# GIS Application for Forest Development in Drylands of Pakistan

**Farooq Ahmad[1] and Sameera Farooq**
**[1]Department of Geography, University of the Punjab, Lahore, Pakistan**
**E-mail: farooq@gis.pu.edu.pk**

## ABSTRACT

**Pakistan is a tropical country with vast semi-arid and arid tracts of land spread over 68 million hectares. Total forest is defined as land with tree crown cover of more than 10 per cent of the ground and area of more than 0.5 hectares. In the case of the tropical region, inventory information is supplemented by a remote sensing survey. If only limited or out-dated inventory data are available, combinations of linear projections and expert opinion techniques were applied to fill in data gaps. GIS connects people and their interests; it can be used most efficiently and effectively for the analysis of large-scale spatial data sets. It facilitates cooperative approaches and with the integration of GIS, there will be a whole new framework for organizations and society to work together and make decisions. Adoption of GIS technologies for forest management started at the beginning of the 1990's. This paper summarizes a set of GIS applications for forest management, which were designed and can be implemented in the drylands of Pakistan. The main focus is given to description of application-specific needs and its accomplishment using GIS technologies.**

## INTRODUCTION

Managing complex drylands forest requires up to date technology in ensuring sustainable resources utilization (Khali *et al* 2001). Much of the current forest management practices can be improved through the use of current technologies including remote sensing, GIS (Geographic Information System) and GPS (Global Positioning System) which may enhance any decision making process. Precision forestry practices can be carried out with the help of these technologies, which is inline with the sustainable forest management (SFM) concept. For instance in practicing SFM and anticipating Forest Certification, forest manager requires more intensive, precise, and documented information about the forest resources and landscape features and attributes which can be gathered through remote sensing and GIS techniques. Forest surveys including inventory assessment and compartment maps are essential for effectively achieving long-term sustainable forest management planning goals. This can be done precisely using GPS technique. All this has been part and parcel of precision forestry practices.

In arid and semi-arid areas most parts are bare of vegetation. In some areas spotty scrub forests have developed. The dry sub-tropical forests dominate up to a height of 1, 000 meters. The hills and foothills of Gujrat, Jhelum, Rawalpindi and Attock districts of the Punjab, Mansehra, Abbottabad, Mardan, Peshawar and Kohat districts of NWFP are covered with dry evergreen forests with some dry deciduous patches. In Balochistan they are confined to the Sulaiman Mountains and other hilly areas where they are represented by scattered patches of dry mixed scrub. Reckless cutting and fire have turned it essentially into an open forest with occasional dense patches. The open areas are covered with grasses and are used for grazing. The dominant trees are *Acacia modesta* and *Olea cuspidate* and chestnut, juniper, walnut and oak are some of

Print

Proceedings

the deciduous trees. *Acacia modesta* occurs at higher elevations. Great damage is caused to the soils by erosion. Running water and wind are the main agents of soil erosion in drylands of Pakistan. Plants check the run-off and act as wind-break as the roots bind the soil particles. Thus by vegetation cover soil erosion is greatly minimized. In Pakistan only 3.8 per cent of the total area is covered with forests.

Aridity prevailing over a large area has made the growth of trees difficult. Over-cutting of trees and over-grazing by animals have destroyed the forests and impeded their regeneration (Kharin *et al* 1999). According to an estimate 14,170 hectares of soils are eroded in Pakistan every year. This is a disturbing situation.

## GIS IN FORESTRY

The use of spatial data for drylands forest resource management and planning has been recognized worldwide. However, the spatial data will be less useful if they are not transformable into information, which can be analyzed and interpreted in a systematic and quick ways. Hence there is a requirement to transfer and keep spatial data related to forestry in a standard computer format preferably in a GIS environment. A GIS is an integrated resource data base system that has the capability to store, edit and process digital data; and that supports development planning and policy analysis. The use of GIS in drylands forestry is becoming very important in which immense accumulation of data is unavoidable. The Ministry of Environment, Government of Pakistan has set up Environmental Monitoring System (EMS) combining NOAA AVHRR data with high resolution Landsat TM data and ground observations with an objective to develop an operational GIS for more effective planning, management, conservation and sustainable development of the forest resources.

## GPS IN FORESTRY

Global Positioning System (GPS) is a highly accurate satellite based radio navigation system providing three-dimensional positioning, velocity and time information. In order to achieve GPS co-ordinate readings, the GPS unit transmitter must detect a minimum of four satellites and the more satellites detected by the transmitter, the more accurate the readings tend to be. Better accuracy can also be achieved if differential GPS (DGPS) is used (Khali *et al* 2001). The idea behind the DGPS is to correct bias errors at one location with measured bias errors at a known position. A reference receiver, or base station, computes corrections for each satellite signal. Some of the potential and useful GPS applications in drylands forestry include tree location mapping, forest compartment boundary survey, forest road survey, ground truth activities and resources inventory.

Using GPS as a tool to map tree location is becoming very important (Zarchan 1996). Tree mapping utilizes both qualitative and quantitative data collection techniques in order to create a database containing the spatial location and attributable information of the trees. Pakistan Forest Institute (PFI) had successfully developed tree location information and other three biophysical information including species, diameter at breast height, height and tree conditions were also recorded for ecological rehabilitation in drylands of Pakistan. These informations were combined

in a GIS database and specific computer programming was done to develop Environmental Monitoring System.

