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Remote Sensing and Spatial Information in Support of Co-Management Planning

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The Nishorgo Support Project design called for production of Protected Area (PA) management plans, demarcation of PA boundaries and monitoring of impact on human and natural environments (Forest Department 2005). Initial site level appraisals (Mollah et al. 2004a to e) generated a mass of descriptive information from in and around the pilot PAs which needed to be joined with spatial information to support detailed co-management planning. For example, the studies identified villages, brickfields, saw mills, furniture shop owners, and other stakeholders using resources from the pilot PAs. The reports also showed how extracted resources flow from PAs to different growth centers and markets (known as hat or bazar). Market names were known but the locations needed to be mapped.

The landscape focus highlighted by Nishorgo required management interventions beyond the borders of FD lands. But the Forest Department (FD) only deals with spatial data (vegetation, offices, roads, rivers, streams, etc.) within the boundary of lands under its jurisdiction. So to meet the broader needs for spatial information, database development was outsourced to Center for Environmental and Geographic Information Services (CEGIS), which is the centre of excellence for Remote Sensing (RS) and Geographic Information System (GIS) in Bangladesh. The GIS based Resource Information Management System Unit (RIMS-GIS Unit) of FD was consulted, and by the end of 2005 a vector database had been developed building on the RIMS base maps which included roads, railways, rivers, civil administrative boundaries (international, district, upazila, union and mauza/village), growth centers, public and community institutions (education, health, etc), and settlements (CEGIS 2005). To this were added landuse/cover maps for the surroundings of the five PAs (plus Sitakunda Eco-park which was expected to be a sixth site) using IRS LISSIII images (CEGIS 2005). As a test case, a very high resolution satellite image (QuickBird) was bought for Roikheong Beat (Whykheong Range) of Teknaf Wildlife Sanctuary to assess its utility for quantification of forest loss, detailed landuse/cover mapping and possible use for communication and outreach.

When it was subsequently decided to initiate co-management in the Modhupur National Park, equivalent digital databases were developed for this area. In addition, considering the complex pattern of change and encroachment there, a database was developed to show the spatial degradation of forest over the last 40 years.

Starting Assumptions and Subsequent Adaptation

At the onset, we began with the assumption that significant starting information was already available in databases (vector) held by different institutions including RIMS of FD, National Water Resource Database, CEGIS, Local Government Engineering Department (LGED), and International Maize and Wheat Improvement Center. However, no existing database satisfied the range of needs across the landscapes (for landuse, administrative structures, forest types

and population centers), so it was decided to merge and update the existing ones.

The project had expected to develop databases by building on the expertise already existing at that time in the FD RIMS-GIS Unit. The aim was to build the capacity of existing staff and new recruits to the Unit, as the best means of delivering cost-effective spatial analysis. However, the RIMS Unit at the time was under nearly constant demand for spatial analyses, and had little spare time and resources to apply to Nishorgo. The one Assistant Conservator of Forest working in

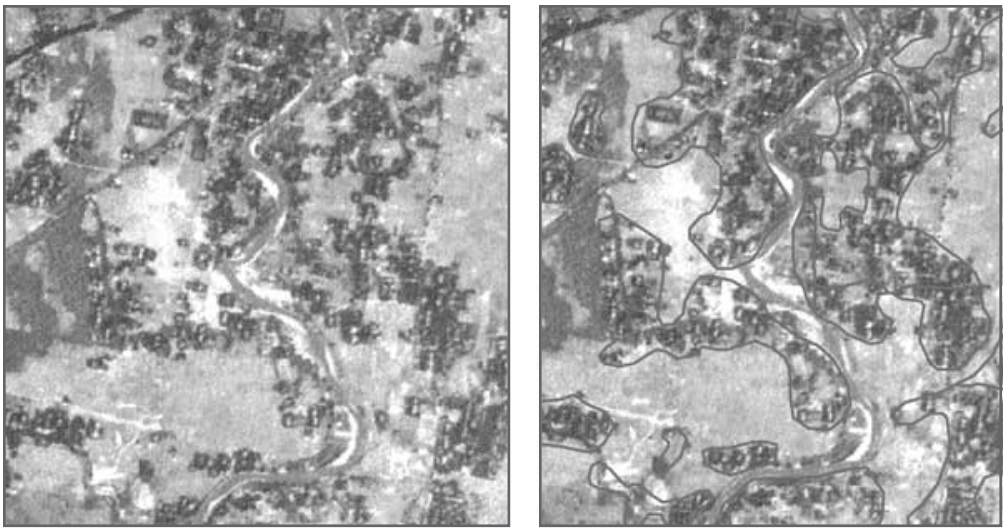
RIMS-GIS Unit was not allocated time to lead such an activity, but did prepare an assessment report on the existing databases for the five PAs (Chowdhury 2004).

