EVALUATION OF IMAGE PROCESSING TECHNIQUES USING REMOTE SENSING FOR ASSESSMENT OF FOREST.

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Abstract:
Forest plays an important role in amelioration of climate, soil and water conservation, biodiversity conservation, habitat for variety of fauna, tourism and recreation etc. For better management of forest it is essential to know the present status of forest in terms of its area, type of forest, growing stock and spatial distribution. Remote Sensing and Geographical Information System (GIS) technology provide essential tool for the required assessment and systematic observation on forest resource. Present study demonstrated different type of images processing techniques for extraction of accurate and reliable information from the satellite image of Bhingra Reserve Forest in Shravasti district, Uttar Pradesh. It covers an area 15828.94 ha and lies between 27\(^\circ\)40'11" to 27\(^\circ\)54'08"N latitude 81\(^\circ\)48'40" to 82\(^\circ\)01'27" E longitude. IRS LISS III and PAN data have been merged through data fusion technique and the merged data was further processed through different image processing techniques such as Contrast enhancement/ Stretching (liner, adaptive, equalization, root and frequency), Spatial filtering (low pass and high pass), Vegetation Indices, Principal Component Analysis (PCA). These techniques have been evaluated by comparing the results. In the Spatial filtering, sharpening filter has given the best result. In vegetation indices, only NDVI has gives best result. Amongst the different PCA, PCA1 image has shown better interpretability. In general, it has been observed that LISS III and PAN merged data set followed by linear stretching has given the best results as it shows good discrimination between forested and non-forested areas and also enhance the overall differences in gray levels of the image.

Keywords:  

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Shivangi Somvanshi is M.Tech (Env. Engg) from IET, Lucknow and working in field of Remote Sensing & GIS from past 2.5 years. She executed/ worked many project of national and state level such as Development of regression models for water quality of Gomti River and Yamuna River, Forest Fire study, Soil salinity study of Haryana state, Forest inventory, Forest Stock Mapping and Volume Estimation Project etc. Written a number of reports and published several research papers in national and international conferences/journals.

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Introduction:

Forests are known to be one of the very important renewable natural resources. Forest holds a very important place in life and philosophy of the people apart from the material gains that it brings about continuously ever since the birth of civilization (Trivedi, 1999). The World Bank remarked stating that “Growing population pressure has always been a major cause of forest depletion. Such adverse effects are now most pronounced in developing countries, a reflection of their typically greater population densities, more rapid population growth, their rural based economies, with large numbers of relatively low income people, and lack of conservation measures” (Prabhakar, 2001). India faces two serious problems in the depletion of its forest and the degradation of its lands, causing considerable harm to society and the environment.

Forest Survey of India (FSI, 2005) reported that in the year 2003 forest and tree cover in India have been estimated as 778,229 km$^2$ which constitutes 23.98 per cent of the total geographical area of the country. The forest and tree cover in Uttar Pradesh is 21,833 km$^2$ that constitute only 9.06 percent of total geographical area of the state. In Uttar Pradesh forested area is distributed largely in Tarai and Vindhayan regions parts of the state.

New technical capabilities for forest measurement may be able to meet some of the nation’s burgeoning forest information needs. An important development over the past quarter century has been the deployment of a range of Earth-observing satellites, along with rapid improvements in computing power to support the analysis of space-based imagery. Timely, accurate and reliable information on natural resources with respect to their potentials and limitations is a prerequisite for sustainable development. Satellite remote sensing data comprise essentially a faithful record of the reflected and/or emitted electromagnetic radiation from a given segment of the earth’s surface (Rao, 2000).

Remote sensing capabilities have evolved rapidly over the past quarter century with the development of new satellites and sensors, information management technologies, and image interpretation techniques. Most importantly, the spatial and spectral resolution of imagery has been enhanced, enabling interpreters to discern more attributes of a forest from a given scene. As more satellites are placed in orbit, the revisit cycle is falling, thereby allowing a more real-time measurement capability. It is now widely accepted and demonstrated by many researchers such as Singh et al. (2005); Joseph (2003); Musa and Sood (2002); Bisht and Kothyari (2001); Jagdeesh et al. (1999); Minakshi et al. (1999); Roy et al. (2002); Chauhan et al. (2003); Mahajan and Panwar (2005); Boyd and Duane (2001); Tirkey et al. (2005); Kachhwaha (1993); Zhang and Zhang (2007) and Song (2007) that Remote Sensing and Geographical Information System (GIS) technology provide essential tool for the required assessment and systematic observation on forest resource. Remote sensing could be deigned to support sustainable forest management in presentation and reporting on the criteria and indicators of sustainable forestry, and in modeling and projections at a variety of scales based on a common under-standing of biophysical and ecological principals (Curran, 1985; Berry and Ripple, 1996).

