A Manual on Participatory Three-Dimensional Modelling (P3DM)

ICIMOD

FOR MOUNTAINS AND PEOPLE

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The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

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A Manual on

Participatory Three-Dimensional Modelling (P3DM)

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Acronyms and Abbreviations

3D	Three dimension
ARCBC	ASEAN Regional Centre for Biodiversity Conservation
ASEAN	Association of Southeast Asian Nations
CESVI	Cooperazione e Sviluppo
CKNP	Central Karakoram National Park in Pakistan
DEM	Digital Elevation Model
DGCS	Directorate General for Dev. Cooperation, Italian Ministry of Foreign Affairs
DNPWC	Department of National Parks and Wildlife Conservation
DSS	Decision Support System
Ev-K2-CNR	Ev-K2-CNR Committee
GIS	Geographic Information System
GPS	Global Positioning System
HKKH	Hindu Kush-Karakoram-Himalaya
ICIMOD	International Centre for Integrated Mountain Development
IPRA	Indigenous Peoples Rights Act
IUCN-ARO	IUCN Asia Regional Office
LGU	Local Government Unit
MIGIS	Mobile, Interactive Geographic Information System
MIID	Myanmar Institute for Integrated Development (Myanmar)
NCIP	National Commission on Indigenous Peoples
NGO	Non-Government Organization
NIPAP	National Integrated Protected Areas Programme
NIPAS	National Integrated Protected Areas System
NTFP	Non-Timber Forest Products
P3DM	Participatory Three Dimensional Modelling
PA	Protected Area
PAMB	Protected Area Management Board
PAWB	Protected Areas and Wildlife Bureau
PGIS	Participatory Geographic Information System
PLA	Participatory Learning and Action
PLUP	Participatory Land Use Planning
PPGIS	Public Participation Geographic Information System
QNP	Quomolongma Nature Preserve
RDBMS	Relational Data Base Management System
SNP	Sagarmatha National Park
UWICE	Ugyen Wangchuck Institute for Conservation & Environment (Bhutan)

Foreword

The expression: "a picture says more than a thousand words" is commonly used. A photo, drawing or image can quickly illustrate and communicate how a place looks with immediate appreciations for its intricacies and detail.

In this way, maps are a powerful means for communicating how a particular area looks. Three dimensional models add elements that convey even more information, about elevation, topography, and terrain. However, the jump from flat maps to three dimensional can require some adjustment for the viewer, so that he or she understands exactly what information can be seen and is available.

Three dimensional models (3D) are particularly suitable for working in local communities, because they allow people to easily understand the location of different elements in the landscape: how rivers, roads, slopes, villages and other features are placed. When working in the area of natural resource management, these models can help local communities make more informed planning decisions in terms of village, forestry, and agricultural development.

Building and ground-truthing 3D models has another interesting impact: it creates an atmosphere of collaboration and participation within the community. Participatory 3D modeling engages a representative group within a community to build the model step by step, as this helpful paper will demonstrate.

ICIMOD strives to assist mountain communities in developing more sustainable livelihoods in the Hindu Kush Himalaya. Participatory 3D models can be used in combination with our efforts in ICIMOD's thematic areas of expertise such as climate change adaptation, water management, and ecosystem services. Once created, 3D models remain in the community where they can be used for many years.

This manual provides clear guidance on all the steps involved in building a 3D model and how to engage communities in this participatory process. The content of the manual reflects years of accumulated experience building these models in a variety of communities throughout the HKH. In particular, I want to recognize the leadership of Mr. Govinda Joshi for his great expertise, dedication and enthusiasm on this topic.

David J Molden, PhD
Director General
ICIMOD

Participatory Three-Dimensional Modelling

Introduction

Human cognition includes sensation and perception, thinking, imagination, reasoning and problem solving, memory, learning, and language development. Location, size, distance, direction, shape, pattern, movement, and inter-object relations are part of the spatial world as we know and conceive it (Montello 1997). Participatory creation of maps, above and beyond their interpretation, started in the late 1980s. At the time, development practitioners were inclined to adopt Participatory Rural Appraisal (PRA) methods such as sketch mapping (Mascarenhas et al. 1991) rather than the more complex and time-consuming scale mapping. In the 1990s, the diffusion of geographic information systems (GIS), remote sensing (RS) based image analysis and application of global positioning system (GPS) revolutionized mapping technology. Later initiatives aimed to integrate geospatial information technologies and systems in the lives of communities. The concept of participatory geographic information systems (PGIS) emerged where geospatial technologies were used to empower underprivileged communities. It is an emergent practice based on participatory approaches to planning and spatial information and communication management (Rambaldi and Weiner 2004). PGIS combines a range of geospatial information management tools and methods. Participatory three-dimensional modeling (P3DM) is one such method. It can be used to represent people's knowledge in physical three-dimensional models, and can serve as an interactive vehicle for spatial learning, discussion, information exchange, decision making and advocacy. The practice came about when Participatory Learning and Action methods spontaneously merged with geographic information technologies and systems (GIT&S). PGIS combines a range of geospatial information management tools and methods such as sketch maps, (Rambaldi et al. 2005). It is also referred to as public participation GIS (PPGIS) (Aberley and Sieber 2002).

Participatory 3D Modeling (P3DM) is a community-based mapping method that integrates local spatial knowledge with data on the elevation of the land and the depth of the sea to produce stand-alone, scaled and geo-referenced relief models (Rambaldi et al., 2005; Rambaldi and Callosa-Tarr, 2002). The relief model produced thus has proved to be a user-friendly tool for planning and management. As its name suggests, Participatory Three-Dimensional Model is constructed with active participation of the community and facilitation by mapping experts. Informants use pushpins (points), yarns (lines) and paints (polygons) to depict land use and cover and other features on the model. Once the features are depicted, a scaled and geo-referenced grid is applied to facilitate data extraction or importation. Data depicted on the model are extracted, digitized and plotted. After the exercise is completed, the model remains with the community. For more information on participatory GIS, please visit www.PPgis.net.

Why participatory three-dimension model

There are different visualizing methods for spatially reproducing people's knowledge. Participatory 3D Modelling (P3DM) offers a substantial advantage over other methods for depicting cognitive maps because it adds the vertical dimension and uses simple communication means like colours, shapes and dimensions (Rambaldi and Callosa-Tarr, 2002). Three-dimensional (3D) models are easier to understand compared to, let's say, GIS maps. A map represents only two dimensions, and therefore, it is not always easy to interpret a map that represents hilly and mountainous terrain. Three dimensional modeling adds a third dimension that makes visualization easy. Local people are likely to feel comfortable using 3D models to communicate with each other and with outsiders. Participatory Three-Dimensional Modelling (P3DM) can be a useful tool to gather spatial information for a variety of purposes. It enhances communities' knowledge about available resources and thus enable them to better manage their resources. They can monitor the implementation of development projects and resolve resource conflicts within their own communities. It empowers people to plan effectively for themselves based on their needs. Participatory mapping can force communities to confront the burning issues with regard to the management of natural resources. This will raise local awareness.