Hiring individual consultants, educational or commercial organizations were considered. Nishorgo opted to go with CEGIS, which was a strategic partner and designated "resource firm" in IRG's project proposal. CEGIS would deploy its team as and when needed based on its experience in delivering high quality products to deadlines. CEGIS is the sole distributor of some satellite images in Bangladesh, and has skilled and experienced geo-informatics professionals, equipment and training facilities.

Project staff, the Assistant Conservator of Forest RIMS-GIS and CEGIS jointly reviewed available data, needs, ways of addressing these gaps, and potential sources. Based on the resultant CEGIS report a two-phase approach was adopted. The first phase included the entire vector data (administrative boundary, roads, rivers, growth centers, etc.) generated from various sources. The second phase included generating new databases to fill gaps, notably generation of landuse/cover maps.

Remote Sensing images were a very useful tool for developing comprehensive geo-spatial databases required for the current project. For images to produce landuse maps, SPOT XS and Landsat ETM+ were considered. However, the later produces coarser spatial resolution (30m) images and since 2003 it provides low quality data. Instead LISS III (MSI) image was selected. The LISS III offers more recent data (2004-05) of a better spatial resolution (24m) and is considerably less expensive than SPOT XS (20m spatial resolution). The current price (2008) of IRS LISS III (MSI) is USD 330 (ground coverage 140 km by 140 km), compared with SPOT (XS) images costing USD 2700 to 3850 for ground coverage of 60 km by 60 km, and IRS Pan or Mono images (6m spatial resolution) costing USD 415 with ground coverage of 70 km by 70 km. CEGIS, being the authorized dealer of the LISS image, also could help FD access images in future. It was agreed to use the latest archived IRS P6 Mono image (6m) for more detailed information on road network, growth centers, and settlements which are not present in any other available database.

It was agreed to use broad landuse classes outside the PAs such as agriculture, homestead and settlements, tea gardens, and water. To generate detailed land cover data used by the FD inside PAs would require thorough field verification. It was decided that CEGIS would try to follow the FD classification system (plantations of different types and ages, high and low forest, scattered trees, etc) to the extent possible and FD would help by incorporating data from the field. It was also agreed that FD staff would continue to update the data sets. Qualified FD staff were to accompany the CEGIS remote sensing ground-truthing team when visiting



Sample of an IRS Pan (6 meter) image from where settlements have been captured. The image on the left was used to capture settlements, on the right, the captured settlement boundary (line) is overlaid on the original image for cross-checking.

different areas of the PAs to generate the classification. A number of factors made this difficult. Most importantly, FD field staff had other occupations that made it difficult to allocate time for this work. In addition, the FD plantation journals that should have guided such updates were in most cases poorly maintained, outdated or unavailable. In the end, CEGIS teams had to proceed to interpret forest classes as closely as possible given this lack of close knowledge sharing with the FD.

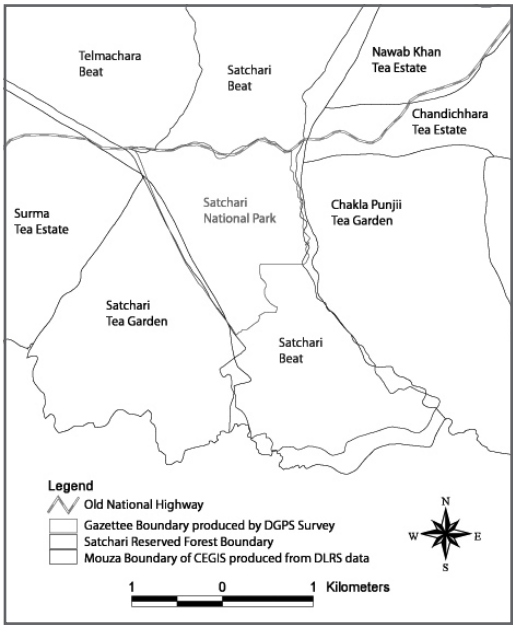
Bundle image (0.6m Pan + 2.4m MSI) product of a high resolution satellite image (QuickBird) was purchased as a test case for one small area to assess its quality, usability in distinguishing types of forest stands, use in determining encroached areas, to encourage research, and to use it as a tool in discussing the extent of forest degradation with local communities. Accordingly an image was purchased and classified for the Roikheong and Saplapur Beats of Teknaf Wildlife Sanctuary, including a small buffer area to the north of the Reserve. The image distinguished precisely and adequately small areas of non-forest landuses (agriculture, settlements, encroached forest areas, open water bodies etc.). Forest areas were distinguished based on canopy density (high, medium and low canopy). But differentiation among vegetation types (natural versus plantation) within forests could not be done since ancillary data from the field level offices were not found. However, FD has said that it will undertake further evaluation of the image to explore the potential application of such imagery for forest and PA management.

