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Forest Resource Management Using Geo-Spatial Technologies

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Abstract:- Natural resources are key for the development of a country, and this stands true in any part of the globe. Planet earth has several natural resources on its surface and subsurface like land (soil), air, sun light, water, agriculture, forests, aquaculture, sand, coal, natural oils &gases, rock/stone formations along with bio life and more. To sustain ecological diversity, preserve resources for future generations, and to maintain living amenities for people, these natural resources must be utilized in an optimal and sustainable way. Sustainable use of natural resources will contribute to a balanced ecosystem with a constructive environment for a longer future of all living things. This is possible with an efficient and sustainable management of resources which may be achieved through conservation of air, soil and water, micro-watershed management, irrigation water management, community forestry, community-based coastal zone fisheries management, conservation of the biodiversity, requisite use of renewable resources etc.

Finding the location and knowing the potential of any natural resource on earth is very essential in the process of its management. The geo-spatial technologies such as satellite sensing, aerial sensing, radar, Lidar & drone based sensing, GIS (Geographical Information Systems)and GPS (Global Positioning Systems) are known as the most reliable and proven technologies in finding the correct location of natural resources along with the extent/potential on the surface and subsurface of earth very precisely. The advancements in sensing technologies resulting in very high-resolution images and the software tools for spatial data analysis have made significant developments in the field of natural resource management. When compared with past centuries or decades, most of the natural resources are under continuous exploitation by some form of human activity in the name of development. The present paper will enlighten few persistent issues related to one of the significant natural resources namely forests and would expedite the scientific processes through the geo-spatial technologies in producing appropriate recommended action plans that are required in forest management.

I. INTRODUCTION

➢ *Management of Forests*

Forest management primarily aims to maintain the environmental values of all types of forests in order to meet the social, economic, ecological, cultural and spiritual needs of present and future generations. Forests supply water, mitigate climate change and provide habitats for bio life, which is essential for sustainable food production, among other things. Successfully achieving sustainable forest management will provide integrated benefits to all, ranging from safeguarding livelihoods of locals (forest dwellers) to protect biodiversity, healthy ecosystems provided by forests and to mitigate some of the effects of climate change. Forest conservation is essential to stop global warming and climate change. The major stake holders of forests include the local government which owns the forest land, forest dwellers who live around or nearby forest areas and depend on what they can forage from it, industries who use forest products for various industrial purposes and the enthusiasts for conservation of wildlife and nature.

II. FOREST STATUS IN INDIA

According to the India state of forest report 2021 by Forest Survey of India (FSI), there is an increment of forest cover in India by 1540 sqkm. This was by considering any land of 1 or more hectare with tree patches and canopy density of more than 10%. This covers all lands irrespective of legal ownership and land use. Total forest cover is 713789 sqkm which is 21.71% of the total geographical area of the country. The target area under forest is 33% of the total geographical area. This reveals that India is not adding to its dense forest, rather it is losing significant areas of natural forests with moderate tree cover. The major category of the Indian forests is the open forest with 40%. FSI has categorised the Indian forests in to four major types, namely, very dense forest with more than 70% tree canopy density, moderately dense forests with tree canopy density between 40-70%, open forests with tree canopy density between 10-40% and the scrub forest tree canopy with less than 10% density.

Table 1 Forest Dense City in India

Forest Category	% to the total forest cover	Increment	Decrement
Very dense forest	3.04%	501 sq km	
Moderately dense forest	9.34%		1582sq km
Open forest	9.33%	2612sq km	
Scrub forest	0.0013%		

5 states namely Andhra Pradesh, Telangana, Karnataka, Odisha and Jharkhand have reported total increment while 11 states shown decrement in forest cover. The increment in the 5 states is the result of local plantation programs and agro-forestry.