The P3DM approach allows villagers to participate in the entire process of 3D model building. The process, however, involves intensive fieldwork and requires a lot of the community's time. P3DM acts as a visual language and is a powerful medium for easing communication and overcome the language barrier and creates common ground for discussion. This holds true particularly in regions like Sagarmatha National Park (SNP) where visitors speak many different languages. Hence the practice of P3DM allows people to share information and concerns.

Outcomes from participatory three-dimensional modelling

Application of P3 DM is expected to bring the following changes in the communities.

A deeper understanding of the geography of the region: Community members would become familiar with the spatial structure of the village. P3DM would allow them to identify creeks, rivers, forests, watershed areas, the altitude and areas of household settlements.

Enhanced capacity for communication and planning: P3DM would provide a basis for different community-level institutions to interact with each other and reach a common understanding for better resource management. It would enable the community to clearly visualize the land and identify sites for constructing terraces, roads/ trails, and settlement. Further, the community would learn about the condition of local watershed, forest, and water source, which would subsequently enable them to make necessary interventions. The model also helps in demarcating village boundaries.

Stronger cohesion and consensus among the communities, as the model will bring community members together to learn ways to protect and preserve the area.

A physical model of the area is developed: The model will serve as a base for information on the environment and natural resources.

ICIMOD's Experience in Participatory Three-Dimension Modelling

Introduction

P3D models are effective tools for community-based natural resource management. Communities have used the models for allocating land for shifting cultivation, natural resource use, village planning and for negotiating with government officials about services and the development of natural resources. ICIMOD uses the P3DM tool to understand the geography of the mountain region and the use of natural resources, watersheds and rangeland management, village level planning, tourism and biodiversity conservation. ICIMOD has conducted exercises and built 3D models in different places of the HKH region at different time periods. One such exercise was conducted at a demonstration site in Godavari, close to the ICIMOD headquarters in Kathmandu, Nepal. The other sites are Nokrek in Meghalaya, India; Mustang, Sagarmatha National Park and Dhungetat, Nuwakot in Nepal; and Bumthang and Paro, in Bhutan and Nyaung Shwe Myanmar.

Participatory three-dimension model in Nokrek, Meghalaya, India and Godavari, Nepal

Participatory Three Dimensional Modelling (P3DM) model exercises have been conducted in the villages where ICIMOD works with IFAD in Nokrek, Meghalaya, India. An original model was scaled up by the project and the communities, and is now available in twelve villages.

The Godavari model was developed for a PGIS training organized by ICIMOD from 23 to 30 September 2003 in Godavari, Nepal. During the event, facilitators and staff received training in Participatory Three-Dimensional Modelling (P3DM). There were altogether 24 representatives from different village communities and 22 representatives from national and international organizations. The 3D model has helped to communicate with communities with limited knowledge about maps and geographic information systems. For instance, Tamang communities used the 3D model to update ICIMOD spatial data on land uses and forest management systems.

The model was developed on a scale of 1:2500 and covered an area of 26 sq. km. The area included Godavari and Manedobhan watersheds (including the peak of Phulchowki) in Godavari and Tripeni, with elevations ranging from 1,455–2,765 masl. The size of the model came out to be 6′ x 8′.

Preparatory Work for Participatory Three-Dimensional Modelling

Selection of area, participants and materials (with reference to SNP model building experience)

Area selection

Area selection will be based on the need and requirement of organizations or local people. In the case of SNP, selection was based on the following criteria:

- prior project area and the demand of the line agencies
- The world's highest peak is situated in this region.
- high flow of tourists
- highly sensitive climatic biodiversity and biophysical situation
- complex terrain conditions

Because of these factors, it was considered worthwhile to develop the 3D model for local people, policy makers as well as those who visit the area for a short time. After the selection, physical, administrative, environmental, cultural and socioeconomic characteristics of the area were identified, along with potential issues or conflicts. Based on the above mentioned criteria and in consultation with the stakeholders, the area was identified on the topographic and administrative maps. A similar type of needs assessment and area selection for model construction should be done in any other area where building a 3D model is being considered.

The area selected for the P3DM was in Sagarmatha National Park. It covers an area of 1,400 sq. km, with elevations ranging from 1,700–8,848m.

Understanding social dynamics

Prior to building a P3DM, one needs to have a thorough understanding of the social dynamics in the area. A stakeholder analysis can provide a sense of different interest groups, problem areas and so on. A stakeholder meeting was held at the initial phase to assess the social dynamics of the region.

Groundwork at community level

Understanding the community is a first step in the model building exercise. It is necessary to interact with the community and grasp the physical and social realities of the area, as well as to read secondary sources of information, consult detailed 2D maps and conduct thorough field observations. During this initial step, the concept of Participatory Three-Dimensional modelling will be introduced to different stakeholders. Community participation will be based on the recommendation of partner organizations, as communities will be involved in model building, following the steps to construct the model.

Planning logistics

Some basic things needed for model construction include a large enough room with a roof to protect against rain and direct sunlight, and transport facilities for delivering construction materials. The location should be accessible for the community. Model construction in the SNP area was relatively expensive and time consuming because the location was remote and not connected to a motor road.

Participants selection

Participant selection is another important task. Priority should be given to locals who have knowledge of local geography and topography. Students, schoolteachers or other resource persons who can communicate easily make good candidates.

Participants may also be recommended by stakeholders interested in the area. These participants may be representatives of indigenous groups, economic sectors, government and non-governmental organizations. Normally 15 to 20 local participants would be required for constructing the model, however, the requirement also depends on the size of the model and the available time.

Gathering secondary information

Contour lines representing the elevation are a prerequisite for P3DM construction. Ideally, contour lines should be in digital formats. If a GIS facility is available, contour lines can be interpolated with minimum error. If not, they have to be digitized, which increases the cost of the model. An alternative solution is to enlarge the topographic maps using photocopiers and trace the contour lines. However, this will lower the accuracy of the model.

Apart from contour lines, there is a need to gather information on demography, land use, vegetation cover, infrastructure and other factors that may help the facilitators understand the physical, social and economic characteristics of the area.

Selection of base map

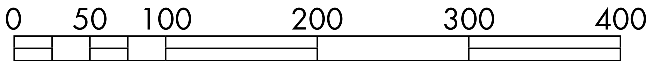
A base map (topographic map) is the first requirement for obtaining necessary detailed information (i.e., contour lines of elevation) on the area. Therefore, it is very important to select and use the base map. A base map has certain properties that need to be taken into account, such as scale and size, contour interval, orientation or projection of the real world, cartographic clarity, date, source, etc.

