PARTICIPATORY THREE-DIMENSIONAL MODELLING:

GUIDING PRINCIPLES AND APPLICATIONS

2010 EDITION

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Online reference sites:

http://pgis.cta.int

http://pgis-tk.cta.int

www.iapad.org

About the author: Giacomo Rambaldi is Senior Programme Coordinator at the Technical Centre for Agricultural and Rural Cooperation (CTA) in the Netherlands. Giacomo has worked in community mapping in developing countries since the late 1980s. In 2000, he launched Participatory Avenues, www.iapad.org, a website dedicated to sharing knowledge on community mapping. In 2004, he launched the Open Forum on Participatory Geographic Information Systems and Technologies, www.ppgis.net . His expertise includes visualising indigenous spatial knowledge for improving communication, participatory spatial planning, networking, information management and communication.

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Publications like this are based on knowledge acquired from direct field experience and supporting research. This handbook embodies inputs from local map makers and facilitators engaged in field activities involving participatory three-dimensional (3D) modelling (P3DM). It reflects the lessons learned from tailoring a method to the interests and capacities of people in contexts where lack of communication poses serious obstacles and is frequently a source of conflict and disempowerment.

Everyone who has had the opportunity to be part of a P3DM exercise – including national and local government agencies, community elders, students, indigenous peoples, non-governmental organisations and the private sector – has been very enthusiastic about what they could see, touch, understand and shape.

Special thanks to all the individuals whose knowledge, dedication and skills carried the process forward from the conceptualisation of these guidelines in the 1990s to this latest update. Special mention goes to all indigenous and marginalised peoples from around the world who contributed to the improvement of the P3DM process while sharing their valuable knowledge of remote areas – the fisherfolk who depicted the hidden features of the seabed, the farmers who visualised and georeferenced the details of their farmlands and the rural women who best dealt with issues of health, education and demography.

The first edition of this handbook was developed in 2000 in the framework of the National Integrated Protected Areas Programme (NIPAP), a European Union-funded project in the Philippines, as Volume V of the series, "Essentials of Protected Areas in the Philippines". The second edition was published in July 2002 by the ASEAN Centre for Biodiversity (ABC). This third edition has been co-published in English, French and Spanish by the Technical Centre for Agricultural Co-operation and the UNDP Small Grants Programme. It takes into consideration experience gained in applying P3DM in South and Southeast Asia, Africa, Latin America and the Pacific.

AWARDS

On 5 November 2007, P3DM was granted the World Summit Award 2007 in the category of e-culture. P3DM was considered to be one of the 40 best practice examples of quality e-content in the world.

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ACRONYMS

3D	Three-dimensional
ACB	ASEAN Centre for Biodiversity
ASEAN	Association of Southeast Asian Nations
CADC	Certificate of Ancestral Domain Claim
CALC	Certificate of Ancestral Land Claim
CTA	Technical Centre for Agricultural and Rural Co-operation EU-ACP
DENR	Department of Environment and Natural Resources
EC	European Commission
FPWIC	Free prior and written informed consent
GIS	Geographic information system
GIT	Geographic information technologies
GPS	Global positioning system
IPR	Intellectual property rights
IPRA	Indigenous Peoples Rights Act
NEA	National Environment Agency (Vietnam)
NGO	Non-governmental organisation
NIPAP	National Integrated Protected Areas Programme
NIPAS	National Integrated Protected Areas System
P3DM	Participatory three-dimensional modelling
PGIS	Participatory geographic information system
PLA	Participatory learning and action
PLUP	Participatory land-use planning
RFD	Royal Forest Department
SFDP	Social Forestry Development Project
TUSFP	Thailand Upland Social Forestry Project
WIPO	World Intellectual Property Organisation

SPATIAL INFORMATION AT THE COMMUNITY LEVEL

Geographic Information Technologies

"Rapid growth of geographic information technologies (GIT) is transforming how earth and environment are visualised, represented and understood. As a result, GIT applications can alter how people view, exploit and manage the physical resource base. Geographic information systems (GIS) produce representations of nature that privilege conventional forms of scientific spatial information, including data on the local environment. As a result, the politics of landscape and the social production of nature are frequently ignored and valuable local knowledge marginalised" (Weiner *et al.,* 1999:18).

In the last decade there has been a strong drive towards integrating GIS into community-centred initiatives, particularly to deal with spatial information gathering and decision making. Researchers around the world have been working on different approaches known under a variety of abbreviations including, among others, Participatory GIS (PGIS) (Abbot *et al.,* 1998), Public participation GIS (PPGIS) (Obermeyer, 1998; Jordan, 2000; Weiner *et al.,* 2002), Community-integrated GIS (CiGIS) (Harris and Weiner, 2002) and Mobile, interactive GIS (MIGIS) (McConchie and McKinnon, 2002). The term most commonly used is participatory GIS, and as a field it has been growing exponentially (Chapin, 2005).

All share the assumption that the system would place ordinary people in a position to generate and analyse georeferenced spatial data and integrate multiple realities and diverse forms of information. This would in turn enable broader public participation in environmental and public policy decision making.

Nonetheless, it has become apparent that because of GIS' heavy technological component, a community cannot use it without considering the resources needed to undertake and maintain it. Therefore, lacking external support, GIS would be outside the capacity of most marginalised or less-favoured communities (Weiner *et al.*, 2001; Abbot *et al.*, 1998).

The very nature of PGIS has forced researchers to confront GIS and society's concerns and to design and adapt geographic information systems that specifically address the needs of participant communities. While the overall characteristics of PGIS are becoming clearer, precise definitions are not easy to determine. As a result, diverse approaches to PGIS implementation are emerging that are characterised by:

- the design of systems that specifically seek to empower communities and individuals and encourage public participation in GIS-based decision making;
- the integration of local knowledge to minimise the structural knowledge distortion of traditional GIS applications;
- systems and structures that provide public access to GIS information;
- provisions for public input and interaction in GIS decision-making processes with concomitant reduction in the enforced public passivity in decision making arising as a direct result of the technology itself;
- research that acknowledges and minimises the surveillant capabilities and potential intrusiveness of GIS into the private life of individuals;
- the use of innovative geo-visualisation and GIS multimedia methods that incorporate and represent different forms of quantitative and qualitative knowledge; and
- the integration of GIS with the Internet.

Adapted from Weiner D. and Harris T, 1999:8. *Community-integrated GIS for Land Reform in South Africa.* URISA Journal, Vol. 15, APA II; 2003.

At the onset of the PPGIS concept, Poiker (1995) expressed concern that the nature of and access to GIS would simultaneously marginalise or empower different groups in society having opposing interests. Abbot *et al.* (1998) questioned whether participation and GIS would even be a contradiction in terms.

PGIS evolved along different lines and among diverse interest groups. Currently, the concept embraces a number of applications ranging "from Internet-dependent spatial multimedia to field-based participatory research methods with a modest GIS component" (Weiner *et al.*, 2001; page 10).

Participatory three-dimensional (3D) modelling (P3DM) has been conceived as a method for bringing the potential of GIS closer to rural communities and for bridging the gap that exists between geographic information technologies and capacities found among marginalised and isolated communities who are frequently dependent on natural resources.

This handbook is intended to assist activists, researchers and practitioners of participatory learning and action (PLA) and GIS in bringing the power of GIS to the grassroots level through the use of P3DM.

Ethics in the Practice

It appears that there is a seemingly unstoppable excitement about georeferencing our human physical, biological and socio-cultural worlds and making the information accessible in the public domain. Stunning innovations (e.g. Google Earth) are now available to all those with adequate access to the Internet or modern GIT. In this context, the path towards making good use of GIT is scattered with troubling dilemmas and overarching issues about empowerment, ownership and potential exploitation which lead to questions of "who" and "whose" (see BOX ON NEXT PAGE). These questions, if carefully considered by technology intermediaries, may induce appropriate attitudes and behaviours in the broader context of good practice (Rambaldi, 2006a).