➢ *Advancements of Geospatial Technologies*

While the Geo-spatial technologies have been evolving along with the introduction of computers to the world since 1960s, the effective way of their functioning only began during 1990s. The major reason behind this was lack of suitable input & output hardware devices, storage media and lower configurations of computers. The geographical inputs for any resource based application or project were available in non-digital formats i.e., paper or cloth and digital conversion was the major challenge during the initial evolution of this technology. Digitizer boards were in use for converting analog/paper map to digital format information till the introduction of large sized scanners to the world during the end of 20th century. Even the processes were limited to vector data due the availability of only DOS based operating system. Under such circumstances it was very difficult to create spatial database for larger project areas.

However, there were consistent advancements in the hardware and software, such as introduction of window based OS, increase of disc space, high resolution graphic card and processing speed, large size (A0) scanners etc., these have simplified many difficulties. During the end years of 1990s, geospatial technologies have gained the momentum in a big way across the globe and stabilized as a technical industry with many stakeholders. Huge database of base and thematic information was created in GIS formats by many states and countries. Another significant achievement in this segment was the sensing and producing of high-resolution imagery of earth features through satellites, drones, Lidars and Radars suitable to various new application domains.

With volumes of reliable spatial datasets, Geospatial technologies are now being applied in diverse areas to assist indigenous people, communities, research institutions, environmental & natural resource scientific organizations, businesses and government agencies at all levels. They have transformed the way spatial/geographic data is created, processed, analyzed and displayed for an increasingly large range of users, for a multitude of purposes. Thus emerged as a powerful and integrated geo-information source for management of any natural resource, these technologies are capable of managing the large amounts of spatially combined information, providing the concerned decision making management with an authoritative scientific base to handle their day-to-day ground based activities. Particularly the geo-reference of cadastral maps, forest areas and topographical features with the respective High Resolution Satellite (HRS) imagery could resolve the basic identification and fixation of the boundaries of natural resources like forests, water bodies, government lands, private lands. The archived satellite imagery products along with the geo-spatial thematic layers will help in easily identification of encroachments, damages to resources etc. Thus providing legally valid scientific inputs in resolving the issues within or with the neighboring features and thereby helps in protecting natural resources from encroachments.

➢ *Major Issues in Forest Management*

Often, in the name of development or industrialisation or socio-economic improvement or due to natural disasters, the forests are disturbed causing reduction in green cover which consequently is changing the global environmental conditions. The following are major issues in the management of forest resources in India.

- Boundary disputes between Forest & Revenue lands leading to encroachment of forest areas
- Cultivation inside Forest (RoFR Act)
- Wild life protection
- Infrastructure intervention
- Compensatory afforestation
- Mining activity
- Disaster - Forest Fire
- Biodiversity loss

Boundary disputes between forest and revenue land has been a persisting issue for many years particularly in India. This is mainly due to the fact that the fixation of the boundary was based on non technical procedures which have ignored the earth's curvature/spherical surface. Also the survey and fixation of boundaries of forests and revenue lands were done separately at different time periods by different organisations. The method of measuring of bearings and distances during the survey and fixation of forest boundaries by using tapes and compass has significant magnetic declination which affect the accuracy of survey. Almost a century ago these forest gazettes were prepared with such boundaries, and it is very difficult to match with present ground conditions. The below pictures is an example to understand the boundary issues between forest and revenue lands.

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Fig 1&2 Boundary Differences Between Forest Gazette (Above) & Revenue Map (Below)

Other dispute between forest and revenue lands was that a few revenue land areas nearer to the forest boundaries were un-cultivated over long periods and covered with natural vegetation growth bearing a resemblance of forest area which could be very difficult to resolve between the respective forest and revenue departments and remain as court cases. There are many villages within the forest areas which were created originally as forest settlements, but now have grown up as major urban areas; also few urban centres/ municipalities close to forest area have encroached into forests.

Below fig-3 shows the expansions of built-up under Yellandu municipality into Yellandu forest block, compartment 27 area. Further, cultivable lands are found inside the forest blocks (for example, inside Singareni forest block in fig4) and also, huge chunks of natural vegetation were observed outside the forest blocks (marked in red colour).