Scale and size of the map

Fewer details are shown on a small scale model than on a large scale model. Large scale 3D models show better resolution and are more comprehensive and useful for the planning process. The larger the scale of the model, the larger would be its detail size. Therefore, the size of the model should be taken into account while deciding on the scale. It is also important to ensure there is enough space to physically construct and store the model. The ideal scale for 3D modelling is 1:10,000 or larger. So if the scale of the reference map is 1:50,000, it needs to be re-scaled to 1:10,000 to make it suitable for activity. On a scale of 1:10,000, one centimetre on the model corresponds to 100 metres on the ground; this scale allows people to pinpoint salient features without much difficulty.

The scale ratio on the map means 1 cm on the map equivalent to:

1:10,000 scale reference



Scale 1:10,000

- 1,000 m on the ground at a scale of 1:100,000
- 500 m on the ground at scale of 1:50,000
- 200 m on the ground at a scale of 1:20,000
- 100 m on the ground at a scale of 1:10,000
- 50 m on the ground at a scale of 1:5,000

Taking into consideration the size of the area and the location where the model is going to be stored, It is proposed that the P3DM model will be constructed at a scale of 1:20,000. The size of the model will come out to be about 6′ X 8′. The vertical scale may be the same as the horizontal scale. However, to enhance the visual perception of the ruggedness of the landscape or to highlight erosion hazards or accessibility, the vertical scale could be exaggerated by one and half the horizontal scale, say 1:15,000.

Contour Interval

Generally, topographic base maps of the high mountain region of Nepal are on a scale of 1:50,000. Those maps have 40 metres contour intervals.

Vertical scale determination

Vertical scale is determined based on the geographical dimensions of the area. In mountainous areas, a scale of 1:1.5 would give the best representation, but in hilly and more homogeneous plain areas, a 1:2 (or more) scale ratio of (horizontal scale) would be desirable.

Table 2: **The choice of contour interval determines the workload**

Scale of the 3D model	Contour intervals	Gradient between the lowest and highest elevation	Thickness of the layers representing contour interval	Number of contour intervals
1:20,000	100 m	7,148 m	6.7 mm	71 layers
1:20,000	20 m	800 m	2 mm	40 layers
1:10,000	40 m	2,440 m	4 mm	60 layers
1:5,000	40 m	2,000 m	4 mm	25 layers
1:2,000	8 m	360 m	4 mm	45 layers

Preparing customized base map

A new map can be prepared after selecting the topographic base map. This map can be customized according to the needs of model building. Customizing can be facilitated by a well equipped GIS laboratory (if available) with several other maps and information, such as satellite images, GPS collected spot heights, building locations, reference points, latest land use information or recent natural and manmade changes. This information can be integrated into the customized base map. Once scale, size and contour interval are fixed, a customized base map can be generated. It is recommended that the sequence of contour lines is plotted in different colours. Elevation labels should be placed close to the contour lines.

Table 1: **Choice of scale: some examples**

Reference map scale	Size of the selected area on the ref. map to be reproduced as a 3D model	Selected scale for the 3D model	Size (cm) of 3D model	Total area represented by the model
1:50,000	24 x 48 cm	1:10,000	120 x 240 cm	288 km^2
1:50,000	48 x 96 cm	1:10,000	240 x 480 cm	576 km^2
1:50,000	40 x 50 cm	1:20,000	100 x 125 cm	450 km^2
1:50,000	40 x 50 cm	1:10,000	200 x 250 cm	450 km^2
1:50,000	40 x 50 cm	1:5,000	400 x 500 cm	450 km^2
1:75,000	40 x 50 cm	1:10,000	300 x 375 cm	1,125 km^2
1:100,000	40 x 50 cm	1:10,000	400 x 500 cm	2,000 km^2

