6. Summary and Conclusion

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Optimal management of natural resources calls for balancing the developmental needs against the possibility of endangering the environment irreversibly. It therefore, necessitates the monitoring of temporal environmental changes for planning precisely and to lead the biosphere into a sustainable system, before the repair implementation cost become prohibitive. The first step in the formulation of an environmentally sustainable development programme is to address existing development strategy, examine lacuna in the present system of implementation and identify viable alternatives.

As the existing conventional system does not take into consideration the interdependencies of the natural resources it has certain limitation when compared to the advanced non-conventional methods like Remote Sensing (RS) and Geographical Information System (GIS) technology. This technology cuts across the narrow confines of sectoral approaches and take a holistic view of a region as a whole. This study therefore has been undertaken to test the potentials of RS and GIS technology in monitoring and planning of social forestry plantation in Matar taluka, Kheda district, Gujarat.

Matar taluka has no natural forest cover though it has cent per cent rural population. The existing tree cover in the taluka is due to the effective implementation of social forestry programme. In addition, the taluka also has vast tracts of wasteland. Hence, a planning model has been developed for maintaining the existing social forestry plantations and putting the wastelands under productive use. This social forestry planning model has been generated by integrating both the spatial and nonspatial data using RS-GIS technology. Thus the entire study can be briefed out in the following manner.

- The use of multitemporal satellite data has proved its potential in the identification, delineation and monitoring of social forestry plantation in Matar taluka.
- Enlargement of positive transparencies of Landsat MSS (1983), Landsat TM (1986), SPOT (1989) and IRS (1991) imageries at 1:50,00 scale have aided in the categorisation of social forestry plantation into three categories viz., the canalside, roadside and other plantations which included farmlands, orchards, village woodlots etc., based on the limitation and precision of False Colour Composite (FCC) used.
- The MSS could delineate the other plantation category. It could not delineate the strip plantation, due to its poor spectral and spatial resolution.
- The delineation of plantation using TM data clearly exhibited its superiority over MSS data in identifying the strip plantations along roadside into National Highway (N.H.8), State Highway (S.H) alongwith other plantations category.
- IRS data proved its potential in mapping of strip plantation when compared to TM data. The advantage of IRS data over TM data was because of its potential to segregate not only the roadside plantation into N.H.8, S.H, and district main roads but also the major canalside plantation.
- SPOT data , due to its better spectral and spatial resolution had an advantage over all the other data used and therefore could delineate almost all the categories of plantations in the study area.
- The early summer data (month of March) has been found to be most suitable for the study of social forestry plantations because of non-interference of other vegetation and presence of full foliage in most of the plant species specifically in the study area.

- All the FCC used clearly showed either total absence or poor existances of plantation in some areas of the taluka viz., Chanor, Vastana, Bamangam and Mehmedabad. This is mainly due to emergence of salinity/alkalinity in these areas.
- Area estimation for three different categories viz., the roadside, canalside and other plantations clearly demonstrated that the order in which the plantation area occurred was other plantation > roadside > canalside. It also showed that there has been a increase in the social forestry plantation in Matar taluka since 1983.
- The accuracy estimation at 90% confidence level for different sensors namely MSS, TM, SPOT and IRS was 76%, 84%, 90% and 87% respectively.
- Attempts on various digital enhancement techniques exhibited that FCC of IRS band 2, 3 and 4 provided the best information for general landuse. In addition, Normalised Difference Vegetation Index (NDVI) using band 3 and 4 of IRS digital data contributed in differentiating the vegetational levels in the study area.
- Supervised classification through digital analysis has yielded ten categories of landuse in the study area. Statistics of the above categories exhibited that the crops covered a major area of the landuse i.e., 28.54% followed by fallow land. The occurrence of more area under fallow land is due to the collection of data in the month of March.The overall accuracy estimation was about 92% at 90% confidence level for the general landuse categories.
- Digital analysis showed its superiority over visual analysis in delineating social forestry plantation based on plantation types namely Eucalyptus spp., Acacia spp., and mixed spp. which was not possible using visual interpretation due to much less difference in the tonal variation.

