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USING GLOBAL POSITIONING SYSTEMS (GPS) AND GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN PARTICIPATORY MAPPING OF COMMUNITY FOREST IN NEPAL

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ABSTRACT

Community forestry is a successful development programme of His Majesty's Government (HMG), in the sector of forest management in Nepal. The process of community forestry comprises the assessment of forest resources and drawing-up of a plan of action for the management of forests. Forest boundary surveying is a mandatory activity in the formal handing over of the forest to the people or Forest User groups (FUG) as they are known in practice. The spatial issues in mapping are more related to the boundary of the forest, location of the forest itself, the geographic characteristics of the forest i.e. slope, aspect, altitude and area covered by particular forest resources i.e. the forest type, Non Timber Forest Products (NTFPs) and information that could be useful in preparing a better management and implementation plan of the forest. The use of Participatory Geographic Information Systems (PGIS) in the field of community forest management combines the collection of quantitative and qualitative information in a way that is beneficial for the FUG (Jordan, 2000) i.e. mapping the boundary of the forest, block division of the forest area and preparing a multiple resource map. The quantitative spatial components can be collected and managed for sustainable forest management i.e. information on the length of forest boundary, resource distribution, stocking and incidence patterns. Without peoples' participation in the application of GIS and GPS in mapping the forest, the accuracy cannot always be assured on the one hand, while on the other, the information cannot be properly utilized as the ultimate users of the community forest maps are the local communities themselves. Prior to handing over of the forest areas to the FUGs, transect walks are carried-out in the relevant areas and features of interest are mapped using GPSs. The data is analysed in a GIS environment and maps i.e. Forest Boundaries, delineating NTFP species as well as the location of poor Households are produced. Assessment of products by plots of the relevant species, are also carried-out. Thus the participatory GIS, incorporates both indigenous knowledge on spatial aspects of community forest management, as well as social, land cover, and cultural features.

Keywords: Community Forestry, Forest Mapping, GIS, GPS, Participatory GIS

INTRODUCTION

Community forestry is a successful development programme of HMG in the sector of forest management. The process of community forestry comprises the assessment of forest resources and a plan of action for the management of forest. It also comprises the social activities of the communities in and around the forest and those depending on forest activities within the wider society. Forest boundary surveying is a mandatory activity (Acharya, date unknown) required for the formal handing over of the forest to the people referred-to in practice as FUG. Community forest management issues occur at a number of spatial scales (Cohen et al, 2001) i.e. at stand level, dealing with variations in tree sizes, at regional and or national level or across a landscape. The spatial organization of forest patches in any landscape is often used to assess human interventions and the ecological conditions of the area (Roy and Joshi, 2002). This means that the pattern of the forest patches in an area shows the extent of human interventions i.e. lopping, over-grazing, good management, operation of scientific silvicultural operations as well as the existing ecological conditions of the forest. This helps to guide users, managers and experts to prepare and implement all further operations within the forest.

This paper is a combination of two sets of works carried-out in collaboration with ForestAction in Two FUGs i.e. Baisakheswori Community FUG (Dolakha) and Sundari Community FUG (Nawalparasi). The work supports on going research efforts on "Developing Methodologies for Sustainable Harvesting of Medicinal Plants in Nepal". It also refers to works carried-out in collaboration with Nepal Swiss Community Forest Project (NSCFP)/SDC) in 6 FUG domains of the Jiri cluster of Dolakha district in support of "Development of local enterprise approaches for non-timber/medicinal plants such as *Chiraito*, *Argheli*, *Lokta* and *Machhino*". Thus, both efforts focus on mapping of the forest area and private lands as well as the preparation of resource maps by delineating high concentrations of non-timber and medicinal species. By carrying out transect walks with local people and developing geo-referenced object/attribute data in the process using GPS units, the forest boundaries were mapped in a GIS environment and the private lands within the forest area delineated and identified.

NSCFP work mainly included, locating the Tole (Village) level of information and well-being ranking of poor households of each of the FUGs in the map. These are important in the context of planning, management and implementation of community forestry development activities and other societal issues within the forest, and which are relevant to the FUG. The ForestAction work mainly included locating the Assessment and Treatment plots of this research. This helped in better visualizing the research theory and principles, for the benefit of the stakeholders; in incorporating their views and attitudes, and ultimately, their participation in research and planning for better management of high value NTFP species for greater impact on livelihoods.