Figure 1: Example of contours drawn in different colours on different scales

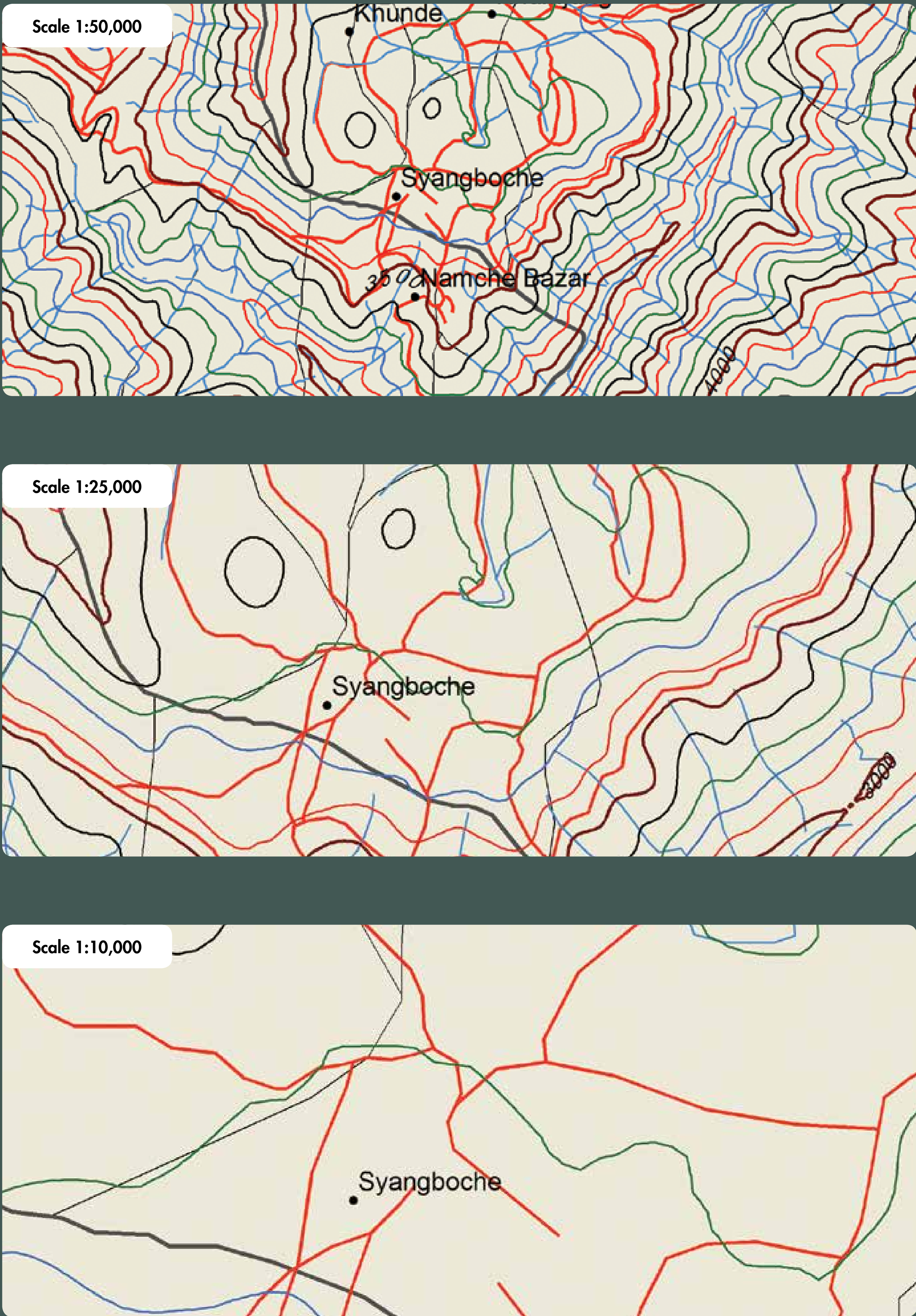


Table 3: **Displaying features on the model**

Points	Water bodies (springs and waterfalls); mountain peaks; social infrastructures (municipal/district halls, administrative centres, daycare centres, schools, rural health centres, hospitals, bus stops); cultural places (churches, burial caves, cemeteries, sacred areas, etc); tourist establishments; human settlements (households); scenic spots, turtle nesting sites; diving spots; docking sites, and others.	Push pins of diverse colours, shapes and sizes
Lines	Watercourses; communication ways (roads, bridges, trails); social infrastructures (rural water supplies), classifications (e.g., watershed classifications), boundaries (administrative units, protected area, ancestral domains)	Yarns of different colours
Polygons	Water bodies (rivers, creeks, lakes, springs and waterfalls); cultural places (cemeteries, sacred areas, etc); tourist establishments; land uses (rice fields, vegetable gardens, sugarcane and coconut plantations, orchards, reforestation sites, residential areas, resettlement areas, etc.); land covers (different types of forest cover, grassland, brushland, mangrove, etc.); landslides and bare land; and others. Land status, areas where destructive methods are employed, fish breeding and spawning areas; feeding grounds of endangered species; fishing grounds; features of the seabed like coral reefs differentiated into 'intact' and 'damaged', seaweed areas, etc); borders, coordinates (grid).	Acrylic paint – different colours
Attributes	Names, annotations	Text on labels

Displaying features on the model

Map symbols should be chosen as point, line and polygon features. Guidelines for displaying features are given in Table 3.

Procurement of materials

A critical task involved in building the Three-Dimensional Model is assembling required materials. Various map symbols with a range of coding items should be available in sufficient quantity to mark the many variables that people may want to record in the model. Procurement is done after the first round of assessment of the various features of the area. A list of materials acquired for SNP P3DM is provided in Appendix 2.

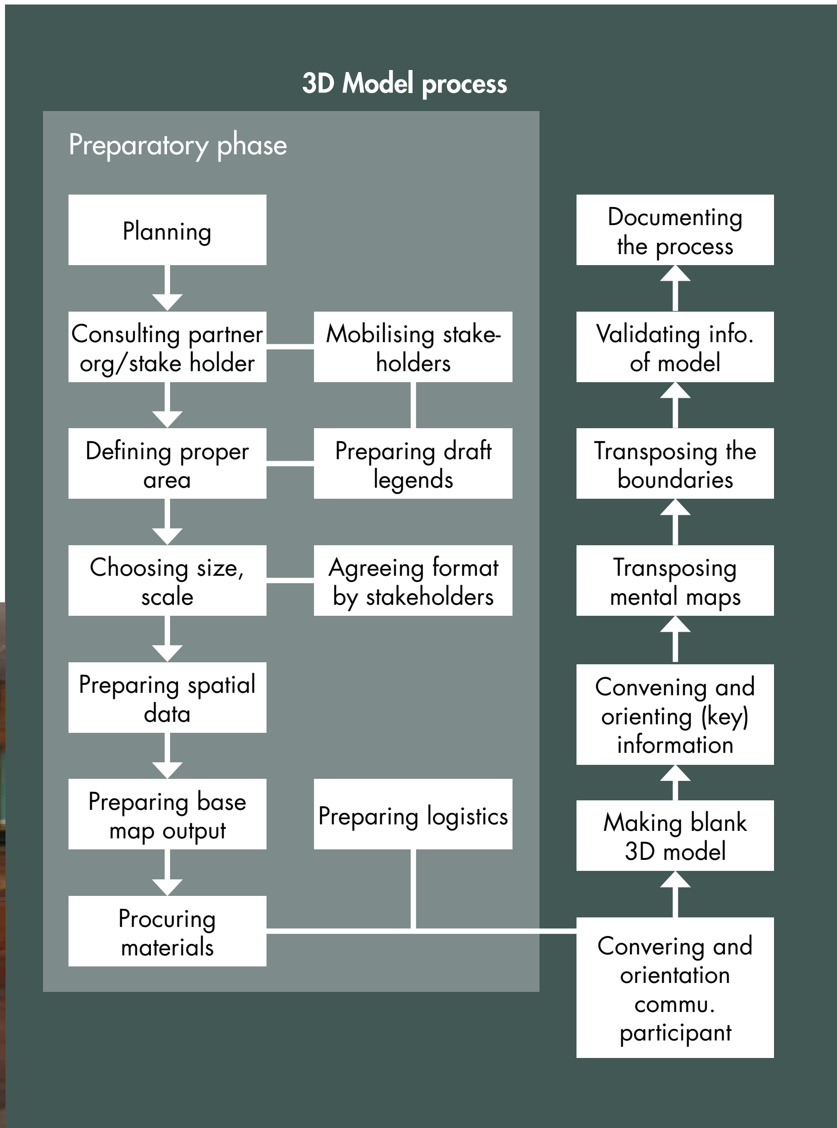
Model Building Process in the Field

Familiarize the participants

As a first step, participants should become familiar with each other and with the tasks ahead. They should get a sense of the mechanics of model construction and learn the basics of map reading. It would be an advantage if they know in advance what sort of material is being used, the scale of the model and the contour interval.

Orientation for participants

After the familiarization, a brief orientation class is recommended to give participants basic ideas about maps, their usefulness, application and use. Many of them may be exposed to the map and mapping activities for the first time. The orientation class should be informal as far as possible. Some participants may already have good skills and be quite familiar with the local environment while others may be less experienced. An



interactive and informal class environment would allow them to share their knowledge and ask questions. During the model building activities in SNP, an orientation class proved to be highly beneficial. Many of the participants had been exposed to maps but few had knowledge of proper map reading.

Participants were shown movies of examples from the Philippines, and this helped familiarized them with the various steps of model construction.