Participatory 3D Modelling: A Means, Not an End

P3DM is a mapping method based on extracting topographic information (i.e. contour lines) from scale maps, and then constructing a physical model (see FIGURE 1) that is used to locate peoples' spatial memories. 3D models work best when used jointly with global positioning systems (GPS) and GIS. The outputs are solid 3D models and their derived maps. The models have proved to be excellent media and are user-friendly, relatively accurate data storage and analysis devices.

Figure 1. The model: a focus for learning and negotiation

P3DM has been gaining increased recognition as an efficient method to facilitate learning, analysis and community involvement with spatial issues related to a territory. P3DM can support collaborative natural resource management initiatives and facilitate the establishment of a peer-to-peer dialogue among local stakeholders and external institutions and agencies.

Representatives from local communities manufacture scaled 3D models by merging spatial information (i.e. contour lines) with their location-specific knowledge. Contour lines are used as templates for cutting out sheets of carton board or EVA/PE sheets of a given thickness (i.e. to express the vertical scale). Cut-out sheets are progressively superimposed on one another to build the model.

Compilation of "who" and "whose" questions

- **Stage I: Planning**
  - Who participates?
  - Who decides about who should participate?
  - Who participates in whose mapping?
  - ... and who is left out?
  - Who identifies the problem?
  - Whose problems?
  - Whose questions?
  - Whose perspective?
  - ... and whose problems, questions and perspectives are left out?
- **Stage II: The mapping process**
  - Whose voice counts? Who controls the process?
  - Who decides about what is important?
  - Who decides, and who should decide, about what to visualise and make public?
  - Who has visual and tactile access?
  - Who controls the use of information?
  - Who is marginalised?
  - Who understands?
  - Whose reality is expressed?
  - Whose knowledge, categories, perceptions?
  - Whose truth and logic?
  - Whose sense of space and boundary conception (if any)?
  - Whose (visual) spatial language?
  - Whose map legend?
  - Who is informed about what is on the map (i.e. transparency)?
  - Who understands the physical output? And who does not?
  - ... and whose reality is left out?
- **Stage III: Resulting information control, disclosure and disposal**
  - Who owns the output?
  - Who owns the map(s)?
  - Who owns the resulting data?
  - What is left with those who generated the information and shared their knowledge?
  - Who keeps the physical output and organises its regular updating?
  - Whose analysis and use?
  - Who analyses the spatial information collated?
  - Who has access to the information and why?
  - Who will use it and for what?
  - ... and who cannot access and use it?
  - Ultimately ...
  - What has changed? Who benefits from the changes? At whose expense?
  - Who gains and who loses?
  - Who is empowered and who is disempowered?

Local knowledge holders first develop the map legend (i.e. the visual language of the map) through a consultative process based on their spatial knowledge. Using the elements of the legend, they depict land use, land cover and other features on the model by using push pins (for points), yarn (for lines) and paint (for polygons).

Once the model is completed, participants apply a scaled grid to transpose georeferenced data into a GIS. The grid offers the opportunity to add geo-coded data generated by GPS readings or obtained from other sources. The grid also allows participants to take approximate coordinates on the model and verify these on the ground by using a GPS. These functionalities are extremely useful when models are used to support boundary negotiations. Data on 3D models can be extracted by digital photography and imported into a GIS.

This method is generally used in the context of demand-driven initiatives designed to address territorial issues, although it has also come to be used for documenting traditional knowledge and facilitating its intergenerational exchange. The participatory process leading to the construction of the models requires local and external inputs and skilled support. Once the models are completed, members of local communities can maintain and use them. Technology intermediaries invited by communities to assist them in the process should have a thorough understanding of the physical, ecological and socio-economic environments of the area to be mapped. The intermediaries should do their best to secure funds to support the participating communities in implementing action plans and in addressing new realities which may emerge in the map-making and follow-up processes.

In manufacturing a 3D model, participants go through a collective learning process (see FIGURE 1) to visualise their economic and cultural domains in the form of scaled and georeferenced 3D models which can be used subsequently for different purposes as discussed in PAGES 6 TO 12.

One major constraint of a 3D model is its limited mobility as elaborated on PAGE 11. Its use is therefore confined to those who can convene around it. To broaden the use of P3DM, the models should be integrated with GPS and GIS to make their content portable and shareable. This allows adding precisely georeferenced data, conducting additional analysis and generating cartographic outputs in printed and electronic formats. The synergies resulting from the combinations of the three systems add accuracy, veracity and authority to local spatial knowledge, paving the way for more balanced power sharing in collaborative development initiatives leading to change and innovation.

Spatial Learning and the Vertical Dimension

"Human cognition includes sensation and perception, thinking, imagery, reasoning and problem solving, memory, learning and language. 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).

Mental maps are internal representations of the world and its spatial properties stored in memory. They allow us to know "what is out there, what its attributes are, where it is and how to get there" (Montello, 1997).

Cognitive maps are distinct to individuals. They are not inclusive, like cartographic maps with a constant scale, but consist of discrete, hierarchically organised pieces of information determined by physical, perceptual or conceptual boundaries (Montello, 1997). Cognitive maps are constructed in the moment to answer a particular question using whatever information is available and relevant, e.g. memories of maps viewed, of travelling in the environment or of descriptions in language. They are not stored in some place in the mind or brain to be consulted, like an atlas. They are not necessarily consistent, and they are likely to have error because people's knowledge is not complete and may be erroneous. A cognitive map is an internal mental representation, while a sketch map is an external physical representation. The two are not necessarily identical; sketching a map or inputting data on a 3D model forces a degree of consistency.

Spatial knowledge develops in humans through three progressive stages: landmark, route and survey knowledge. The first refers to the capacity of memorising places in relation to an event, and the second refers to developing a sense of ordered sequences of landmarks. The last and more progressed stage (FIGURE 2) is where the knowledge simultaneously embraces more locations and their interrelations and allows for detouring, shortcutting and creative navigation (Montello, 1997).

This is the learning path undertaken by informants confronted with a blank 3D model. First, they look for landmarks on the model to establish their physical location. In a few minutes, they locate themselves and/or their households, and establish spatial relationships among different landmarks. Once this

Figure 2. Assembling the cognitive patchwork

is done, informants link the model to the real world and are in the position to precisely depict their mental landscape.

Practitioners using 3D models at the community level in Southeast Asia have experienced that when informants are provided with a blank 3D model instead of a blank contour map or a blank sheet of paper, they can easily depict their spatial knowledge in a scaled, georeferenced manner and add a lot of precise details.

Because 3D models augment the power of the mind (see BOX) and facilitate scaling, they allow participants to complete information about a given area more fully and accurately. Generally this is not the case with sketch mapping, which has been used widely to represent spatial knowledge in the context of participatory action research. The difference between a contour map and the corresponding 3D model is that the vertical dimension provides essential cues for stimulating memory and establishing spatial associations. Among the different visualising methods[1] used to spatially reproduce people's knowledge, P3DM is the one which offers substantial advantages for depicting mental maps because it adds the vertical dimension and uses simple means of communication like colours, shapes and dimensions.

Cross-cutting Functionalities of Participatory 3D Modelling

Twenty years of experience in developing countries has shown that 3D models – which are used independently or which are integrated with GIS and GPS and made part of broader action-oriented processes – contribute to a number of basic functionalities in human development and interaction.