Survey Techniques

Five kinds of forest surveying techniques were used namely; Sketch mapping, application of Orthophoto, GPS mapping, Cadastral survey and Chain and Compass survey. The major technique of forest mapping in Nepal is the chain and compass survey and is hugely favoured by governmental institutions. Other mentioned techniques have been tested and used by some forest development institutions other than governmental bodies. Like with boundary surveys, there are several spatial issues being dealt with in community forestry. By their nature, these issues can be dealt with quite conveniently using Geographic Information System (GIS) with a high likelihood that the methods can be widely dissemination. Furthermore, the integration of local peoples' participation in the process of forest mapping with GIS and GPS can be best handled under the participatory GIS approach (Giacomo et al, 2004). This process can facilitate some of the key issues in forest management, i.e., data collection, maintaining quality and increasing the usefulness of the maps (Jordan, 1998). However, within the umbrella of community forestry there are several identified frontiers of resource management in Nepal. These also include Adaptive Co-Management or ACM and NTFP management.

In applying these approaches to resource management within forests, there is always the need to assess existing resources on the one hand, and on the other, that of establishing the spatial distribution/disposition of the resources. The spatial issues tend to be more related to the boundary of the forest, location of the forest, geographic condition of the forest i.e. slope, aspect, altitude and area covered by particular forest resources, e.g., NTFPs, which could help in preparing a better action and implementation plan of the forest. These issues can be dealt with by using GIS and GPS technologies efficiently and easily as compared to other traditional means of forest mapping adopted in NEPAL. In applying the survey techniques in the field, three important considerations, *the Natural Resource Space, Participatory land use planning and the need for public participation in the process,* stand out as requirements enabling the use of Participatory Geographic information Systems.

The Natural Resource Management Space

The use of Participatory GIS (PGIS) in the field of community forest management combines the collection of both quantitative (more objective) and qualitative (more subjective) information in ways that are beneficial to the FUG (Jordan, 2000). These include mapping boundaries of the forest, block division of the forest area, preparing the resource map, locating social as well as peripheral components in mapping the context of community and forest development. The quantitative spatial components are also captured and managed for sustainable forest management (Jordan, 2000) i.e. forest boundary information, resource distribution patterns, distance to prominent resource areas from villages, spatial extents of resources, etc.

Participatory Land Use Planning

"Participatory land use planning (PLUP) thus aims at making the best use of the available resources, both in the interest of achieving sustainability and finding effective solutions with available funds, staff and capacities. While this process may need initial support from the outside, it has to become self-supporting in the medium to long term in order to become sustainable" as reported by Christ (1999).

Traditional Chain and Compass approaches to mapping, requires laborious field measurements and tedious office work to plot the field-measured latitudes and longitude on a paper map. The forestry experts themselves have realized that this is really difficult work, and as a result the mandate of most of the Forest User Groups (FUGs) have not yet been renewed as they all require updated forest boundary maps as part of new Operational Plans. This requirement is part of the pre-requisites in the amended Constitution regarding the renewal of user rights in the handing over process of forests by the State to the FUG.

In this scenario, GIS and GPS technologies can provide a cost-effective solution in enhancing the value of community forests to local people as well as facilitating the job of bureaucrats, administrators, policy makers and managers by helping in the fulfillment of basic requirements of forest measurements required in both management and administrative procedures.

New ways of using GIS and GPS in forest management are being explored. Some bilateral organizations in the forestry sector have started to work on Photomap technology, some of them have used Orthophoto (Shrestha and Tuladhar, *in prep*.) and some have used GPS technology at pilot level i.e. Churia Community Forestry Development Project (ChFDP) to map forest areas of various user groups.