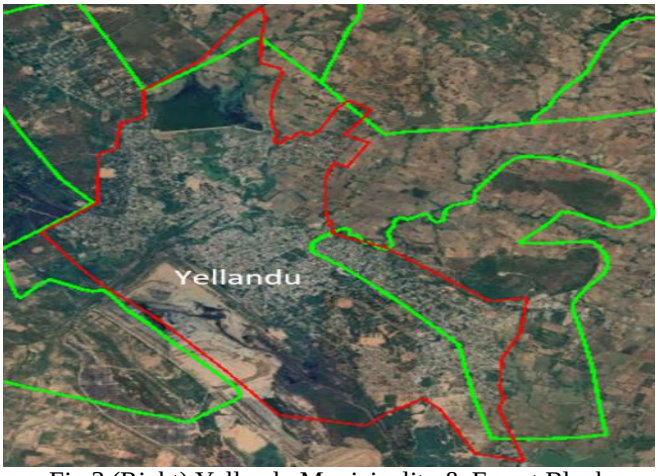

Fig 3 (Right) Yellandu Municipality & Forest Block

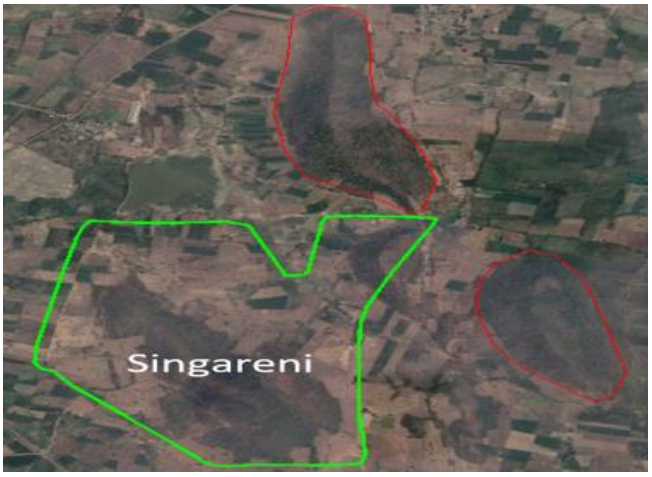

Fig 4(Left Below) Singareni Block;

Fig 5 (right below) Ponnal & Keshavapur blocks

➢ *Cultivation in side Forest Under Rofr Act*

The Recognition of Forest Rights Act (RoFR), 2006 was passed for the marginal and tribal communities of India. The RoFR Act recognizes and vest rights of the forest land to the scheduled tribes and other traditional forest dwellers on which they were traditionally dependent. The intention of the RoFR Act was to support the true tribal farmers who are making their livelihood through cultivation in forest areas while protecting the natural forest and bio-life without causing damage due to human activity. This Act reaches millions of tribal people and other traditional forest dwellers in different parts of India, and provides restitution to deprived forest rights across India. This includes 'individual rights' to cultivated land in forest land as well as 'community rights' over common property resources.

This Act is aimed to improve livelihood, alleviate poverty and encourage growth within the poorest millions of India. The Act is significant as it provides scope and historic opportunity of integrating conservation and livelihood rights of the people. This Act also dictates the right to protect, regenerate or conserve or manage any community forest resource which the communities have been traditionally conserving for sustainable use.

➢ *Implementation of Rofr Act*

A multi-layered system has been set up by the government to ensure proper implementation and governance of the RoFR Act. The Forest Rights Committee as elected by Gram Sabha calls for claims and verifies claims as per the rules set under the RoFR Act. The Sub-divisional Level Committee (SDLC formed by the State Government) provides forest, revenue maps and electoral rolls to Gram Sabha and the Forest Rights Committee, who in turn prepares a list of claims. The SDLC consolidates maps and claims lists as provided by the Gram Sabha/ Forest Rights Committee.