Preparing mini model

Before starting work on the real model, it is advisable to prepare a mini model. For example, in Sagarmatha National Park (SNP), a mini model was prepared at 1.5’x1.5’, scale 1: 100,000 with contour intervals every 1000 m. The real model was constructed on a scale of 1:20,000 with a 100 m contour interval.

Constructing a mini model helps participants understand the process of building the real world model and reduces the cost and time required for constructing the real model. It will also improve the model’s accuracy and build participants’ confidence for constructing the real model.

Listing important details

After a thorough discussion with the community, participants should list important information that needs to be incorporated in the model.

Names of peaks, mountains, park boundaries, roads, settlement names, land cover names should be given in the local language and be provided by the participants.

Tracing contour lines for mini model and cutting mats based on contour lines

The 3D model consists of mats that are cut along a specified contour line, glued on top of each other. Before cutting, the contour lines are traced on the mats.
In case of the SNP 3D mini model, participants traced contour lines with 1000 m contour interval. This step was very useful before starting work on the larger model.

Biodegradable mats and other locally available materials are used for model construction.

Mats will be cut after tracing contour lines for the mini model. The tracing and cutting process demands great attention to detail, as this will largely determine the accuracy of the model.

Organizing work for the large 3D model

Participants should be divided into groups to do specific tasks. The groups should be assigned tasks that can be performed simultaneously and workload should be divided evenly among the participants. If space is limited, it may be better to reduce the number of participants working at the same time.

Table 4: **Workgroups and facilitators required for SNP Model** (size was 7′ x 8′)

Working Group	Assemblers	Tracers	Cutters	Gluers
Number of participants	3	4	5	4
Facilitators		1	1	1

Table 5: **Workgroups timesheet** (2 weeks on average)

List of work	Participants	Days	Hours
Assemblers (for table)	3	1	15
Tracers	4	5	140
Cutters	5	5	150
Gluers	4	5	130
Transposing	5	5	150
Colouring/painting	5	5	150
Finishing	4	3	75
Cross checking	4	2	50
Facilitating	3	8	140

Total 1000 hours

The work process for the large 3D model

Establishing a base table and joining the mats before tracing

The model should be placed on a wooden base table. The table should be of appropriate size and strong enough to support the weight of the model. The base table should be placed in the middle of the room to allow easy access to all sections of the model.

Mats should be joined properly before tracing contour lines of a specific elevation. Mats should be marked so that once they are taken apart, they can be put back together in precisely the same way. A first mat layer without elevation lines will be pasted on the table.

Joining topo sheets and tracing contour lines using mosaic carbon paper

If the model building area is larger than the area of the topo sheet, multiple sheets need to be used. The sheets can be joined together. Printed and plastic laminated topo sheet maps need to be arranged very carefully to avoid errors in the model. The topo sheets should be carefully taped together with transparent tape.

In order to trace contour lines on the mat, pieces of carbon paper are stuck on the backside of the joined topo sheets.

While tracing contour lines, the lines get printed on the mats through the carbon paper. While tracing a contour line, the 'next' contour line with a higher elevation should also be traced. The first line indicates where the mat needs to be cut and the second, higher elevation line indicates where the next mat should be pasted.

Cutting and pasting mats based on tracing contour lines

After tracing the contour lines on the mat, the mat needs to be cut properly along the contour line. Imprecise cutting will introduce an error in the representation of the terrain shape in the model.

After cutting, the mat layers should be pasted using fevicol glue.

The mat layers that have been cut should be added on top of each other according to their elevation. By adding the mat layers, the shape of the 3D topography will appear.

While pasting the mat layers according to their elevation, it is necessary to double check and fix the layers properly with nails and pins.

Evaluating accuracy of layers and enhancing visibility of contour lines

Participants must check to ensure that the mat layers are placed accurately following the contour lines and that the accurate 3D shape has been created. Some errors may have been introduced due to inaccurate tracing, cutting or pasting.

Sometimes traced contour lines are not clearly visible on the model. Therefore it may be necessary to redraw these lines.

Smoothing terraces, small parts of the model and adding small peaks

Remaining bits of the mats can be pounded and mixed with Plaster of Paris and used to smoothe the terraces. Alternatively, Plaster of Paris alone can be used for this purpose.

Small parts of the model may need to be prepared as a block before being pasted onto the main model. Peaks should not be missed. Otherwise the accurate topography will not be represented.

Small peaks need to be added onto the model. It is necessary to refer to the topo map to ensure that all peaks have been included.

Plastering

For making smooth form terraces using white cement and sand.

A second coating of white cement may be needed to create a smooth surface on the model.

The result at this stage is a blank relief model that also represents the shape of topography. The next step involves painting the land cover.

Defining legend, symbology, and painting the model

Defining legend

The participants must be well aware of the legend they are going to use before they mark the features on the model. Participants are then invited in groups to locate the water courses, mountain peaks, valleys, roads, trails, social infrastructures and other landmarks they use to orient themselves while moving around within their domains. Pins, yarns and paint are used to mark point, line and polygon features respectively.

Secondary information

After the informants transfer and cross check mental maps, they can add secondary information to the model. Secondary information like administrative boundaries, park boundaries, infrastructure, settlements, etc. can be placed in the model. Settlement and peak names can be flagged with pins as writing on the model will be difficult.

Painting and adding symbology to the model

Painting land cover on model and name tagging

After adding the layer of primer, land cover can be painted on the model (with green colour small pieces of mats) using a land cover map as a reference. While transposing the land cover on the model, care should be taken to represent the actual shape, size, orientation and extension.

Name tags of peaks (with height) and settlements can be added to the model as well. It is better to stick name tags on the model rather than writing on the model directly.

Showing boundary with woollen threads

Different types of boundaries, e.g., national boundary, park boundary and Village Development Committee (VDC) boundary, can be shown using woollen threads. The differences can be represented by using threads of different widths and colours.

Gridlines with geographic coordinates can also be shown using threads. This makes it easier to locate places with specific XY coordinates.

Final checking of the model

As a final inspection, all the features and details of the model should be compared with secondary information and the base map. If any details are missing, the model should be updated.

After updating the final details, the actual ground information should be represented in the model. A complete model will show land cover, boundaries, name tags, etc.

Interest and uses

After building the model, participants should hold a group discussion on its use and application. Participants may offer different views as they come from different backgrounds and often know the area represented in the model very well. Ideas generated from the group discussion will be useful in guiding the model's future use.

If possible, the model should be enclosed in a glass case for protection.

Handing Over of the Model

After the model is ready, the ownership of the model has to be formally transferred to the community. The model is never final as such and needs to be regularly updated with the latest information. It has to be entrusted to an entity that has the capacity and commitment to safeguard and maintain it, and to make it accessible to those who would like to use it, update it with the latest information and accurate existing information.