> "The usefulness of a visual representation of the landscape (e.g. map, 3D models, illustrations, paintings, etc.) originates from the interaction of its physical format with the way humans process information in their mind.
>
> Whereas the information humans can mentally process is limited, both in number of items (memory) and in number of operations (processing), external visual representations are virtually unlimited. Whereas mental information processing is fleeting, external representations are permanent. Whereas human information processing is a private, internal event, external representations are public, transportable and shareable. External representations enlarge human memory and enhance processing by offloading those burdens from the mind to visible, rearrangeable space. People are limited in the amount of information and mental operations that they can keep track of, but people are excellent at pattern recognition.
>
> Turning internal information and operations into external patterns augments the powers of mind." (Adapted from Tversky and Lee, 1999:1)

Discovery learning

Over the past century, 3D models have played an important role in displaying geographic information for educational purposes.

Starting in 1987, 3D models have been used as interactive instruments through which people could learn by doing. Considering

1 Visualising methods include sketch mapping, transect diagramming, participatory aerial photo-interpretation, relief modelling, mapping, etc.

the fact that the act of learning causes a relatively permanent change in cognition or behaviour (Montello, 1997), the process of manufacturing a 3D model represents an important individual and, eventually collective, learning experience. By providing a "bird's-eye view", a 3D model widens the participants' evaluative frame of reference on spatially defined issues like watersheds, linked ecosystems and resource tenure and access, thus stimulating active learning and analysis. In other words, it helps the individual understand the ecological and social dynamics that go beyond his/her cognitive boundaries.

In addition, when maps are fed with memories from older generations, the 3D map-making process is a catalyst in stimulating memory, articulating tacit knowledge and creating visible and tangible representations of the biophysical and cultural landscapes.

Figure 3. Bird's-eye view on the Pamitinan Protected Landscape, Rizal, Philippines, 2000

P3DM is tailored for areas where poverty, isolation, marginalisation, low literacy and language barriers frequently shape society. The tendency for most people residing in these areas is to learn by concrete sensorial experiences, rather than by abstract concepts. Therefore, it has been seen that villagers – when properly oriented – can manage the P3DM process with ease and great enthusiasm, progressing through the various stages of learning. In fact, the physical nature of the method enhances discovery learning through verbal, visual and tactile experiences, stimulates feedback, promotes debate and negotiation and generates shared information in visible and tangible (FIGURE 3 and FIGURE 4) formats.

Figure 4. Information is made tangible

As with a GIS, 3D models use differentiated means of coding to accommodate overlapping information layers; they thus facilitate community-based spatial analysis and decision making.

Because 3D models are important repositories of local knowledge, they frequently become local landmarks. They are used to introduce the area to newcomers, to teach local geography and history and to enhance people's interest in safeguarding and sustainably managing natural resources.

Visualising knowledge

"Knowledge can be considered as the sum of interconnected rules of interpretation through which we understand, give meaning, perceive or interpret the world around us" (Leeuwis, 2001). Knowledge is what we store in our mind and what leads us to take decisions, act and react to stimuli received from the external world. Knowledge is very subjective and builds up in everybody's mind through a continuous learning process involving, among other things, concrete experiences, observations, reflections and the formation and testing of concepts.

At one end of the spectrum is what is considered to be our *explicit knowledge*. This is knowledge of which we are aware, upon which we have reflected and which we can easily capture in verbal, textual, physical or visual formats (Leeuwis, 2001). Explicit knowledge transforms into *information*.

At the opposite end of the spectrum is *unconscious knowledge*, which is characterised by perceptions and motives of which we are not aware and which is "sealed off" by psychological conditioning. This means that we have to overcome emotional barriers in order to gain access to it. Our *unconscious* fades into what is frequently referred to as *tacit knowledge,* which corresponds to knowledge which is difficult to articulate, about which individuals are not immediately aware (see BOX), and on which they base their day-to-day actions. This kind of knowledge can be elicited through in-depth discussions and interactive exercises. In many instances, 3D models proved to be catalysts in stimulating memory and making such knowledge explicit. Participants in P3DM exercises become aware of what they know and the importance such knowledge has for them and their community. Usually this gained awareness triggers great excitement among participants and stimulates their desire to "discover" and learn more by doing.

Concluding remarks of an elder after a series of PLA exercises:

"At the beginning we thought we were playing. Later on we realised that we were analysing our lives. We knew that we knew, but we were not aware of how much we knew and how important our knowledge is to us."

Captain George, 1997, Barangay Tawangan, Kabayan, Philippines

It is important to appreciate these differentiations because this handbook revolves around a method that facilitates the visualisation of *tacit* (spatial) knowledge. This method, through an intensive learning process, increases the amount of awareness that P3DM participants have about their knowledge. This augments participants' capacities to analyse, communicate and interact on specific issues, which gets much clearer in their minds.

As discussed in detail on PAGE 5, mental maps are internal representations of the world and its spatial properties stored in memory. They frequently represent portions of our tacit and explicit knowledge and are visualised with the use of sketch maps, transect diagrams, scale maps, drawings and physical or virtual 3D dimensional models.

Compared with technology-dependent GIT, P3DM is a fully tested method that can be handled in rural areas with locally available technical capacities. It is a method that can help visualise spatial knowledge, particularly among communities characterised by low literacy, language barriers and lack of basic utilities (e.g. electric power) (Gaillard *et al.*, 2009; Hoare *et al.*, 2002; Rambaldi *et al.*, 2000 and 2007; Tan-Kim-Yong, 1992 and 1994). Different from other visualising tools (i.e. sketch mapping) characterised by varying levels of accuracy, 3D modelling offers the opportunity to produce relatively precise georeferenced and scaled qualitative and quantitative data, adding substantial value and the power of communication to local knowledge.

Participatory legend making and visual language

Participatory legend making (see PAGE 30) is vital for the process to be genuinely participative and owned by the map makers. It is critically important that legend items are generated by the community members in their own language.

To facilitate a good legend-making process does not necessarily require prior exhaustive knowledge of the particular language. Nonetheless, it helps to have some appreciation of the various cultural systems and how natural resources are considered and used. The process of legend making provides a helpful framework on which local people can overlay the distinctiveness of their culture. It does not necessarily capture all of the complexity of the cultural systems, but with additional tools such as the matrix (see FIGURE 5), it al-

Figure 5. Use of a matrix to elicit information on climatic zones among Ogiek people in Nessuit Kenya, 2006

lows complex knowledge to surface and be captured and represented in a medium that can be understood by people with different cultural backgrounds.

Legend making is perhaps the most important element of the P3DM process. A legend, if made correctly, puts the knowledge holders in the driver's seat. It allows them to express a complex network of ideas, concepts and interlocking criteria that will be visualised and coded on the model. A well-prepared legend allows clearer meanings and maps out the relationships between natural and cultural features. The P3DM process allows participants to document and locate their tangible and intangible heritage and show cultural sites, knowledge systems and important physical sites.

Intra- and intergenerational knowledge exchange

The P3DM process helps reclaim lost memories about the traditional ways of living. In the presence of elders (i.e. custodians of traditional knowledge) and youth, it facilitates intergenerational knowledge exchange and raises awareness across generations about the status of the environment (FIGURE 6).

In many instances, participants conclude that they gain a more holistic understanding of their social, cultural and biophysical environments, and that they realise the importance of working together towards a common goal. They also become aware of the value and potential authority of their spatial knowledge after it is collated, georeferenced, documented and visualised.

Supporting community cohesion and self-determination

Experience documented in a number of developing countries has shown that P3DM exercises – conducted at the community level and in response to local needs or external threats – have revived local knowledge and yielded positive effects in terms of community cohesion (FIGURE 7) and identity building (Crawhall, 2009; Muchemi, 2009; Rambaldi *et al.*, 2007; Rambaldi *et al.* 2006c, PAFID, 2001).