The SDLC is involved in conflict resolution between Gram Sabha and claimants. It is also responsible to communicate the responsibility to conserve forestland, biodiversity and maintain ecological balance to the holders of forest rights. The District Level Committee (DLC formed by the State Government) approves and examines all claims submitted by SDLC and resolves petitions from aggrieved persons. The State Level Monitoring Committee (SLMC) is responsible to oversee the whole process, including, monitor resettlement, the process of recognition, verification and vesting of forest rights of the state.

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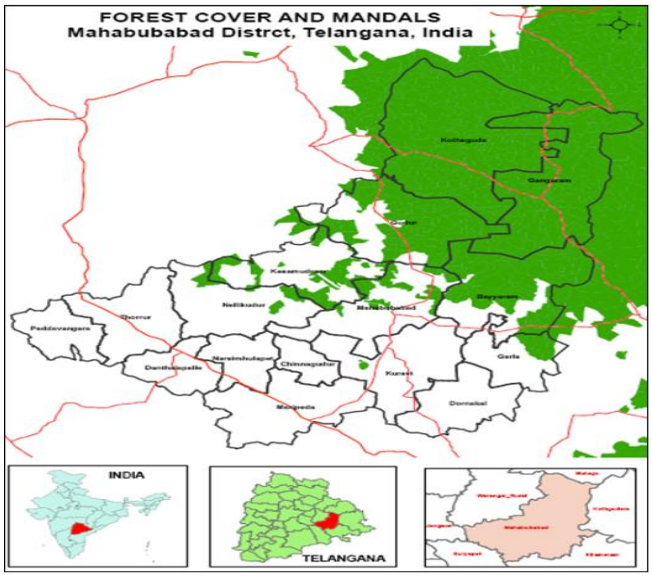

Fig 6 Mahabubabad District Mandals with forest Cover

The RoFR Act has been planned almost flawlessly to provide essential benefits to marginalized communities. However, monitoring and evaluation is crucial to assess the impact of the RoFR Act. Through this paper, we present the results of an extensive visible impact assessment of the RoFR Act. This will prove beneficial to determine the efficacy of the Act and help guide the way forward. This paper closely examines the environmental impact of the RoFR Act by employing effective methodologies/ tools to monitor and evaluate the usage of allotted forest land. This paper undertook a scientific study by utilizing geospatial technologies on the changes in vegetation growth over a period of 20 years in a pilot project area i.e., Mahabubabad district (above fig.6) of newly formed Telangana state and addressed the impact of the RoFR Act. Change detection of vegetation before and after implementation of RoFR Act is examined by utilizing satellite imagery and mapping technologies such as GIS. The extent of forest cover, location of land allotted under the RoFR Act as per the published information by the Telangana Forest department have become crucial in the analysis.

The study has observed huge gap in the understanding of the recognized rights of forest land along with the responsibility for sustainable use, conservation of biodiversity while ensuring livelihood and food security of the scheduled tribes and other traditional forest dwellers. Hence much education and awareness is needed on the subject of recognition of forest rights to the responsible authorities and to the forest dwellers. The below fig-7 represents significant changes of forest depleted during the post implementation of the RoFR act under the study area. The study intends to observe the visible impact of the RoFR act than publishing the statistical details.