In the case of SNP, the model was handed over to the visitor information centre of the SNP Park Office.

References

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Montello, D. (1997) *NCGIA Core Curriculum in GIS, National Center for Geographic Information and Analysis*. University of California, Santa Barbara, USA.

Rambaldi, G., Kwaku Kyem, A.P.; Mbile P.; McCall, M., and Weiner D. (2005) *Participatory Spatial Information Management and Communication in Developing Countries*. Paper presented at the Mapping for Change International Conference (PGIS'05), Nairobi, Kenya, 7-10 September 2005.

Rambaldi, G., and Weiner, D. (2004) *Summary Proceedings of the 'Track on International PPGIS Perspectives: Third International Conference on Public Participation GIS (PPGIS)'*, University of Wisconsin-Madison, 18-20 July. Madison, Wisconsin, USA.

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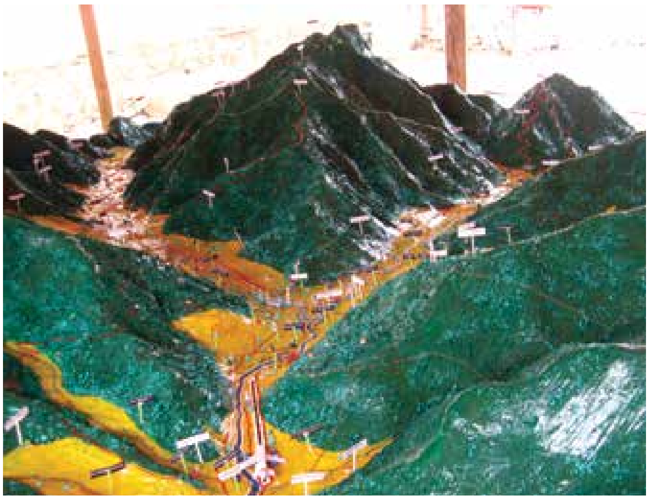
Relief models: Examples from Bhutan, Myanmar, and Nepal

Godavari, Nepal, 2001

Mustang, Nepal, 2006

Solukhumbu, Nepal, 2009

Bumthang, Bhutan, 2012



Paro, Bhutan, 2013



Nyangse, Myanmar 2015



Dhungetar, Nuwakot, Nepal 2016

Appendix 1: Map Reading

Map reading entails identifying and understanding details shown on a map. A map represents a part of the Earth's surface. Traditionally, maps printed on paper base. A hard copy of a map can be scanned and converted into a digital image. While using GIS technology, maps are prepared directly in GIS vector or raster format.

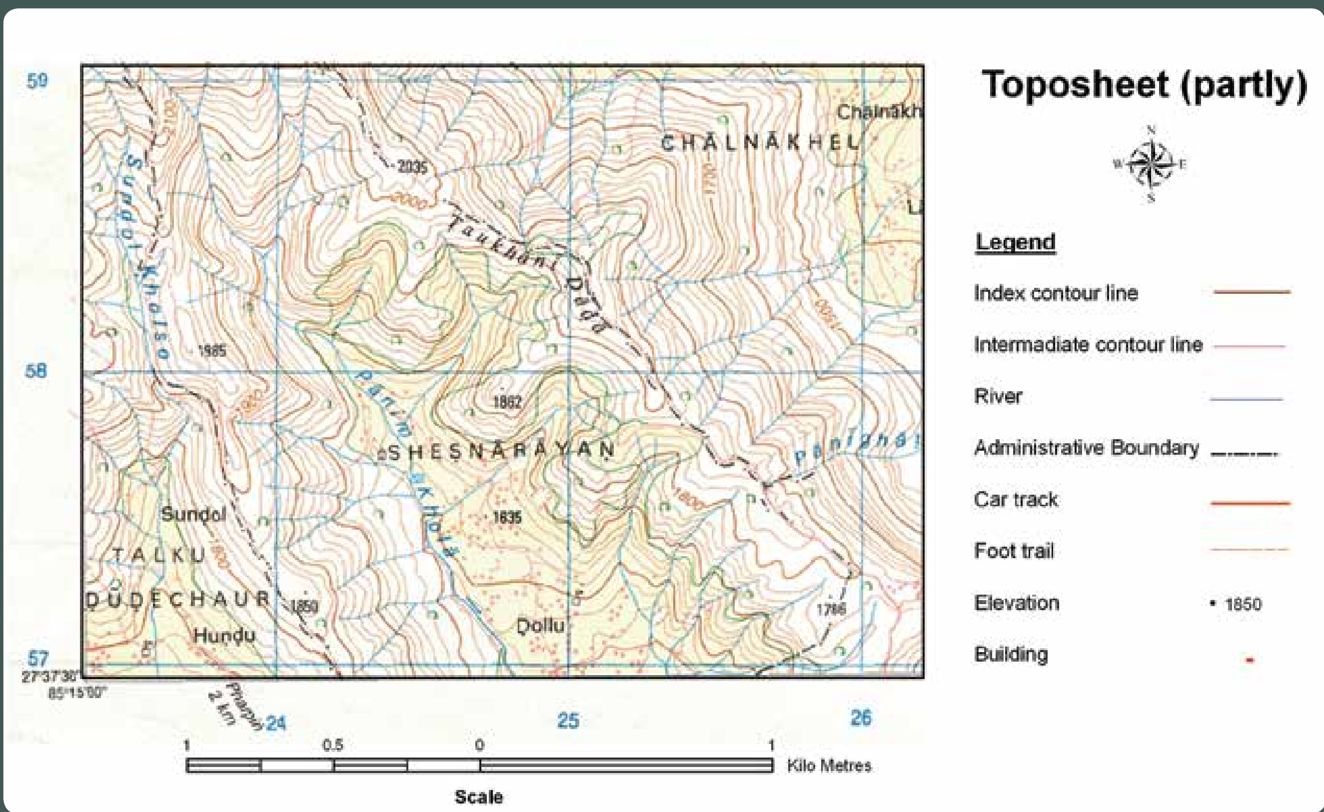
On a topographic map, contour lines represent elevation. Contours lines are drawn on a map to represent points of equal elevation on the land surface. Elevation is the height Above Mean Sea Level (AMSL). On the map, elevations are usually shown as dark brown lines of two different widths. The thicker lines, which are called index contours, are usually numbered, and their height is provided in metres. The thinner lines, which are a shade lighter, are intermediate contour lines and do not have numbers. There can also be lighter-coloured supplementary contour lines with dotted lines that delineate a particular area, and its interval will be half of the contour normal interval. The contour interval is the height difference between two contour lines. It varies from map to map depending on the scale of the map. The closer the contour lines, the steeper the slope. Based on the contours, it is possible to measure the height of mountains and the steepness of slopes.