Figure 6. Pupils from a local school view the model of their location, Nessuit, Kenya, 2006

Figure 7. Indigenous peoples working on the 1:10,000-scale model of the Mt. Pulag National Park, Benguet, Ifugao and Nueva Vizcaya, Philippines; 1999

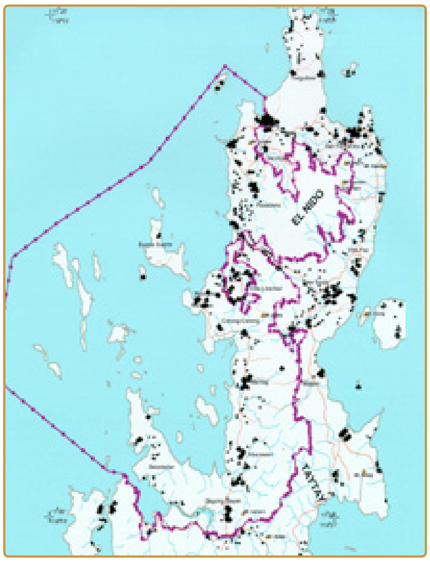


Figure 8. El Nido-Taytay Managed Resource Protected Area, Philippines, 1999; 1:20,000-scale model and derived maps

The power of maps has led the way towards legal recognition of ancestral rights claimed by indigenous peoples in the Philippines (De Vera 2005) and has strengthened the negotiating positions of Ogiek Peoples in Kenya (Rambaldi *et al.*, 2007). These maps were created by integrating 3D modelling (FIGURE 8 and FIGURE 10), GPS and GIS in a context of strong advocacy and an existing legal framework that accommodated the desired results.

Manufacturing a 3D model has positive effects in stimulating community cohesion because it gathers people to share information and concerns and frequently reinforces community self-actualisation through the revival of local knowledge. "Old people share history with young people, passing on legends and religious beliefs, sacred rites and places so essential to conserving tradition" (Alcorn, 2000:1-2) (Rambaldi *et al.* 2007; Chambers, 2006) (see BOX).

A well-displayed 3D model is appealing, fuels community esteem and a sense of intellectual ownership and becomes part of the local cultural landscape. Villagers frequently use these models to introduce visitors to the area – a simple act that signifies peer-to-peer information sharing and calls for silent acknowledgment of the existence of local knowledge.

Feedback from participants

"I learned new things about my village. I learned names of places, names we do not use anymore, names that our elders used and I am so glad that I and future generations have learned and will use them again." (Statement made by a resident of Ovalau Island, Fiji, after completing a 3D model of the island, April 2005)

"I discovered that when working together we are more powerful."

"I learned that we can show the rest of the communities in Kenya and the world that we have our own home."

"I felt overwhelmed to see it [the past landscape] brought back."

"We are happy because we have learned things about our land we had forgotten."

"I have learned more about my land and my community, so I'm very happy to discover more."

(Statements made by Ogiek indigenous people after completing a 3D model of the Mau Forest, Kenya, August 2006)

Figure 9. Participants sharing their feelings about their P3DM experience; Democracy Wall exercise, Nessuit, Kenya, 2006

Improving communication

Three-dimensional models provide local stakeholders with a powerful medium for easing communication and overcoming language barriers.

In providing open access to information, 3D models add transparency and create common ground for discussion. They broaden individual perspectives and limit the distortion[2] of messages between communicating parties by offering a shared language of colours, shapes and dimensions. In doing this, 3D models bridge language barriers and ease communication on issues bound to the territory and its resources. This is particularly relevant for people with different education levels, cultural backgrounds and diverse or conflicting interests.

> The information on a 3D model is easily understood because multiple stakeholders have played an active role in compiling it and in defining its legend, which is the actual key for decoding what is on display.

Maps reproduce people's georeferenced knowledge in a cartographic format which is understood by the "outside" receivers; this places insiders (i.e. community members) and outsiders (e.g. scientists, government officials, consultants, etc.) on an equal footing, thus facilitating interaction, reciprocal learning and negotiation (Alcorn, 2000, 2001; Gaillard, 2009; Poole, 1995, 1998; Rambaldi *et al.*, 2002, 2006b, 2007).

Bridging isolation and supporting change and innovation

Innovation has to rely on the concurrence of both technical and social-organisational elements. Change must be supported by building networks of coordinated action at different institutional levels and with involved decision makers. This process can be facilitated through the use of communicative strategies. In bringing about change, communication is used primarily to facilitate learning and negotiation (Leeuwis, 2000).

In this context, participatory mapping has gained importance. Increased access to modern GIT has begun to allow those who were traditionally disenfranchised by maps to experience the power that comes from recording and controlling space. Maps have been the most commonly used reference medium when dealing with geographically defined issues in a community-led negotiation process.

While making and displaying a 3D model allows for interpersonal communication that facilitates learning and negotiation, the model's main constraint is its limited mobility. To use the model as a channel for interaction, insiders and outsiders have to physically gather around it. This is a constraint, considering that central, regional and provincial governments are generally the locus of decision making.

To reach central institutions, information displayed on 3D models has to be portable and widely shareable. This is made possible by fully integrating P3DM with a GIS, which allows for the conversion of the data depicted on models into a mobile and reproducible cartographic format. In turn, a GIS can generate data sets, which can be entered onto the 3D model (see PAGE 45) to enrich the learning and negotiation process. If adequate linkages and networks are established, and depending on the existing regulatory framework, innovations supported by P3DM outputs (e.g. models, maps, plans) and advocacy campaigns can reach higher institutional levels and may influence national policy making, as exemplified in the case of the Philippines (De Vera, D. 2005, 2007a, 2007b; PAFID 2001).

Models and maps can be used as part of a communication strategy to foster legal and policy reform at the national level. Consensus surrounding a map gives legitimacy in

2 Having the vertical dimension of a landscape represented reduces distortion in the transmission of a message because one layer of interpretation is removed.

Figure 10. **Map of the Ancestral Domain of the Tagbanua Peoples, Coron Island, Philippines, 1998 (Source of information: 3D model)**

political debates in an open society (Alcorn, 2000). The combination of P3DM, GPS, GIS and Web 2.0 applications has proven to be quite efficient in increasing the capacity of local stakeholders to interact with national and international institutions. The P3DM process and its outputs appear to be the

Figure 11. **1:5,000-scale model of the Kankanaey Ancestral Domain, Palina, Kibungan, Benguet, Philippines; 1998. Image courtesy Dave de Vera, PAFID**

foundations upon which participatory GIS can release its full potential.

Scaling the territory

By miniaturising (i.e. 1:5,000–1:20,000) real world features as they are known and perceived by participants, P3DM has proven to be particularly effective in dealing with relatively large and remote areas and in overcoming logistical and practical constraints to public participation in land- and resource-use planning and management.

Specific Applications of Participatory 3D Modelling

Documenting and safeguarding traditional knowledge

With the development of modern biotechnology, genetic resources have gained increasing scientific and commercial value for a wide range of parties. In this respect, efforts have been made to extend the laws and practices covering intellectual property rights to the traditional knowledge associated with such resources. In 2000, the World Intellectual Property Organisation (WIPO) Member States established an "Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore" (the IGC) to address misappropriation, misuse and the intellectual property aspects of access to and benefit-sharing in genetic resources. The IGC, which met for the first time in 2001, is, in 2009, discussing draft provisions for the enhanced protection of traditional knowledge and traditional cultural expressions.

In the Philippines, indigenous peoples have been in the position to extensively document their use of resources and occupation of lands since time immemorial and to obtain Certificates of Ancestral Land Claims CALC) or Certificates of Ancestral Land Titles (CALT). The use of GIT, including 3D models, played a crucial role in the process (FIGURE 10 and FIGURE 11) (De Vera, 2005; PAFID, 2001, Rambaldi *et al.*, 2001). Ancestral knowledge and folklore were extensively documented through P3DM processes in Kenya (Crawhall, 2009, 2008; Muchemi *et al.* 2009; Kiptum, 2007; Rambaldi *et al.* 2007), Malaysia (Wong *et al.* 2009) and Ethiopia (Belay, 2009). These experiences offer examples on how the method can be used to document intellectual property rights (IPR) concerning traditional knowledge.