In Bangladesh each organization working with spatial data sets uses its own choice of geographic reference format including Bangladesh Transverse Mercator (BTM), Modified Universal Transverse Mercator of Bangladesh, Universal Transverse Mercator (UTM), and Lambert Conformal Conical (LCC) projections. Similarly the Survey of Bangladesh uses 1:50,000 and 1:250,000 scales with a permanent grid, LGED uses 1:50,000 for upazila maps, and RIMS uses 1:15,000, 1:25,000 and 1:50,000. As a result, data sharing among different

agencies is made difficult on technical grounds. Inter-institutional constraints further reduce the possibilities for sharing spatial information, and this became quite clear during Nishorgo's attempts to both obtain and harmonize data across some of these departments. Harmonizing all data sources in the country was beyond the objectives of the Project. In the end, we were obliged to select one source for geo-referencing all other spatial data sets, and so proceeded to use the IRS pan image. We believed this to be an acceptable solution since the CEGIS-archived IRS Pan images retain high geometric positional accuracy, which are geo-referenced by using Ground Control Point coordinates collected by Differential Global Positioning System (DGPS) survey.

It became apparent during the development of spatial data sets that important contradictions existed between the PA boundaries as represented on the maps used by the Forest Department and a number of recognized geo-referenced points on the new maps. During field surveys an attempt was made to correct the PA boundaries. Neither reserve forests nor PAs have well demarcated boundaries, and often the forest boundary (produced by RIMS-GIS Unit) does not match with the mauza boundaries the Directorate of Land Records and Surveys (DLRS) which were digitally captured and corrected by CEGIS, ownership of the corrected data lies with CEGIS). This results in areas with either overlapping ownership/status or blank areas (with no clear status) along the periphery of the forest reserves. In discussion with FD, it was evident that currently the boundary marks are not identifiable in the field and consequently the delineating points are also incompatible with the mauza maps of CEGIS.

Mismatch in digital PA boundary between RIMS and CEGIS (DLRS data), an example from Lawachara NP



Mismatch in digital PA boundary between RIMS, CEGIS (DLRS data) and map produced from Gazette Notification through DGPS survey, an example from Satchuri NP

CEGIS assisted with a DGPS survey using gazette notification bearing and distance values of stations for PA boundaries in the three northern PAs and from this created boundary maps for Lawachara and Satchari National Parks. The method included identifying one, two or more existing boundary pillars in the field, collecting their positions using DGPS, recreating the map using AutoCAD by bearing and distance values, and geo-referencing the map using the corresponding coordinate values of boundary pillars. However, neither FD nor CEGIS mauza maps were found to be consistent with the recreated DGPS surveyed maps based on gazette notification values. This means the original survey for proposing an area as a PA was not done by a professional surveying team equipped with standard instruments or the PA boundaries did not follow any of mauza boundaries. As a result the Project identified revised digital PA boundaries for FD with reference to DGPS corrected latest IRS Pan or higher spatial resolution images.

The maps illustrate the differences found in boundaries, while the table aggregates the implications for PA areas based on CEGIS (2006). This shows that these problems of differences in area were much smaller in the case of Satchuri National Park where the boundary was originally demarcated by plane-table survey employing the surveyor frequently used by the Divisional FD who was involved during the preparation of the proposal for a National Park. But even in this case there are differences in boundary alignment.