Public Participation in the Process

Local people who are eligible to manage their own forest lands handed over to them by the government, are those who should be involved in the mapping exercises. It means that in the case of community forestry management practices, these FUGs are the most concerned with the process of participatory GPS mapping of the forest. They are the most involved in the process of mapping, field measurements and in sharing their knowledge on the boundary of the forests, resource localization and handling of the GPS units with some guidance from GIS experts. After the first manual analysis of the collected data, the expected results were discussed and revised with the participation of the local people. The final maps prepared were lodged with the community who thus have the ultimately responsibility of implementing the community forest management process. Some communities are even expected to use the maps to renew their stakes on the forest.

Finally, without peoples' participation in the process of GIS and GPS mapping of the forest, accuracy cannot be achieved on the ground on the one hand and on the other, the results obtained cannot be properly utilized because the ultimate users of the community forest mapping results are the local community. So, Public participation is crucial while preparing forest maps.

OBJECTIVES OF THE STUDIES

- Inclusion of peoples' indigenous knowledge on the spatial context of community forestry into a GIS environment
- Ensure Public Participation in a GIS-based forest mapping process of community forests
- Incorporate well-being ranking of households and Tole (village) level information in the mapping process
- Boundary delineation of user group forests
- Delineation of high-value resources within forests

STUDY AREA

The first study area lies in Terai region of Nawalparasi district while the second lies in Mid-Hill region of Dolakha district. One FUG, (Sundari Community FUG) was selected from Terai (Nawalparasi) region, while 6 others were selected from the Dolakha district of Mid-Hill region of Nepal (see table 1)

Table 1 List of FUGs

District	FUGs
Nawalparasi	• Sundari Community FUG
Dolakha	• Baisakheswori CFUG • Hanumanteswor CFUG • Thulnagi CFUG • Kalobhir CFUG • Kyangse Setep CFUG • Buddha CFUG

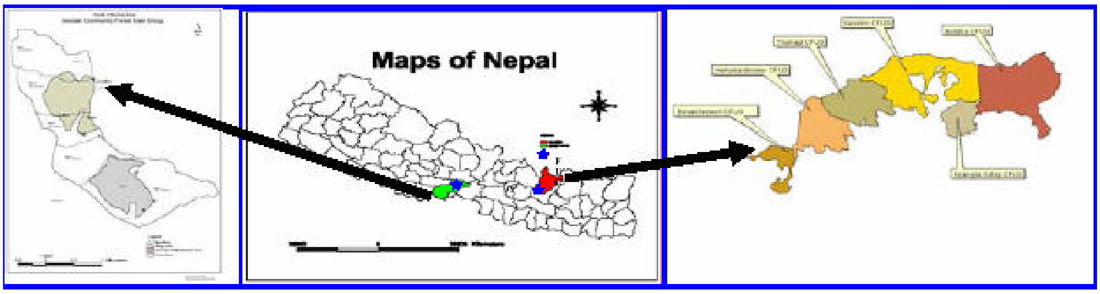

Figure 1 Location map of study area

METHOD

The methodology used in the study, were divided into two main streams based on the techniques applied in realizing the expected results. One stream is based on data collection using GPS; the data transfer to the GIS environment and map preparation. The other is based on using the existing maps of the FUGs and geo-referencing them with the help of Ground Control Points (GCPs) collected from the field and integrated into the GIS using geo-referencing tools or extensions. This first stream also has at least two phases; wherein, the first concerns the identification and localization of points identified during the transect walk and also while delineating the forest boundary and the second, highlighting and localizing the concentration of forest resources on the map. However, the entire process can be sub-divided into six mini-phases; *Reconnaissance Survey of the field*, *Orientation*, *Participatory field measurement*, *Map Layout*, *Verification and cross-checking* and *feed back*.