A topographic map shows not only contours, but also other natural and manmade features. Each feature is represented by symbols and colours.

Colours and symbols are applied according to standards, which differ from country to country. Some coding is common worldwide: forestlands, for instance, are shown in a green tint, waterways in blue. A road may be represented in red or black solid or dashed lines depending on its size and surface.

The legend displays and explains the symbology used in the map. Map features are represented by points, lines and polygons. The map also contains other information such as title, legend, scale, author and source.
Toposheet

Toposheet

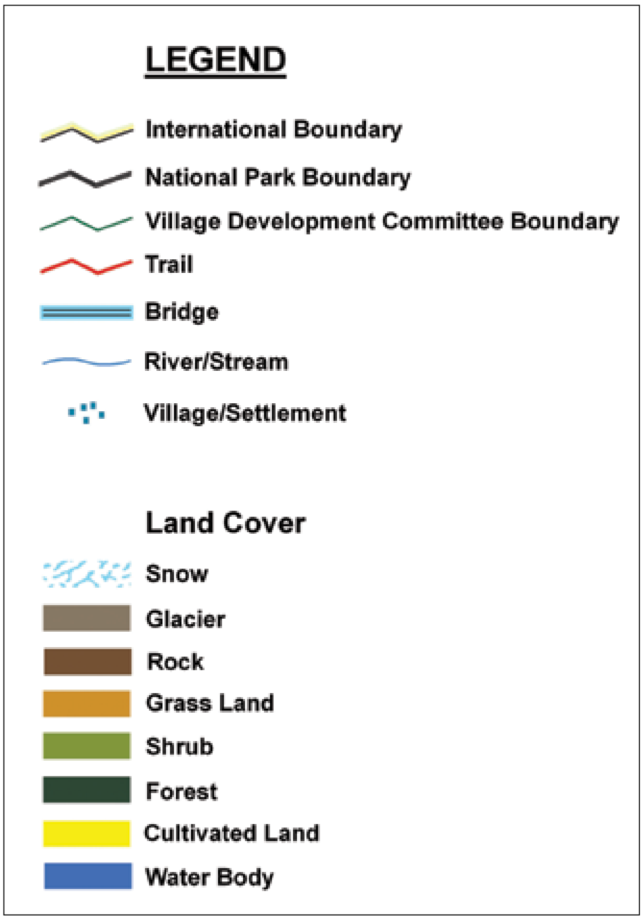


Appendix 2: Materials for Sagarmatha National Park, Scale 1:20,000 Model, Solukhumbu, Nepal. Area coverage: 1,400 sq. km

S No.	Material specification	Quantity	Unit
1	Trekking mat (2'x6', 7mm)	200-300	sheet
2	Carbon paper	2	packet
3	Glue (Dendroid)	5	litre
4	Mobicol (Glue)	15-20	kilogram
5	Scissors 8 inches	4	piece
6	Cutter knife – big, small	4/2	piece
7	Cutter knife blade	4/2	packet
8	Plastic bucket 5, 20 litre	6/6	Piece
9	Artist brush fine art no. 1 and 2	5	piece
10	Artist brush fine art no. 9 and 12	5	piece
11	Brush 1", 2", 3", 4"	4/4	piece
12	Enamel (green, apple green, emerald green, white)	1/1	litre
13	Enamel (yellow, red, orange, blue, black, brown, violet)	.5/.5	litre
14	Map pins different color (big head)	10	packet
15	Map pins of different colours (small head)	10	box
16	Dressmaker pins	10	box
17	Pushpins of different colours	10	box
18	Hand knitting woollen thread	5	lacchi
19	Crochet thread	2	roll
20	Stapler m/c 10	3	set
21	Stapler m/c 3	1	set
22	Pencil	2	dozen
23	Marker pen	6	set
24	Pencil sharpener	6	piece
25	1/2/3/4 inches iron nails	4/4	kilogram
26	Clip board with corner file type	3	piece
27	Name tag	40	set
28	Plastic scale (12")	6	piece
29	Measuring tape	1	piece
30	White cement	50	kilogram
31	Gloves	5	set
32	Base maps	2	set
33	Base table	1	piece
34	Compass	1	piece
35	Turpentine	2	litre
36	Flip chart/cardboard paper	3	sheet
37	Masking tape (2")	4	roll
38	Surgical knife (10/15/20)	10/10	pieces
39	Laser/Inkjet transparent sheet	30	sheet
40	Certificate paper	50	sheet
41	Transparent cello tape .5", 1"	3/3	roll

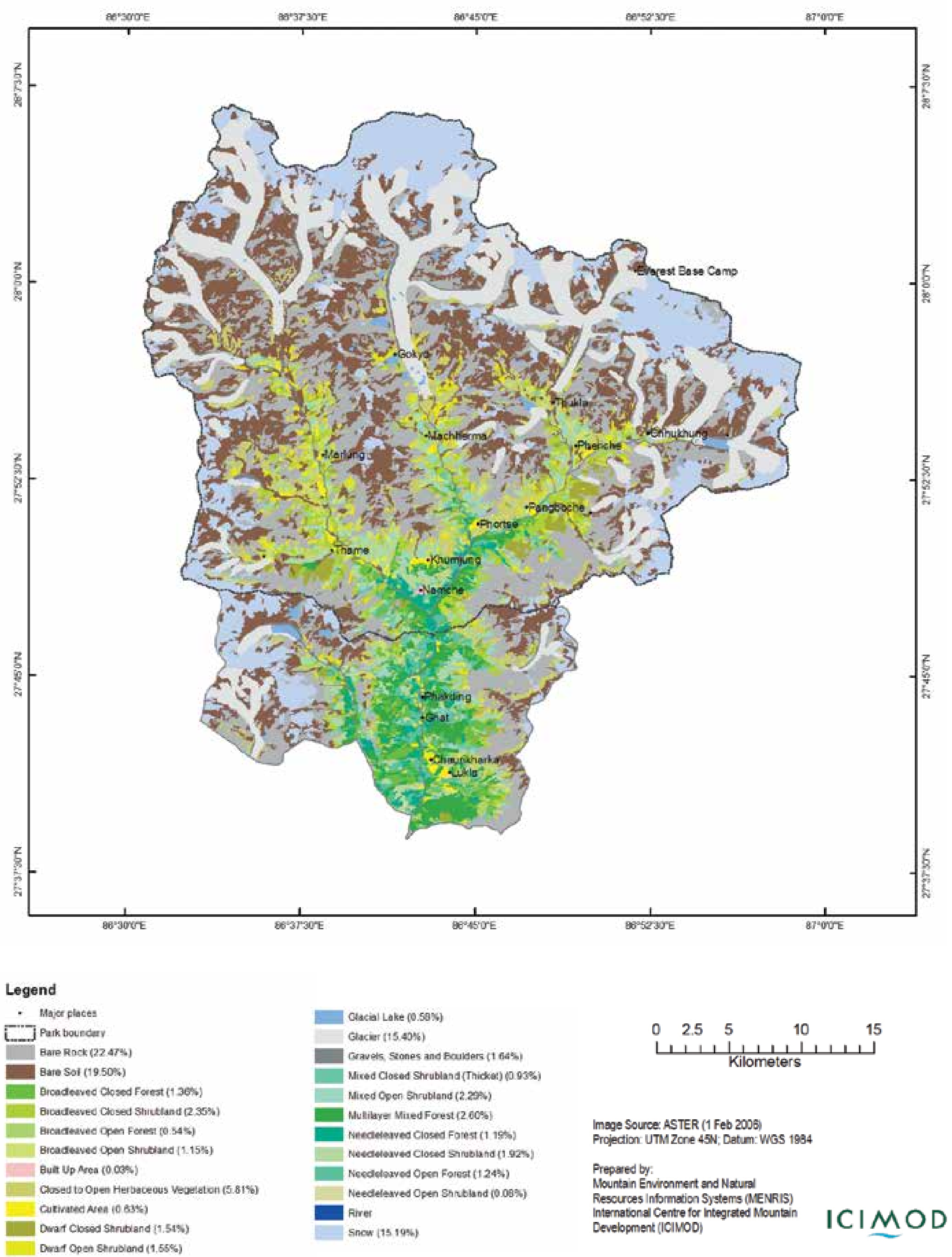
Note: May need to arrange one Laser jet/Ink jet Printer and projector.