Area differences for the pilot PAs between GIS database and Gazette Notification

Protected Area	Notified Area (ha)	GIS database (ha)	Difference (ha)
Chunati WS	7,764	7,810.50	+46.50
Teknaf GR	11,610	11,445.00	-165.00
Lawachara NP	1,250	1,221.20	-28.80
Rema-Kalenga WS	1,796	1,785.00	-11.00
Satchari NP	242.82	242.87	+0.050

The process was repeated for Modhupur National Park in greater detail, as historical data on the area exists. In particular, it was deemed important as a base for any future conflict management processes that a clear picture of the forest loss process be gathered from existing data. Accordingly, degradation over a 40 year period was captured using the following satellite images held in the CEGIS archive: Corona Space Photo Satellite (12 m, 1967), Landsat MSS (80 m, 1973), Landsat TM (30 m, 1989), Landsat TM (30 m, 1997), SPOT Multispectral Image (20m, 1999), and IRS P6 LISS-III (23.5m, 2007) (CEGIS 2008). A high resolution QuickBird (panchromatic and multispectral, spatial resolution: 0.60m and 2.4m respectively) 2003 image was also procured to prepare a detailed landuse/land cover map for Modhupur area (CEGIS 2008) to help in developing a better management plan. This time series of land cover change over 40 years may be used as a basis for Modhupur conflict mediation as well as management planning, but that level of dialogue had not yet taken place at the time of publication of this book.

Lesson Learned

Geo-spatial databases can be a tool for better management planning. The databases developed were important inputs to the process of defining the landscape areas for the five pilot PAs, for example in Teknaf Wildlife Sanctuary (Forest Department 2006). Mapping stakeholders with respect to each PA helped to understand the areas the project needed to work with and links between communities and forest PAs. Later in the project, the remote sensing maps were key base maps used to inform decisions on trail development, locating construction, and tourism planning.

All spatial databases of FD need to be updated with reference to recent images. The use of IRS pan image with 6-meter spatial resolution matches with the traditional FD maps at the Beat level (1:15,840). As a result it was found effective to capture features (roads, settlements, etc.) and develop base maps based on IRS pan images. It is recommended to procure IRS pan images for the other PAs and geo-reference existing databases with respect to such images.

Cost effective remote sensing data for forest monitoring. Forest Department can use IRS LISS III image (SPOT XS has been preferred by FD, but it is costly) to interpret forest classes or landuse. This is more cost effective than SPOT XS and gives a similar spatial resolution (20 m in SPOT XS compared with 23.5 m in LISS III) and spectral resolution (both have four bands: Green, Red, Near Infra Red and Mid Infra Red wavelengths). Using similar classification techniques, the forest types used by FD can be identified.

A mechanism to improve field collected handheld GPS data. All our spatial data used the BTM-JICA projection and was DGPS corrected. However, we did not find a way to convert the field data generated from handheld GPS to match the accuracy of the database. Handheld GPS collected data never gives the accuracy of DGPS collected data, but the accuracy of handheld GPS data can be enhanced using post-correction methods. A post correction method can be used for future spatial data collection.

There is a need to re-survey the boundaries of PAs. The traditional method of plane table survey used for Protected Area boundary demarcation used for Gazette Notification did not make use of re-validation using aerial photographs. As a result, the notified boundaries often do not coincide with natural features like the foot of hills, and so the official government Gazette notified area does not match with the RIMS database area (see earlier table). Under NSP, we could not correct or rectify inconsistencies in PA boundaries except for Satchari NP. We propose that a plane table survey is really needed (starting from Gazette notification boundaries) in collaboration with DLRS whereby DGPS will be used for geo-referencing the survey outputs for all PAs to correct the notified boundaries and boundaries in the field as necessary to eliminate inconsistencies.