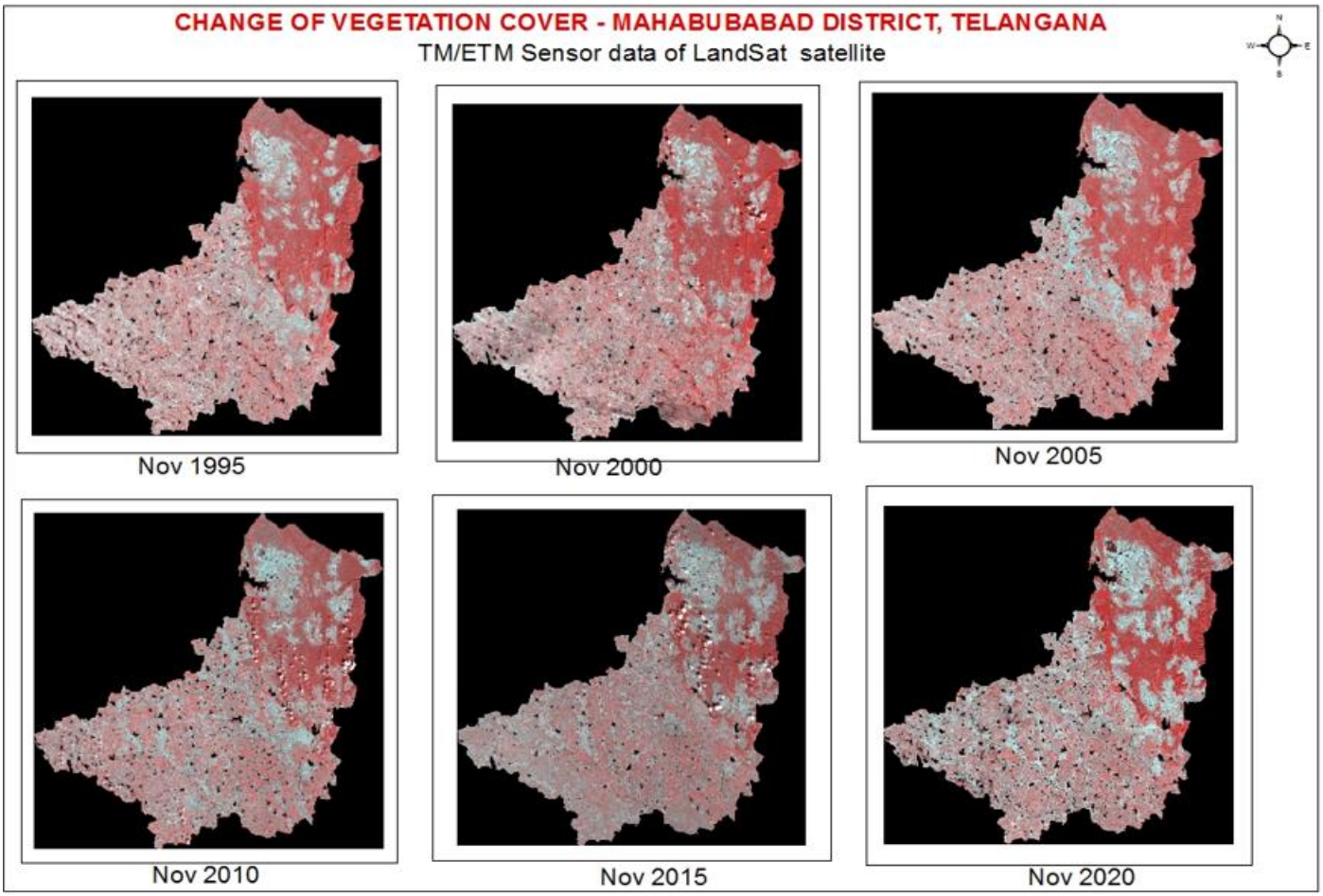

Fig 7 Forest Cover Before and After Rofr Act Implementation in Mahabubabad District of Telangana