Collaborative planning

The physical three-dimensional representation of space offers users a "bird's-eye view" and a common perspective from which to acquire a holistic view of the landscape wherein landmarks and salient features are visible to everyone (FIGURE 12). The process of making a 3D model, or of using it as a reference for discussion and planning, facilitates the mental comprehension of spatial data. Imagine discussing the outlining of a 20-km long road while sitting around a desk with no reference at all, or while using a topographic map, or while using a scaled 3D model. The last scenario is likely to be the most productive, as discussed in detail at PAGE 5.

Figure 12. There we are!

The transparency of displayed data is also very helpful in this process. All features shown on a model and on its legend are the result of collaborative efforts by various stakeholders. Having a common understanding of the landscape greatly enhances individuals' capacity to analyse the territory for comprehensive planning and to interact on a peer-to-peer basis. The concurrence of all these factors makes 3D models excellent tools for collaborative planning and helps stakeholders deal with issues and conflicts associated with the territory and the use of its resources (FIGURE 13).

Figure 13. Indigenous peoples in Kalinga working on a 1:5,000-scale model, Philippines; 2001

As discussed on PAGE 36, the use of a coding system based on a rich assortment of materials and colours allows a 3D model to function like a rudimentary community-based GIS, accommodating overlapping layers of information. This is extremely useful in any planning exercise because users can establish visual relationships among resources and their tenure, use and jurisdiction.

So far, participatory 3D models have been successfully used in preparing land- and resource-use plans (Tan-Kim-Yong, 1992; Tan-Kim-Yong *et al.,* 1994; GTZ-HDP, 1998; Jantacad *et al.*, 1998; Rambaldi *et al.*, 2006c), watershed management plans (GTZ-HDP, 1998; Hoare *et al.*, 2002), community-based fire management plans (Hoare *et al.*, 2002), protected area management plans (Rambaldi *et al.*, 2002), ancestral domain management plans (De Vera 2007, 2006, PAFID, 2001, Zingapan 1999), and disaster risk reduction plans (Galliard 2009, Maceda, 2009, Purzuelo, 2007) – the last three including both terrestrial and marine components.

Collaborative research

Participatory 3D models made at scales equal to or larger than 1:10,000 can facilitate selective pinpointing of resources, households and other features and can be used as valid support to conduct on-field research in various domains including biological diversity, socio-economics, demography, health and social vulnerabilities. What substantially differentiates the method from other modern GIT, like aerial photography and satellite imagery, is that it can be used to depict invisible features like values, tenure, resource-use domains, sacred areas, spatially defined rights, cultural boundaries and others (FIGURE 14).

Figure 14. Informants working on the model of the Pu Mat National Park, Nghe An, Vietnam; 2001

If the method is applied in a genuinely participatory manner, it generates relatively accurate qualitative and quantitative georeferenced data (Chambers, 2002 and 2007) that are intellectually owned and understood by those who have compiled them as discussed in detail on PAGE 42.

The opportunity of using P3DM for mapping water bodies deserves special mention because of the partially hidden nature of these environments and the value of human cognition in their description and depiction.

Mapping wetlands and coastal areas characterised by shallow waters is difficult, because of their instability and frequent changes (e.g. river deltas). Nonetheless, in cases where the topography has been stable for a long period and reliable contour and bathymetric lines are available, the production of a participatory 3D model has led to the generation of an extremely rich information base about existing ecosystems and their interaction with wetland-dependent communities (Grundy, 2009).

The reproduction of the seabed also depends on the availability of bathymetric lines. Exercises carried out in northern Palawan in the Philippines (FIGURE 15) have demonstrated how well fishermen could map the details of their fishing grounds, including detailed descriptions of coastal and marine ecosystems.

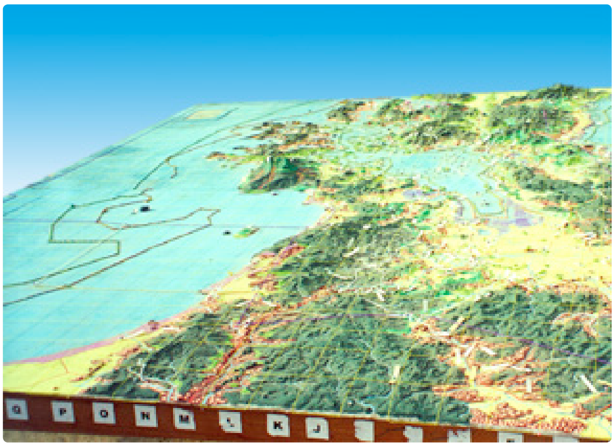


Figure 15. 1:20,000-scale model of Malampaya Sound Protected Land and Seascape, Palawan, Philippines; 2000

Collaborative protected area management

The use of participatory 3D models in the context of protected area management (FIGURE 16) has been initiated in the Philippines, as discussed on PAGE 21.

Recorded uses include:

- generating spatial georeferenced data based on a community perspective on land use, vegetation cover, resource distribution, tenure, etc.;
- storing and displaying such data at the protected area/community level;
- conducting a preliminary census of protected area occupants;
- planning field activities at the protected area office level;
- involving communities in developing resource-use and management plans,

including zoning and boundary delineation;

- conducting preliminary collaborative research on distribution of species;
- monitoring changes in land use, vegetation cover, human settlement, infrastructure development and other features;
- substantiating public hearings and planning workshops;
- serving as reference during Protected Area Management Board meetings;
- supporting students' learning about local geography and resource use;
- raising awareness about, for example, the hydraulics of watersheds (e.g. upstream-erosion / downstream-sedimentation effects); and

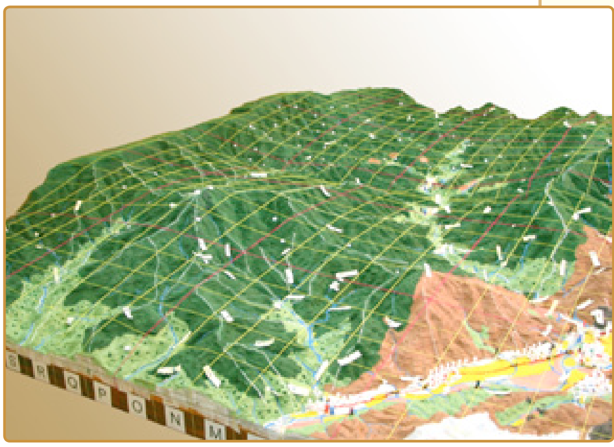


Figure 16. 3D Model (1:10,000-horizontal scale and 1.5 vertical exaggeration) of the south-western portion of Pu Mat National Park, Nghe An, Vietnam; 2001

- introducing visitors to the area.

Participatory monitoring and evaluation

Frequently, when spatially defined issues are monitored through a process involving community members, comparisons are made among sketch maps, transect diagrams or other spatial tools produced at different times. Using these kinds of tools presents an inherent weakness because their outputs generally lack georeferencing and may be inconsistent in terms of coding. P3DM overcomes this weakness because the 3D model is a constant with its embedded legend.

A working participatory 3D model is never completed. As with any dynamic system, change is a constant. A 3D model, like a GIS, can accommodate regular updating, but if revised, it cannot store past scenarios. This is where GIS adds value and becomes a vital ingredient for monitoring change – provided that the data on the 3D model are updated at given intervals, periodically extracted, digitised, plotted as thematic maps and finally returned to the community for assessing change and identifying its causes and effects (FIGURE 17).

Most protected areas in developing countries do not have demarcated boundaries. Three-dimensional models can give stakeholders a clear, factual understanding of their whereabouts for the first time. This facilitates a bottom-up approach to boundary delineation and zoning, activities which otherwise tend to be characterised by heavy bureaucracy, expensive logistics, frequent confrontation (based on insufficient access to information) and lengthy negotiations.