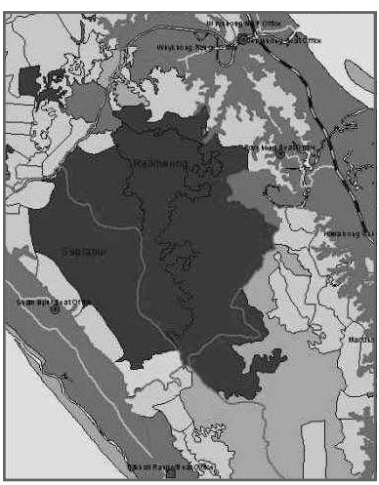
Need to strengthen and streamline RIMS activity. The full potent of satellite images (LISS III) for identification of various landuses adopted by FD (natural forests and plantations of different types) was not achieved, although planned for the field work. This failure was the result of RIMS not having an updated database. The RIMS-GIS unit has to update data for all the FD Management Divisions with limited manpower. Yearly updating (mapping and entry for planting, thinning, clear-felling, failed plantations, etc.) of data sent from field level including

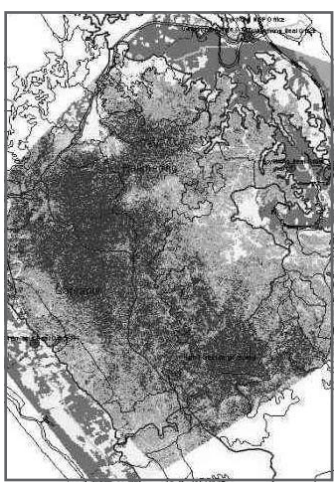
PAs takes a considerable amount of time. Moreover, the Management Divisions do not send yearly updates, rather data for 2-3 years are sent at one time so without a planned spread of work, backlogs arise and the RIMS-GIS data are not up-to-date.

Priority is systematically given to remote sensing needs of the FD territorial divisions over the Wildlife Circle, and this needs to be re-dressed. It became apparent during the five year project that wildlife-related mapping and remote sensing needs in the Forest Department are a second level priority after actions concerning the territorial divisions. This seems to reflect a wider emphasis on production forestry and plantation management over landscape and ecosystem management in and around Protected Areas. Without re-dressing what appears to be a bias in this sense, it would not be possible to vastly improve the remote sensing activities of the FD RIMS in support of biodiversity conservation.

Need to strengthen research at FD and educational institutions. Much spatial and non-spatial data (inventory data) generated by past projects and now by NSP is held in RIMS (Chowdhury 2004). Rather than keeping these data in the vault, RIMS unit enabled by a strong institutional mandate should encourage the use of this valuable data by making it available to educational institutes for collaborative research. The implicit FD policy on spatial information sharing has been not to allow open access to databases, and to allow limited access only when requested by a recognized government partner with appropriate letters of request. Under Nishorgo, the FD made a number of critical spatial databases openly available (for example, the coverage of the Sundarbans made available in the Sundarbans CD). Data on the Nishorgo pilot sites were made available in the Applied Research Support Tool CD (see Chapter 20). Without openly publicizing the fact that it is willing to make data available to interested researchers, the FD will not be able to tap into productive learning partnerships with national researchers and research organizations.

Lack of use of satellite images in communication. It was intended to use satellite images (QuickBird images for Whykheong region, see following images) to mobilize local communities by showing them comparative maps from two different times in high resolution. The images from QuickBird are similar to photographs, and we believed that approaches might be tested in





The dark colored area of the left hand map is the natural forest identified from aerial photographs of 1995.

The spotted darker area in the right hand image is the extent of natural forest in 2003, identified from QuickBird image.

We expected that purchase of this high resolution image for Roikheong and Saplapur Beat would be useful for management purposes, including mobilizing the poor against various issues.

those areas to engage communities in the interpretation and use of such information. Although entreaties were made to university researchers to use such information, it was not taken up by any of them. The images were extremely useful, however, in communication to national policy makers, especially insofar as they demonstrated loss of important blocks of natural forest in high detail. But it was considered too complex and redundant to explain these to local communities who were assumed to already be well aware of the trend of forest loss.

Gradual phased implementation of detailed plans is needed to strengthen RIMS. A major over-haul is needed for RIMS including an increase in staffing, enhanced capacity of RIMS personnel through training, updating GIS and remote sensing software, and use of GIS in the management information system of FD. Rather than making changes haphazardly, a detailed plan laying out the steps necessary to make the Unit fully effective is vital.

Conclusions

The RIMS-GIS Unit of FD was established to provide planners with reliable up-to-date spatial and statistical data for realistic planning. However, that is not the case at present due to lack of institutional commitment, vision and support. Nishorgo has highlighted how systematic improvements could be made based on strengthened capacity and critical assessment of the priorities for use of GIS and cost effective choices of images and methods. These changes would not only contribute to better informed PA management but to all activities of the FD.

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