- Eucalyptus spp. occurred predominantly in the plantations types and were present mainly in the villages like Antroli, Alindra, Radhu, Heranj, Undhela etc., specifically in the farmlands.
- Acacia spp. were found mainly in the woodlots and village commonland occupying very less area, though in reality it occupied larger area. The reason being that these plantations occurred in small patches which are difficult to be delineated by remote sensing. On the other hand some of these patches have gone under mixed spp. category.
- The mixed spp. comprised of Dalbergia, Peltophorum, Albizzia, Samania, Ficus. Acacia etc. These are not spectrally seperable and hence categorised under mixed plantation.
- The area estimated under Eucalyptus spp., Acacia spp., and mixed spp. was about 1926 ha., 318 ha., and 1069 ha. respectively. Village-wise area covered by these plantations showed that out of 82 villages 56 villages have less than 5% plantations. The remaining 26 villages are mainly concentrated on eastern side of the taluka.
- The accuracy estimation at 90% confidence level for different categories namely, Eucalyptus spp., Acacia spp., and mixed spp. was 100%, 85% and 93% respectively. The overall accuracy was about 92% at 90% confidence level.
- Wasteland map generated from IRS digital data brought out three categories viz., waterlogged, pasture/grazing land and three categories of salt affected land namely strongly, moderately and slightly. The total area covered by these wasteland categories was about 28.38% of the total geographical area.

- The three categories of salt affected lands have amounted to more than 40% of the total wasteland. The area covered by these lands are in the order of slightly > moderately > strongly which occur mainly in the northern and southern portion of the study area.
- The chemical analysis of salt affected soils exhibited very distinct characteristics. The strong salt affected soil showed the pH ranging between 8.5 to 9.1, ECe ranging between 2.1 to 2.6 dSm^{-1} and ESP varying between 21.5% to 23.4%. On the other hand, moderately salt affected soil had pH, ECe and ESP ranging between 8.4 to 8.6, 0.59 to 0.65 dSm^{-1} and 14.5% to 16.3% respectively. The slightly salt affected soil exhibited distinct pH value ranging between 8.0 to 8.2, ECe and ESP values ranging between 0.6 to 0.75 dSm^{-1} and 14.5% to 16.3% respectively. The ionic status of all the salt affected soil showed the order of cations as $Na^{+} > Ca^{2+} > Mg^{2+} > K^{+}$ and anions like Cl^{-} to be morethan So_4^{2-} with trace of Co_3^{2-} and HCo_3^{2-}. Negligible difference was observed at different depths of soil.
- The waterlogged soils were found interspersed with salt affected soils and they covered about 31.40% of the total wastelands. These lands concentrated mainly in the southern region of the taluka. The chemical analysis of these soils exhibited either the characteristics of slightly or moderately salt affected soil.
- The major causes for the occurrence of these ecological hot spot areas are the introduction of Mahi River Bank Canal (MRBC) irrigation system, absence of proper drainage and lack of adequate land and water management. Such conditions have led to the transformation of this fertile soil into wet deserts.
- Pasture/grazing land occupied about 28.6% of the total wasteland and soil chemical characteristics of soil of this area showed no abnormality.
- Village-wise area statistics of the wastelands depicted that out of the total 82 villages of the taluka, villages having greater than 20%, 10% and 5% of wastelands are 22, 13 and 9 respectively.

- The criterion based analysis for village-wise land capability map generated by GIS technology yielded four categories of land such as Good, Moderately good, Moderately poor and Poor based on the limitation it holds.
- The analysis of village-wise fuel and fodder availability and requirement using RS-GIS technique broughtout three categories viz., surplus, sufficient, and scarcity in 29, 10 and 39 number of villages respectively.
- The composite map of site suitability generated using land capability, need vs availability and wasteland maps yielded four categories of suitability for the development of plantation in the study area. They are mostly or highly, moderately, less and least suitable classes. The area computed for most, moderate, less and least classes was about 52.29 sq.kms., 1.83 sq. kms., 56.94 sq.kms. and 38.08 sq.kms. respectively.

It can be concluded from the above study that the visual and the digital analysis of satellite data alongwith Geographical Information System can play a vital role in the monitoring and planning of social forestry plantation in Matar taluka. The information generated for this taluka will aid in understanding the spatial distribution of social forestry plantations, wasteland, suitable land for plantation etc., which ultimately will help in further planning and taking intime appropriate decision for meeting the requirement of the rural population.