This process adds to the learning aspects discussed on PAGE 6.

Management of conflicts bound to the territory and its resources

Resolving conflict involves using area-based mechanisms to prevent, mediate and resolve local disputes and to strengthen communities in dealing with their management. Disagreements over boundaries, resource use and tenure are often root causes of conflicts.

The strategies and processes leading to conflict resolution are complex and articulated and need the backing of appropriate institutional, legal and – where applicable – traditional mechanisms.

By creating shared vantage points and offering a common visual vocabulary, 3D models and derived maps are instrumental in bridging communication barriers, facilitating dialogue and limiting subjective inter-

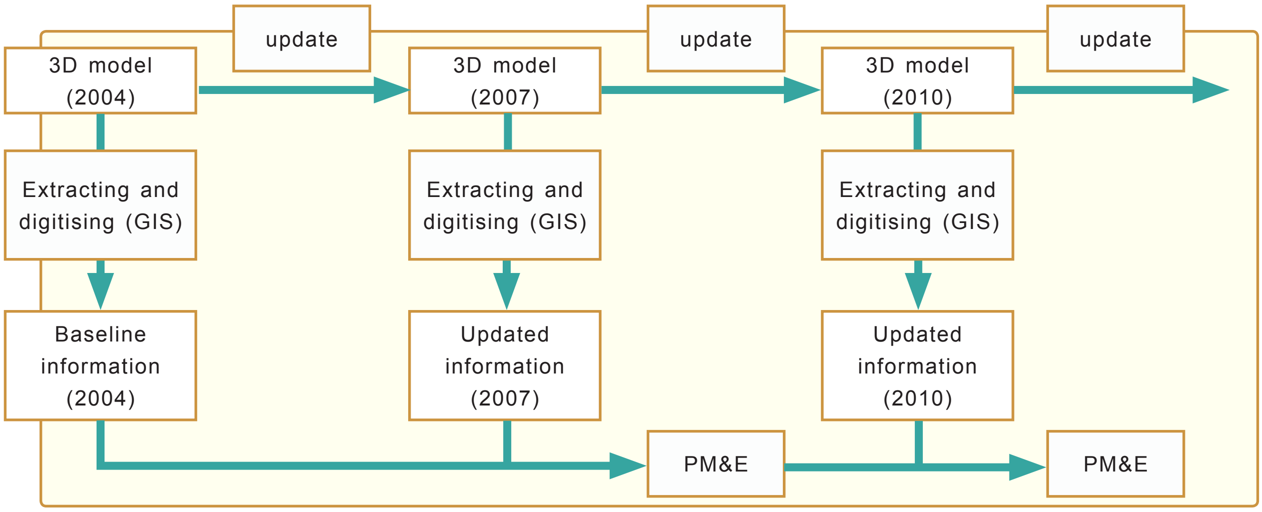


Figure 17. The function of P3DM in a participatory M&E context (diagram)

pretations; they thus establish the basis for fruitful negotiations (Rambaldi *et al.*, 2002).

Three-dimensional models have been used to resolve conflict throughout Northern Thailand (Tan-Kim-Yong, 1992; Tan-Kim-Yong *et al.*, 1994; Srimongkontip, 2000; Hoare *et al.*, 2002) and in the Philippines under the auspices of the Office of the Presidential Adviser on the Peace Process (OPAPP) (PAFID, 2001; Rambaldi *et al.*, 2002).

Reconciling conflicts through a common perspective

Opinions are frequently based on different perspectives and means of communication. A case in point is a long-lasting conflict among tribal communities in the northern part of the Philippines. The origin of the conflict is territorial and relates specifically to boundaries of tribal domains which were agreed upon by elders a century ago and formalised as written peace pacts, passed on from generation to generation. A number of factors have led to diverging interpretations of the scripts and have triggered violent confrontations.

In 1998, the Office of the Presidential Advisor for the Peace Process (OPAPP) stepped in to facilitate a negotiation process aimed at reconciling the conflicts. The turning point of the process was the establishment of common ground for understanding the territory.

By using a 3D model that embraced the entire area of conflict, it became apparent that diverse ethno-linguistic groups were using different names for natural landmarks, such as creeks and peaks. Residents of different locations would construe “the boundary running along the highest mountain” differently, depending on their own viewpoint. Different interpretations of natural features were ineluctably sources of disagreement.

The model was constructed with the active participation of all parties concerned. It is georeferenced and represents a total area of approximately 700 sq. km at a 1:5,000-scale. At planned intervals, the confronting groups have gathered around the model to learn, using a common ground, and to negotiate. In one year and a half, almost all conflicts have been settled and new peace pacts have been signed.

In such a context, there is no doubt that the third dimension and the holistic view offered by the relief model have been key factors in facilitating the consolidation of the negotiation process: there was only one highest mountain and one creek to be named, seen, felt and touched by all concerned (Figure 18).

During the construction of the model and follow-up negotiations, data were extracted, digitised and fed into a GIS. In support of the data displayed on the 3D model, the voluminous process documentation includes a description of the boundary corners and the names of the individuals who will be responsible for identifying them during the forthcoming ground survey.

This final act, which will conclude the peace process, will be conducted with the assistance of a licensed geodetic engineer. The fact that the elders and the barangay captains have already defined a survey plan represents a reasonable guarantee for the respect of the right to self-delineation enshrined in the IPRA law (Rambaldi *et al.*, 2002).

An interactive process involving 3D modelling may set the basis for constructive action, but it may also be instrumental in making latent conflicts explicit. Therefore, it is important that the process be carefully prepared, well-managed and embedded in a long-lasting, articulated (multi-actor) intervention, which could eventually deal with follow-up arrangements to accommodate new realities emerging from the process (Leeuwis, 2001).

Some groups have expressed concern that the mapping process enables outsiders to be in command of information previously controlled by local communities (Poole, 1995).

Figure 18. Elders warming up "Peace Pacts" in Balbalan Municipality, Kalinga, Cordillera Administrative Region, Philippines, 2000. Image courtesy dave de Vera, PAFID

Inherent Risks and Mitigating Measures

Because of their accuracy, 3D models, like other repositories of geographic information, pose some risks in terms of disclosing sensitive information. Alone or combined with GIS, "they turn local knowledge into public knowledge and conceivably out of local control. This can be used by outsiders to locate resources and meet development needs, or merely, to extract more resources, or increase outside control" (Abbot *et al.*, 1999). Researchers, planners and practitioners should be aware of these possible drawbacks and be careful applying the method.

Being on a map means to exist in relation to the external world, and thus to be in the position to get or claim services and assistance. On the other hand, 3D models may carry undesired development pressures for communities wanting to maintain their cultural identity and traditions. From a conservation perspective, depicting habitats of endangered species or rare resources which are in demand on the black market may lead to their further depletion.

Therefore, exercises dealing with sensitive issues should be carried out with caution and behind closed doors during focus group discussions. Culturally sensitive data or data at risk of abuse should be removed from the model and eventually stored as confidential GIS layers with limited or protected access (Harmsworth, 1998).

Scaled 3D Models in History

Strategic Planning Instruments

Three-dimensional, raised-relief models have a special place in the history of urban representation because of their essentially strategic function. Historians report of 3D models made in China as early as the beginning of the first millennium depicting miniature roads, rivers, mountains and passes. These models were made out of wood, glue-soaked sawdust, beeswax and wheat paste. According to Needham (1986), Emperor Shenzong of Song (1067–1085) ordered that all the prefects administering the frontier regions should prepare wooden maps which could be sent to the capital and stored in an archive. Italian engineers probably fine-tuned the technique in the fifteenth century to study means of protecting Levantine cities from the Turkish armies (Faucherre, 1986). The period of glory for 3D models came with the reign of Louis XIV (1661 to 1715), who ordered the manufacture of 140 1:600-scale models[3] (FIGURE 19) depicting cities that had been incorporated into the Kingdom of France (Faucherre, 1986; Polonovski, 1998).