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III. RECOMMENDED MEASURES FOR SUSTAINABLE MANAGEMENT

Depletion of green cover due to irresponsible farming activity by the RoFR beneficiaries could be a dangerous threat to the forest cover in the country as the Act is being implemented across the country as a social development. As a way out to balance between the implementation of RoFR act and protecting the green cover, it is advised to conduct country wide training and capacity building programs to enlighten the need of preserving the green cover through cultivation or agro plantation by adopting appropriate irrigation methods such as drip etc. The programs should involve the field level forest officials and the farming community representatives/forest dwellers (RoFR beneficiaries) and effectively conducted by involving recognized key resource centres and relevant scientific societies. Geo-tagging and geo-fencing of all truly recognized cultivable lands by integrating with respective genuine forest dwellers across the country by using GPS or GPS embedded instruments will help in identifying illegal or wrong beneficiaries or unauthorized cultivation in the forest areas. Furthermore, yearly or seasonally monitoring of actual cultivation activity in the recognized cultivable land parcels inside the forest area by using satellite imagery to trace out un-irrigated lands for long periods (probably 2-3 years). Such areas could be encouraged for agro-forestry activity by providing selective tree saplings to the respective recognized forest dwellers or taking back to the forest land and rising plantation by forest department with appropriate notification can be looked at as a directive in the country.

- *Geo-Spatial Technologies in the Management of Forest Resources*

Geo-spatial technologies are at their best inresolving any land related issue or activity in present day conditions. Particularly the advancement in producing high resolution satellite imagery (HRS) and latest software tools providing potential solutions in handling all the issues that are raised in the management of forest resources. HRS data which is being produced in visible bands with very high spatial resolution(below 50 cms) enables each and every stake holder or individual involved in forest management to analyse and assess the tree canopy density, natural forest cover or agro forest/plantation or crop pattern. Since 86% of Indian forest cover is under moderately dense and open forest, the satellite pictures with less than 50cms of spatial resolution provides the desired interpretability in identifying natural vegetation and man grow vegetation. The technical processes such as geo-reference, geo-tagging, cogo and other geo-processes of GIS software have been simplifying the overlay & analysis of revenue maps, forest gazette to their respective true positions with best possible accuracy. Usage of HRS data products and the technical capabilities of geo-spatial software could address the disputes between forest and revenue lands to a great extent.

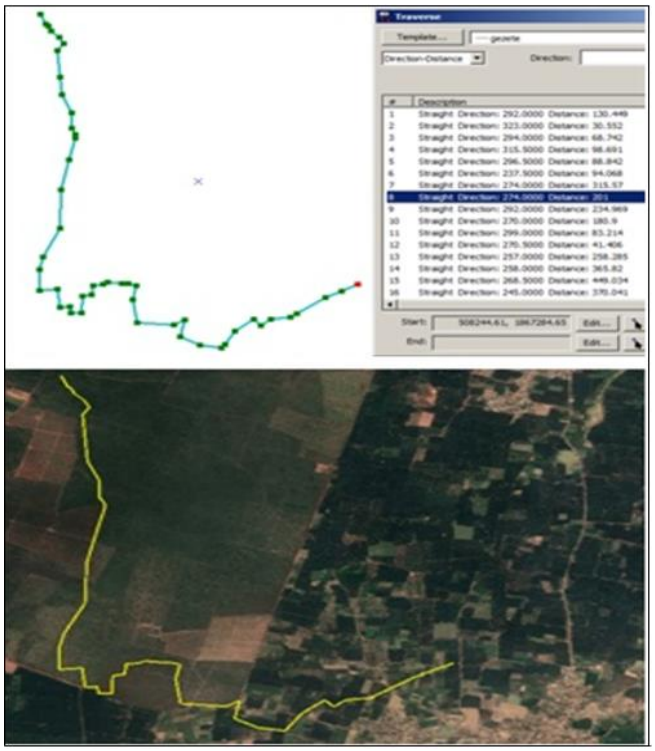

Fig 8 Mapping of Forest Gazette Data Using COGO Tools

Other issues like infrastructure intervention and compensatory afforestation areas, wildlife sanctuaries, eco-sensitive or protected areas, buffer zones etc., can be identified with location and measurement. The GPS/DGPS surveys & GIS processes combined mapping with HRS imagery as reference will provide complete solution in identification of the above mentioned areas with reliable accuracy in positioning and fixation of permanent boundaries. Conducting studies on environmental and social conditionals, integration of stakeholder data with respective areas/zones, preparation of master plans suitable to local conditions would yield effective results in management of these sensitive and protected areas.