A preliminary study was carried out to test the suitability of GPS for mapping. A DGPS technique involving the use of two GPS; a stationary base station receiver left at known reference location and a "rover" receiver used in the field to map the tree location was used to locate the tree position. The tree location information was transferred into forest compartment map in a GIS database system. The study indicates that DGPS can be used to determine tree position in the natural forest environment.

Forest harvesting in Pakistan is generally based on sustainable forest management. Tree mapping using GPS prior to harvesting operation will also facilitate reduce impact logging activities. It will contribute in making careful planning and comprehensive harvesting plan because tree distribution and location are known. For instance, road and skid trails planning can be done efficiently (density and distance might be reduced). It is also anticipated that directional felling can be practiced precisely to avoid potential crop trees and watercourses by directing the felling towards existing natural gaps, thus minimizing damage to the residual trees (Khali *et al* 2001).

It is no doubt that tree mapping in drylands forestry using GPS will become a very important issue in near future. It is a part and parcel of any forest information system intends to be developed. By incorporating tree information in the harvesting planning it has its unique role in ensuring precision forestry practices and in achieving sustainable forest management concept.

**REMOTE SENSING IN FORESTRY**

Space technology, through satellite remote sensing, has found a very valuable application in drylands forest management not only for resource surveys, but also for studying the role of forests in maintaining ecological balances and elucidating their impact on global climate. Satellite remote sensing contributed to the various aspects of drylands forest management, such as forest cover mapping and monitoring changes, evaluation of ecosystem, estimation of biomass, carbon flux and productivity, and the feasibility of developing an integrated information system. Remote sensing systems collect information about objects without coming into physical contact with it; in earth observation the most important medium to transmit this information is electromagnetic radiation in the optical and microwave region. Major advantages result from its synoptic nature, comprehensive spatial information and objective, repetitive coverage. While remote sensing has initially been used primarily for resource mapping and inventory it turns out that monitoring and predictive modelling is becoming more important and successful. Remote-sensing systems, and in particular Earth observation satellites, provide significant contributions to detecting deforestation, forest degradation, land cover assessment and monitoring, particularly by providing methodological pathways for scaling up the results of field investigations and by supplying the spatial information needed for regional-scale analyses. Besides airborne systems for individual surveys on local to regional scale, several geostationary and polar-orbiting satellites (*e.g.*, METEOSAT/GOES, NOAA-AVHRR, Landsat, SPOT-HRV and VEGETATION, IKONOS) are available which operate in the reflective and emissive domain and can be used for regional to global assessments. As continuity for most operational remote sensing systems seems guaranteed they can be used for continuous environmental

Print

Proceedings

monitoring but also for retrospective studies on environmental change that has occurred in the past. In the future, one can expect that remote sensing systems with increased spectral resolution as well as active or passive microwave sensors may further increase application perspectives.

It is widely agreed that forest degradation in arid, semi-arid and dry sub-humid ecosystems is not necessarily driven by climatological variables but frequently triggered by processes which result from adverse human impact on these fragile ecosystems. The productivity of drylands systems largely depends on surface properties which, as they control water availability, the spontaneous emergence and development of new plants and dust production during wind storms, might dominate climatic variables. Our ability to draw concise conclusions with respect to land resources and environmental change will thus depend on the capability to assess not only vegetation conditions (*i.e.*, cover, structure, biomass) but also specific surface characteristics (*i.e.*, parent material and soil substrate, including mineralogical and biologic crusting) from remote sensing data. Resource assessments and continuous monitoring of environmental parameters are complementary issues to be observed for a sustainable management of drylands ecosystems. It seems obvious that the identification of forest degraded areas in the sense of environmental inventories provides the fundamental basis for better understanding the processes of deforestation and forest degradation in their spatial context. It is essential to monitor both, namely soil conditions and the disturbance regime of plant communities over time, including their successional recovery. The integrated interpretation of the satellite-derived information layers, available climatic records and results from detailed field studies may provide new perspectives to understand environmental change in arid ecosystems.

## CONCLUSIONS

Forest vegetation in Pakistan is diverse in its structure and composition. This is due to variations in climatic and ecological conditions under the change in latitude from $24^{o}$ to $37^{o}$ North and altitude from zero, or sea level, in the south to more than 8,000 meters in the North. These changes also account for a progressive decrease in the mean annual temperature and increase in rainfall from the south towards the north. Current awareness on the importance of sustainable forest management has pave the way for the Ministry of Environment, Government of Pakistan to make full use of the latest technologies including remote sensing, GIS and GPS. Necessary steps have been taken to make full use of the technologies so that precision forestry can be practiced in line with the sustainable forest management concept. It is anticipated that with sufficient research support, the findings will provide the opportunity to revolutionize the use of these technologies as a tool for forest planning. It may enhance decision making process as well as contribute to the successful implementation of the management strategies.

## REFERENCES

Khali Aziz, H., Ibrahim, S., and Norizan, A.P. (2001), "Tree mapping using Differential Global Positioning System (DGPS) – A step towards precision forestry", *Paper in Teknologi Remote Sensing dan GIS dalam Aplikasi Perhutanan,* Kuala Lumpur, July 31, 2001, pp.10.

Kharin, N., Tateishi, R., Harahsheh, H. (1999), "Degradation of the drylands of Asia", *Center for Environmental Remote Sensing (CEReS), Chiba University,* Japan.

Zarchan, Paul (1996), "Global Positioning System: Theory and Application", Volume 1, *American Institute of Aeronautics and Astronautics, Inc.*, Washington D.C.