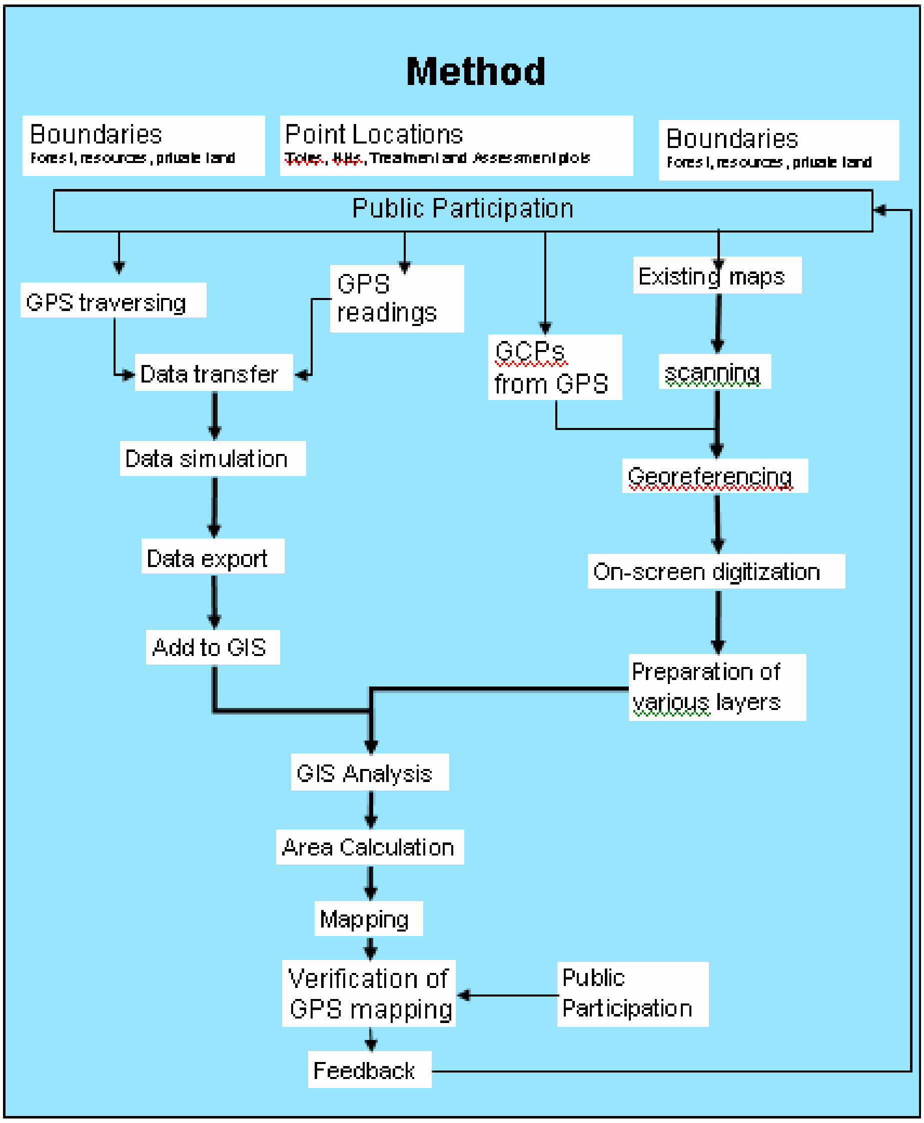

Figure 2 Complete Methodological chart

Reconnaissance Survey of the Field

The FUGs were visually accessed prior to going out for complete field work to ascertain whether they satisfied the research/development objectives or not. In the case of Sundari

CFUG and in case Dolakha FUGs for instance, it was important to understand the condition of forest in different seasons in other to make a plan.

Orientation

Before going to the field, participating experts were first of all briefed on the realities of the use of the forest by the local people. The local people where also briefed on the technologies to be applied. The aims of this briefings were to prepare the both the local people and the external experts on the challenges of the technology and context, respectively, and thus enable both groups adopt the appropriate mental orientations

Participatory Field Measurement

The participatory measurement using GPS (Global Positioning System) to acquire Latitude, Longitude and Altitude of the different points of observations where carried-out extensively during the transect walks. During this transect walk process official knowledge and indigenous spatial and technical knowledge on the boundary were more or less integrated in a participatory atmosphere. Knowledge exchange also included boundary information, location of resources, knowledge of the routes through which resources could be accessed, etc. The GPS-facilitated data collection methods proved easier than the chain and compass survey and the officials present were quick at acknowledging this. The GPS field measurements included the taking of GPS reading of locations of Toles (villages) and Pro-Poor Households in case of Dolakha district FUGs and location of Treatment and assessment plots in case of Nawalparasi district FUG.