Several scientific inputs based sustainable development projects such as watersheds programs; agro-plantation, horticulture development, etc. were taken up for increasing the productive land extent under the revenue land category. Geo-spatial technology has had a crucial role in these projects by not only producing scientific based thematic data but to speed up the processes in deriving the action plans for implementations. Programs like joint forest management (JFM) and Vana Samrakshana Samithi (VSS) are encouraging people from nearby habitats to involve and raise plantations in the nearby forest areas across India. Very limited extent of forest areas were treated under these projects and large extents of vacant/gap areas are found under the largest forest category ie., moderately dense & open forest.

With the advancements of geo-spatial inputs and technological process, it is high time to take up scientific studies on each and every forest block particularly under this open forest category. Block wise HRS satellite products draped over DEMs (digital elevation models) generated

from free sources (earth portals) will be helpful in revealing the aspect or slope in such blocks. Different slope wise integration of tree cover density, other land use & land cover features, soil characteristics, water potentials, etc. would form the scientific base to derive suitable action plans to be taken up in that block. The effective data can be produced in GIS labs without much field works.

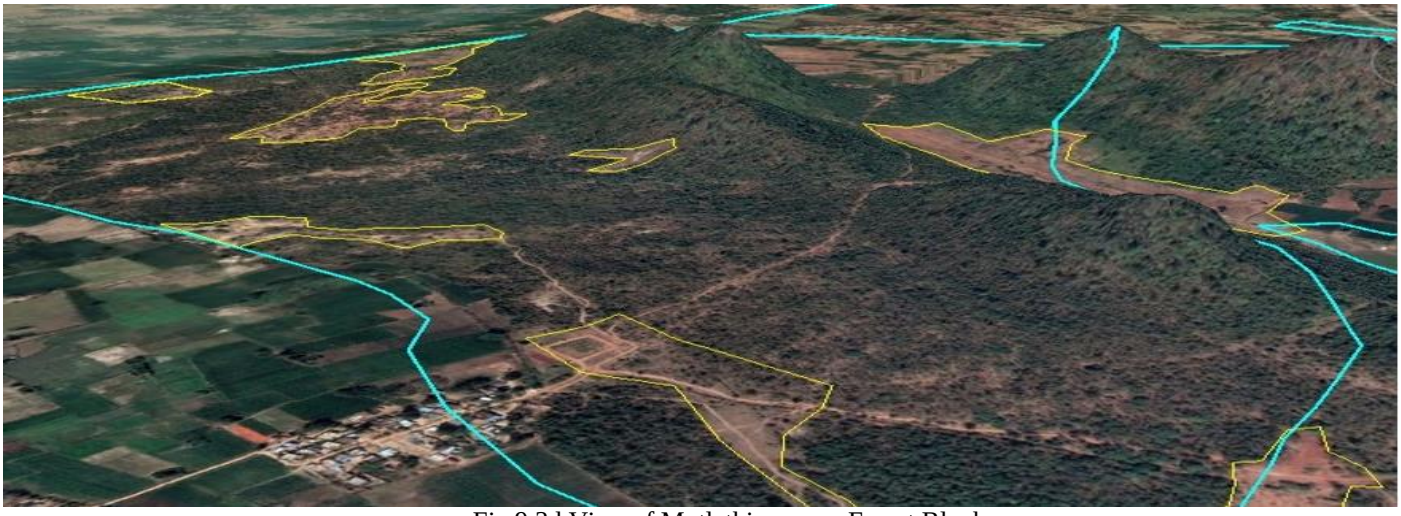

Fig 9 3d View of Motlathimmapur Forest Block

Fig-9 is a 3D representation of a forest block under open forest category wherein the scope for plantation areas are marked in yellow colour, which could be treated with appropriate green activity by considering other scientific inputs like water potential and soil parameters. Variety of bamboo species are available to grow even in the alkaline soils and water logged areas. The geospatial techniques with HRS imagery have made processes simpler and are very lucrative if put into utilisation for the management of forest resources.

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