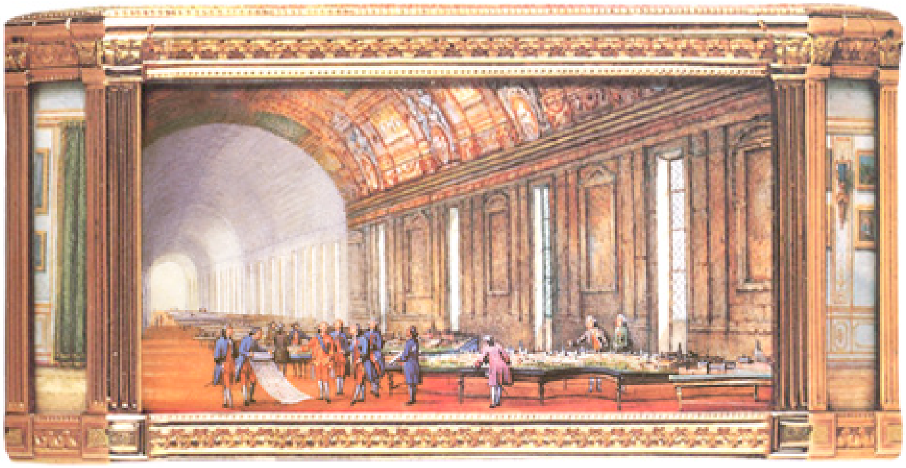


Figure 20. The Sun King and his advisors consulting 1:600 scale 3D models in the "Galerie du Bord de l'Eau" at the Louvre in Paris; miniature by Nicolas van Blarenberghe [French, 1716-1794] decorating a tobacco box

The 3D models were instruments of exclusive knowledge management. The gallery in Paris (FIGURE 20), where these were stored, was kept secret from the eyes of the public (Siestrunck, 1980; Pernot, 1986). Like a hidden vault, accessible only to a selected elite, it contained spatially defined, visualised knowledge enshrining the entire power of the kingdom. Interestingly, this may be considered to be the first example of large-scale geographic information storage and management with a strategic purpose.

Because of the strategic function of 3D models, the engineers who manufactured these took great care in providing an exact representation of the settlements in relation to their surrounding landscape. It was extremely important for engineers to know whether or not a city could be targeted from a particular hill, in order to take the necessary protective measures (Perrin, 1999).

After the reign of Louis XIV, other scale 3D models were manufactured for defensive engineering and commemorative purposes (Polonovski, 1998). The former application

Figure 19. Three-century-old scaled 3D model of the city of Perpignan, France (year of manufacturing: 1686)

3 A total of 64 relief models have been preserved and are on permanent display in Lille and at the Hôtel National des Invalides in Paris, France.

fell into disuse at the end of the nineteenth century (Faucherre, 1986).

The use of physical topographic models for strategic purposes persisted throughout the First and Second World Wars (Pearson, 2002) until the present time.

Many public administrations have used scaled 3D models for urban planning. Today large-scale urban or rural development projects are frequently reproduced as scale models for communication purposes.

From warfare to welfare

In the United States at the end of the nineteenth century, dramatic increases in the quantity of geographic information stimulated a flurry of innovation in visualisation and communication methods. Techniques for producing 3D models were developed and their production increased dramatically during the last two decades of the century. The models became a popular medium for communicating the state of geographic knowledge in schools, museums and major public exhibitions. Some 100 3D models were displayed at the World's Columbian Exposition of 1893 in Chicago (Mindeleff, 1889 and 1900; Baker, 1892-94).

Over the past six centuries, the use of 3D models has undergone substantial change. Conceived essentially for defensive purposes, they were used by military engineers to interact efficiently with the monarch and highly placed government officials – a select, restricted, power-holding elite.

At the end of the nineteenth century, they were used for educational and communication purposes with the public.

Today, scaled 3D models are used mainly as a communication device to exchange information between planners and government institutions and between these and the public.

Throughout these 600 years of history, however, engineers and artisans have fabricated 3D models behind closed doors. Only in modern history has the public been included, but mainly as a spectator or commentator in a process of consultative participation – by no means has the public been included as an actor tasked with inputting data and generating, displaying and owning the resulting information.

> In consultative participation, the public participates by being "consulted" and planners and/or institutions may listen to their views. However, planners and/or institutions define problems and solutions, and may modify these in light of people's responses.
>
> Such a consultative process does not concede any share in decision making and professionals are under no obligation to integrate people's views.
>
> (Adapted from Pretty, 1995)

Adding "Participation" to 3D Map Making

The paradigm shift

In the late 1980s, development practitioners were inclined to adopt participatory rural appraisal (PRA) sketch mapping tools rather than venture into more complex and time-consuming scale mapping. This was particularly because community-based processes and interdisciplinary communication were preferred over actions that would enable communities to interact efficiently with policy makers.

Over the past two decades, in an attempt to put ordinary or disadvantaged people first, there has been a dramatic shift in the development and conservation sectors from using a prevailing top-down approach to using a bottom-up planning approach (Chambers, 1983). Participatory technologies have fast developed and have become almost a requirement for development, land redistribution and biodiversity conservation initiatives. This has led to an array of approaches ranging from ornamental to genuine participation.

At the community level, spatial analytical tools – including sketch mapping, participatory aerial photo-interpretation, P3DM and Internet-based mapping – have gained a progressively important role since increased attention has been paid to the spatial relationships between a territory and its inhabitants, resources, users and/or customary custodians. Indeed, these tools acquired additional relevance with the diffusion of GIS, low-cost GPS and remote-sensing image analysis software, open access to data via the Internet and steadily decreasing cost of hardware. This resulted in a dramatic change in terms of access to geo-data and technology; spatial data, which was previously centrally controlled, became increasingly available on the open market to sectors of society traditionally disenfranchised by maps. With GIT within reach of the larger public, many researchers, development practitioners, facilitators and activists began to assimilate these tools into participatory research, planning, negotiation and advocacy processes.

Several methods were developed in order to translate people's knowledge (i.e. mental maps) into high quality georeferenced information. Some of these methods enabled the knowledge to be visualised in a cartographic, reproducible format accepted at the institutional level as part of a negotiation process.

Janis Alcorn (2000:12) highlighted the power of maps, "which communicate information immediately and convey a sense of authority. As a consequence, community-based maps empower grassroots efforts to hold governments accountable. This mapping is not action research; it's political action."

The Origin and Spread of P3DM

Thailand

In the context of development work, 3D models were first used in Thailand as a tool for facilitating a dialogue on resource use and tenure among government officials and hill tribe people. These models were first used proactively by the Royal Forest Department (RFD) in the framework of the Thailand Upland Social Forestry Project (TUSFP, 1989; Tan-Kim-Yong, 1992; Poffenberger, 1993; Tan-Kim-Yong *et al.*, 1994; TG-HDP, 1998a). The Faculty of Social Sciences at Chiang Mai University started using 3D models as a learning and communication tool, while researchers at the university began using them in the framework of the innovative participatory land-use planning (PLUP) approach they were spearheading (Tan-Kim-Yong *et al.*, 1994). Although the first experimental 3D model was made by project staff, subsequent models were constructed by collaborating villagers. As the devices demonstrated their key role in providing open access to information for learning, discussion and negotiation, they began to be constructed in many villages to support multi-stakeholder collaborative planning by newly established watershed management networks.