Appendix 3: Legend of SNP P3DM

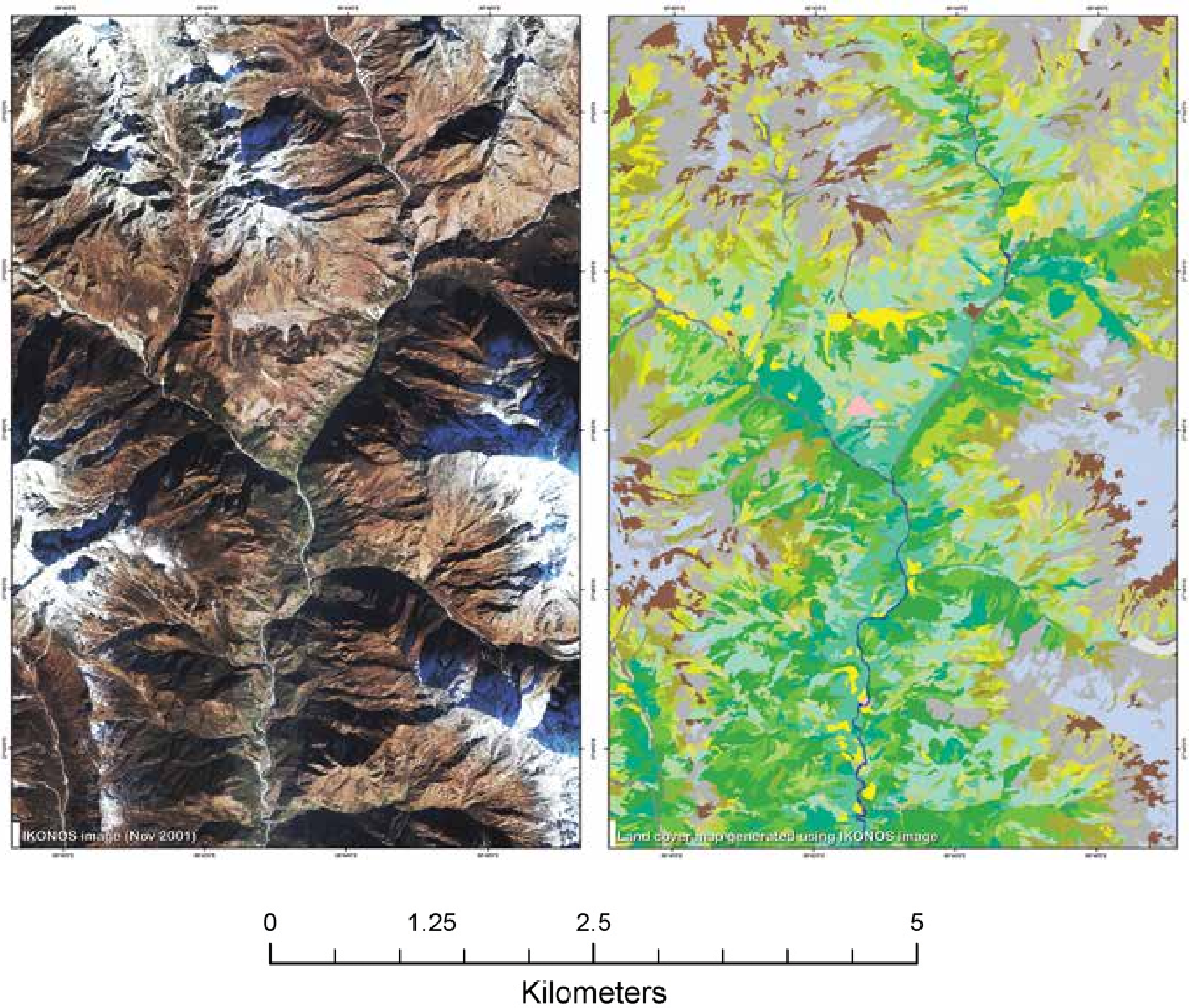


Appendix 4: Land cover map of Sagarmatha National Park and Buffer Zone (SNPBZ)

Land Cover 2006



Appendix 5: Land cover map of SNP (central part) based on IKONOS 4 m resolution, November 2001.



Legend

- Bare Rock
- Bare Soil
- Broadleaved Closed Forest
- Broadleaved Closed Shrubland
- Broadleaved Open Forest
- Broadleaved Open Shrubland
- Built Up Area
- Closed to Open Herbaceous Vegetation
- Cultivated Area
- Dwarf Closed Shrubland
- Dwarf Open Shrubland
- Glacial Lake
- Glacier
- Gravels, Stones and Boulders
- Mixed Closed Shrubland (Thicket)
- Mixed Open Shrubland
- Multilayer Mixed Forest
- Needleleaved Closed Forest
- Needleleaved Closed Shrubland
- Needleleaved Open Forest
- Needleleaved Open Shrubland
- River
- Snow


Lukla airport, Nepal


Phakding, Nepal


Namche Bazar, Nepal


Khumjung, Nepal


Bumthang, Thimphu, Bhutan


Nyaung Shwe, Myanmar

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