The data thus collected during the transect walks and relevant to particular species were added to the information stock to develop resource distribution maps of each of the forests. The most important identified species included *Lokta*, *Argheli*, *Machhino* and *Chiraito* in case of the FUGs of the Dolakha district; and *Kurilo* and *Harro* in the case of the Sundari CFUG. The latitude, longitude and altitude information of each point on the transect walk was stored in the GPS unit. The data loggers involved in field measurements and transect walks were thus able to locate the resources on the transects, as well as locate the center of the Toles and plots. The main role of the local people during the field measurement was guiding the external 'experts' to gather accurate and locally relevant information in mapping the forest area relevant to each particular FUG. During the process of data capture using a GPS system, some more enthusiastic forest users within the FUG also played a key role in capturing and storing the GPS data in the field with little help from the GIS experts. This served as on-field capacity development process.

The data captured and stored in GPS units were downloaded into databases and exported into a GIS environment using appropriate software. Some of the GPS readings were used as GCPs in geo-referencing the existing maps of the forest during the handing-over process. The polygon information on the forest was analyzed in two ways; (i) from the GPS data collected during the transect walk as well as (ii) digitized data from the geo-referenced community maps. The point information were prepared and analyzed using the data from the GPS point location data. The area covered by the polygon set of data was thus calculated in a GIS environment i.e. forest boundary, interior private lands, resource occurring area, and enhanced in graduated color/category.

Map Laying-out

The analyzed data in a GIS environment was composed to prepare the maps i.e. Forest Boundary maps and Resource maps, delineating the high value NTFP species; Location maps of Toles and Pro-poor Households and Location maps of Treatment and Assessment plots.

Specific visualization schemes and symbols were applied to display all the layers of interest in this study.

Verification and Cross-checking

As the technology is being newly applied in the field of community forestry in NEPAL, local bodies involved in forest governance are not yet fully familiar with the output. As a means of cross-checking, they verified the accuracy of GPS mapping output by manually measuring the lengths of randomly selected segments on the ground as well as on the map. They found acceptable results and were thus encouraged, to use the resulting maps in amending their FUG maps. In Baisakheswori District CFUG, the forestry Office appointed a ranger to verify the GIS-mapped length measurements in selected places using tapes and later-on that ranger reported that the measurements were acceptable.

Feed Back

After the verification of maps by local community and the local forestry administration, the feedback to the rest of the local communities was completed. Relevant modifications were made where agreement was not total, especially in the location of boundaries.

RESULTS AND DISCUSSIONS

Forest Boundary Maps

One of the outputs of this study is the forest boundary map. It has been prepared for each FUGs. The prepared map has been shown in Figure 3. The boundary of the forest and boundary of private land within forest have been delineated and demarcated because of which the boundary conflict i.e. boundary conflict between two forest user groups or boundary conflict between private land and forest, could be dealt by having clear map with high precision and updation.

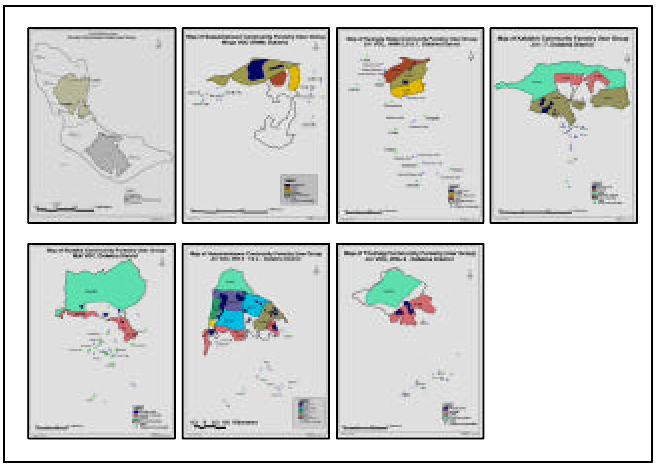

Figure 3 Forest boundary maps of different FUGs

Resource Maps

The other sets of outputs were the resource maps of high-value NTFP species in each FUG domain. The resource maps prepared for each FUG are shown in Figure 4. The resource maps visualize the condition of the high value NTFP resource and their spatial distribution in the forest. This visualization provides support to the local people and helps in planning, additional research and implementation of the management plan, especially for enterprise development.