However, to obtain the best results, it is imperative to adopt the appropriate technique of data analysis. For this purpose, present study was conducted to find out suitable procedure of extracting information from satellite data coupled with the use of GIS technique. The study demonstrated different type of images processing techniques for extraction of accurate and reliable information from the satellite image in Tropical Moist Deciduous Forest in Tarai region of Uttar Pradesh. These techniques have been evaluated by comparing the results.

Study Area:

The study area covers Bhinga reserved forest in Shravasti district of Uttar Pradesh having an area of 15828.94 ha and lies between 270 40’ 11” to 270 54’ 08” N latitude 810 48’ 40” to 820 01’27” E longitude. The study area covers parts of 63E/13, 63E/14, 63I/01 and 63I/02 topographical maps of Survey of India on 1:50,000 scale. The location map of study area is shown in Figure-1.
Indian Remote Sensing Satellite IRS-1D, LISS-III and PAN merged images acquired on 27 March, 2000 were used to prepare detailed forest map. Collateral data from forest department such as compartment boundaries, range boundaries, old working plan etc. were also referred. Survey of India toposheets were used for base layers preparation and ground truth.

Methodology:

In order to achieve the objectives of the study, the image processing technique was carried out using Indian Remote Sensing Satellite IRS-1D, LISS-III and PAN merged images of 27 March 2000. The higher resolution PAN data was georeferenced with the help of Ground Control Points (GCPs) taken from Survey of India topographical maps as well as from GPS observations in the field. The LISS III and PAN data were merged through image fuse process Intensity-Hue- Saturation (IHS) transformation and ‘Cubic convolution’ re-sampling methods of resolution merging technique, using Geomatica / Easipace 9.1 software. The merged images have the advantage of both multi-spectral data from LISS III as well as higher ground resolution from PAN data.

The merged data was further processed through different image processing techniques such as Contrast enhancement/Stretching (liner, adaptive, equalization, root and frequency), Spatial filtering (low pass and high pass), Vegetation Indices, Principal Component Analysis (PCA) using ERDAS IMAGINE / ARC GIS 9.1.

Results:

IRS LISS III and PAN merged image gives more information as compare to LISS III and PAN considered individually. Figure - 2 shows IRS LISS III, PAN and Merged image of part of study area. Results of the digital Image enhancement techniques such as Contrast enhancement/stretching, Spatial filtering, Vegetation Indices, Principal Component Analysis etc. were compared and evaluated. The results of different contrast enhancement / stretching techniques are represented in Figure - 3. In comparison between adaptive and equalization, open areas are more distinguishable in equalization enhancement. In root enhancement, teak forest area is more clearly demark able as compared to other techniques. In frequency enhancement, small pockets within forest types and non-forested areas could be also distinguishable but image became noisy. The water bodies are more enhanced in all enhancement techniques except in Infrequency enhancement. The linear features were also highlighted in all enhancement
techniques. In the spatial filtering; sharpening filter has given the best result as shown in Figure - 4. In vegetation indices, only NDVI has gives best result as shown in Figure - 5. Amongst the different PCA, PCA1 image, in general, has shown better interpretability. PCA1 shows better discrimination between forested and non forested areas (Figure – 6). In general, it has been observed that LISS III and PAN merged data set followed by linear stretching has given the best results.

Fig. 2 IRS LISS III, PAN and merged image of the part of the study area.

Fig. 3 Different types of image enhancement techniques

Fig. 4 Different types of spatial filtering techniques

Fig. 5 Different types of vegetation indices
Conclusion:

Remote sensing data can be used with existing maps so that it can be updated and verified, or to create new maps where they do not exist. Some of the benefits of remotely sensed data and resulting inventories and maps are: (1) they provide synoptic view of larger forest area and could also show neighboring and regional landuse, which is less possible with ground samples; (2) they enable users to detect changes in land cover, forest fires, insect infestations, and the like as well as repeated observations over the same area; (3) they provide information about forest and local distribution; (4) they provide accurate information about forest health; (5) they are cost effective; (6) they can be a valuable tool, particularly for stewards of large timberlands or other properties, when assessing forest classification and health as a part of an effective forest management plan (Musa and Sood, 2002; Navalgund et al., 2007). Yang (2007) demonstrated integrated use of remote sensing and GIS in riparian vegetation delineation and mapping. Kumar et al. (2007) used remote sensing and GIS techniques for stratification of forest density. Yang and Liu (2005) used satellite imagery and GIS for landuse and landcover change mapping. Ganzin et al. (2005) used remote sensing as an operational tool for national planning in Namibia for rangeland resources.

The increasingly rapid destruction of forest globally has prompted professional foresters and politicians to think alike and find a way to control, stop and even reverse the process, and take suitable action without undue delay. A sustainable effect of such action can be expected only if the root causes are properly tackled. Therefore, the problems need to be examined from a cause and effect point of view. Satellite remote sensing and GIS enables study of forest and its environment, and monitor change at global, national, regional, and even micro levels. Rapid changes in forest cover and conservation issues require fast data and information retrieval in assisting forest and environment conservation and management that could be obtained by the use of proper and suitable techniques of remote sensing and GIS.

References:


