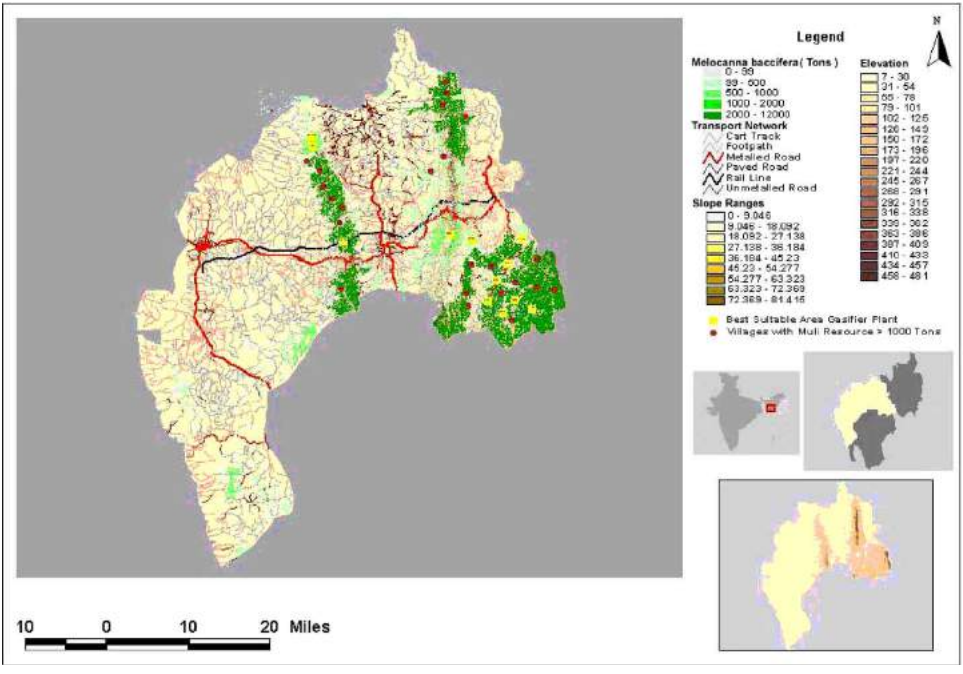

Figure 5. Best suitable area for gasifier plant. This figure is published in colour on http://www.ingenta.com

in quick time. This helps in better scientific planning of the resources and also sustenance of industries.

GIS for monitoring

Monitoring is the important aspect for the assessment of the developmental work undertaken in the area. GIS helps in maintaining the database where quick updating is possible. As the main criterion between successful and failure of any developmental project is based on quantifiable change in the social-economic life of the people, therefore, use of GIS becomes imperative.

In order to monitor the economic change in the life of the local communities village level database is generated. This socio-economic database is linked to the village point data. Household level and village level survey has also been conducted to collect first hand information. The database will be updated on a semi-annual basis. This database can be queried in GIS environment to know the change in the monetary condition of the local communities.

Monitoring and identification of root-cause analysis of the functioning of the industries is another aspect that can be understood in a much more scientific manner using GIS. This not only helps in understanding in how industries are

functioning but would also be a milestone in developing a correlation between various parameters considered for identification of suitable locations.

GIS for evaluation

Impact analysis and other case studies can be facilitated by the GIS system provided the baseline is in place, and other relevant information is collected periodically and input into the system. In the present projects, numerous small enterprises are being set up, as also nurseries and plantations. All activities and villages/households are being geo-referenced with attached attribute socio-economic data. This is expected to make it possible to *a priori* analyse why a certain enterprise succeeded or failed based on the GIS system itself, and based on this, some could be selected for detailed evaluation on the ground. It is expected to be possible to identify possible reasons for success and failure from the data, as also determine criteria for assessing the comparative location-specific economic advantage of a given village or household. For example, it is possible that a given household enterprise succeeded because the bamboo resource was upstream or on the slope above the enterprise and hence their was a transportation advantage that gave an added economic benefit to the enterprise. In another instance, a similar enterprise might have failed or not succeeded as well since the resource was downstream or on the hill slope below the enterprise, resulting in greater expenditure on resource procurement. But it is also possible that ultimately both had a similar level of success because the latter was located closer to the road and had better market access. Such analyses would likely become possible once the system has a threshold data resource base.

CONCLUSIONS

As bamboo is a very useful resource and its growth and regeneration takes lesser time as compared to tree therefore the need of the hour is to use it in a much more scientific manner for sustainable development at micro level. The use of GIS and remote sensing for such resource based livelihood development is immense. GIS not only provides a platform for analysing various set of conditions based on physical attributes but its capability to query the database is enormously helpful for planners. In addition, because of its ability to link into remote sensing, it is possible to monitor and assess progress of resource growing activities in a shorter time period, undertake monitoring in areas that are not easily accessible by road or road access is not available, and perhaps reduced costs. A likely spin-off is that the ‘eye in the sky’ and objective ability of the system will both increase efficient use of project financing, as well as reduce misuse of funds.

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