Location Maps

In Dolakha FUGs, the location of Toles (villages) of FUGs and Pro-poor households were located on the maps to produce Toles and Household location maps of all FUGs shown in Figure 5 (a) and the location maps of the treatment and assessment plots were prepared in Sundari CFUG as shown in Figure 5(b). Additionally, a Jiri cluster map was also produced as shown in Appendix I.

Figure 4 Resource Maps of different FUGs of focused NTFP species

Figure 5 Location maps of Toles and Pro-poor Households

Area Information

Forest Area

Table 2 Area of forests of all FUGs

District	Name of FUG	Area in Map (in ha.)	Private Land (in ha.)	Net Forest Area (in ha.)
Dolakha	Baisakheswori	115	13	**102**
	Hanumanteswor	298	25	**273**
	Thulnagi	305	10	**295**
	Kalobhir	579	12	**567**
	Kyangse Setep	146	3	**143**
	Buddha	592	6	**585**
Nawalparasi	Sundari	454	63	**391**

Resource Areas

Table 3 Area of depicting by different species from resource maps in all FUGs

Name of FUG	*Lokta*	*Argheli*	*Chiraito*	*Machhino*	*Machhino* and *Argheli*	*Argheli* and *Chiraito*
Baisakheswori	10	-	9	47	-	-
Hanumanteswor	48	38	14	30	-	72
Thulnagi	150	75	-	-	-	-
Kalobhir	280	69	-	-	222	-
Kyangse Setep	45	59	-	-	44	-
Buddha Sundari CFUG	449 ***Kurilo*** 69	- ***Harro*** 69	-	-	-	72

CONCLUSIONS

The application of Participatory GIS is a fundamental tool in visualizing the spatial contexts of community forests in NEPAL. Due to the lack of peoples' involvement in the process of visualizing the spatial components in traditional GIS, this has hitherto been considered largely as a professional exercise and affair for the experts. Participatory GIS concepts and practice however, by involving local people both during the field data collection phases, by guiding expert handling of the tools of this Information technology (such as the GPS unit), including verification has added value and increased the ownership of the mapping process at local level. The involvement of local people in finalizing the spatial information output has also increased mutual confidence and helped empowered the local people to participate increasingly in spatial analyses of their forest domain.

As compare to the conventional maps, the Participatory Geographic Information Systems-assisted maps and databases, by virtue of local participation, avails themselves to better interpretation by local people who jointly conceived them. More importantly, the symbols used in the legend and the way they have been interpreted incorporates local realities, perceptions and knowledge.

ACKNOWLEDGEMENTS

This paper is based on work that was conducted while working with ForestAction (www.forestaction.org) in their research project entitled "Developing Methodology for Sustainable Harvesting of Medicinal Plants in Nepal" sited in Dolakha and Nawalparasi districts and the work that was conducted while working with Nepal Swiss Community Forest Project (NSCFP/SDC) for the support of "Enterprise development in Jiri cluster for high-value NTFP species".

So I wish to acknowledge ForestAction and NSCFP both for allowing me to prepare this paper.

APPENDIX

Appendix I

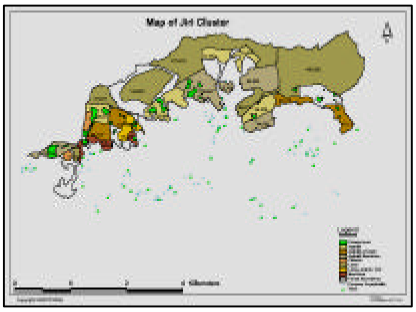

Figure 6 Map of Jiri cluster

Appendix II

Scientific Nmes of Local NTFP Species

Kurilo: *Asparagus racemosus*
Chiraito: *Swertia chirata*
Machhino: *Gaultheria fragrantissima*
Argheli: *Daphne papyracea*
Lokta: *Daphne bholua*
Harro: *Terminalia chebula*

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