Since the PLUP process was geared towards inducing behavioural change among insiders and outsiders through learning, negotiation and conflict resolution processes, information and communication systems were considered to be key ingredients. This required all parties to gain equal access to information to develop a common understanding of resource management issues (Tan-Kim-Yong *et al.*, 1994). It became apparent that in a situation with language barriers,[4] information exchange could best occur with visual means of communication like diagrams, aerial photographs and 3D models in particular. These means provided the focus for organised discussions and were instrumental in providing participants with a clearer understanding of local problems within a wider social and environmental context. A progressive learning and negotiation process led to dispute settlement among villagers, between villages and between villagers and government officials, thus opening up avenues for dialogue among people of different ethnic backgrounds and cultural conditioning (Tan-Kim-Yong, 1992; Tan-Kim-Yong *et al.*, 1994).

The PLUP experience has since been widely recognised as an example of effective local

4 RFD government officials and TUSF programme staff had a hard time communicating with the hill tribe communities because spoken languages differed considerably.

resource management by minority groups (TG-HDP, 1998:27) and has been adopted by other projects in Thailand and neighbouring countries.

The Thai-German Highland Development Programme (TG-HDP), which started in 1981 and went through several phases, adopted 3D mapping in 1990 (TG-HDP, 1998). In their 1998 final review and "lessons learned", the TG-HDP management stated that "of the many working tools such as maps, aerial photographs and GPS that have been used during CLM, the 3D model has been found to be the most useful" (TG-HDP, 1998a:48).

Philippines

In 1993 in the Philippines, the Environmental Research Division of the Manila Observatory assisted the Mangyan Alangan community in Mindoro Oriental in producing a 3D model and related cartographic information to file an ancestral domain claim and to prepare the related management plan (Walpole et al. 1994). In 1995, the Philippine Association for Intercultural Development (PAFID), an NGO set up in 1967 to advocate for customary land tenure by indigenous peoples, adopted P3DM and tailored it for developing ancestral domain management plans, delineating domain boundaries and addressing boundary conflicts. As of the writing of this handbook, PAFID had assisted more than 100 indigenous groups in preparing their maps[5] and plans and in obtaining the desired tenure instruments.

In 1997, PAFID assisted Green Forum-Western Visayas (GF-WV) – a coalition of NGOs and people's organisations – in adopting P3DM, GPS and GIS. A combination of these three technologies has been used since by the GF-WV to assist indigenous communities in applying for tenure instruments, raising local awareness on outsiders' interventions (e.g. large-scale mining operations) and enhancing community participation in natural resource management (Purzuelo, personal communication, 2002).

In 1996, the National Integrated Protected Areas Programme (NIPAP) (1995-2001) adopted P3DM while establishing protected areas in the framework of the National Integrated Protected Areas System (NIPAS) Act. In this context, the project promoted the method with the Department of Environment and Natural Resources (DENR). On 4 January 2001, the DENR institutionalised it by virtue of Memorandum Circular No. 1, S. 2001 and recommended its adoption in protected area planning and management (APPENDIX 1).

Vietnam

In Vietnam, terrain models were first used in the framework of the Social Forestry De-

Figure 21. 3D model made in the framework of the Social Forestry Development Project in Na Nga village, Chieng Hac Commune, Yen Chau district, Son La Province, Vietnam; 1999

Figure 22. 1:10000 scale model of Pu Mat National Park and its buffer zones, Nghe An, Vietman, 2001

5 The delineation activities have been carried out under the auspices of the Department of Environment and Natural Resources (DENR) and the National Commission on Indigenous People (NCIP).

Figure 23. 1:10,000-scale model manufactured by Ogiek indigenous people in Nessuit Kenya, 2006

velopment Project (1993–2004) (FIGURE 21) (Forster, personal communication, 2001).

The tool – a simplified 3D modelling process – was used to address conflicts on land use, facilitate land allocation, discuss potentials and constraints and develop land-use plans (SFDP, 1999). The models were seen as a low-cost tool aimed at addressing specific time-bound situations. They were produced by villagers using mud, coloured powder, tree branches and leaves (Forster, personal communication, 2001).

In 2001, the National Environment Agency (NEA), in collaboration with the Social Forestry and Nature Conservation Project in Nghe An, the Vietnam National Parks and Protected Areas Association (VNPPA) and the ASEAN Centre for Biodiversity (ABC), organised a P3DM exercise for the southeastern portion of Pu Mat National Park covering a total area of 700 km^2 (FIGURE 22). Ethnic minority groups locally residing in the area manufactured the model, which has since been used for collaborative planning and zoning. During the same year, the Mountain Agrarian Systems Programme produced a 1:3,000 scale model in Cho Don, Bac Kan Province as part of the CGIAR-coordinated initiative. The model was used to conduct a participatory diagnosis on spatial management of livestock systems (Martin, 2001).

Other 3D models were built in the Ba Be National Park, the Yok Don National Park, the Song Thanh Nature Reserve and Elephant Conservation Area (Steeman 2010) and in the Bi-Doup Nui-Ba National Park (Bond 2009).

P3DM was officially recognised as a planning tool in Vietnam when land-use planning guidelines – including the recommendation to use P3DM (Wode 2009) – were adopted in December 2008 via Decision No. 2311/QĐ-SNN issued by the Department of Agriculture and Rural Development (Nguyen Viet Nhung *et al.*, 2008).

Kenya

Introduced in Africa in 2006 by the Technical Centre for Agricultural and Rural Cooperation (CTA), P3DM has been used by Kenyan NGOs and community-based organisations (CBOs) to document and safeguard intangible cultural heritage among minority groups, to support intergenerational knowledge exchange and to advocate for rights of access to resources (Muchemi 2009; Rambaldi 2007). As of the writing of this report, models have been manufactured by Ogiek (FIGURE 23), Yiaku and Sengwer indigenous peoples (Muchemi 2009, Rambaldi 2007).

Other countries

Supported by the presence of a steadily growing and vibrant online community[6] engaged in the participatory use of GIT, freely available online resources[7] and development actors supporting its adoption, P3DM made its way into India, Nepal, Cambodia, Malaysia, Indonesia, Sri Lanka, East Timor, Fiji, Solomon Islands, Papua New Guinea, Australia, Ethiopia (FIGURE 24), Morocco, Colombia, Nicaragua, Guyana, Peru, Italy and France[8] (FIGURE 25).

Enabling and Disabling Conditions: Lessons Learned

During the last decade, P3DM has been adopted in the areas of biodiversity conser-

6 PPgis.Net – The Open Forum on Participatory Geographic Information Systems and Technologies www.ppgis.net

7 IAPAD – Integrated Approaches to Participatory Development www.iapad.org

8 Updates on the location and actors involved in P3DM across the globe are found on www.p3dm.org

vation, natural resource management and human rights advocacy.

Philippines

The method has spread the fastest in the Philippines, supported by committed and efficient NGOs and a relatively favourable legal environment. In the 1990s, the Philippine legislature passed two groundbreaking laws recognising the rights of indigenous peoples and ensuring their participation in protected area management and their rights for self-determination: the National Integrated Protected Areas System (NIPAS) Act of 1992 and the Indigenous People's Rights Act (IPRA) of 1997. The NIPAS act institutionalised the participation of indigenous and local communities in the Protected Area Management Board, a body mandated to manage protected areas and composed of representatives from local governments, NGOs and CBOs including indigenous cultural communities.

Figure 24. Elders presenting the work of their communities at the inauguration of the P3DM model of the Wechecha Mountain Complex, Ethiopia, 2009. Image courtesy MELCA Mahiber

Figure 25. Location of P3DM models across the world

The IPRA law allows for grants of collective and individual land rights to indigenous peoples through certificates of ancestral domain and land titles. (Farhan Ferrari 2004). Article 51 of the IPRA law specifies that self-delineation[9] shall be the guiding principle in the identification and delineation of ancestral domains. The law recognises the rights of indigenous people to define their development priorities through their own Ancestral Domain Sustainable Development and Protection Plan (ADSDPP), exercise management and utilise the natural resources within their traditional territories. Nonetheless, in 2007, nine years after the issuance of the law, only 34 titles covering half a million hectares of land were awarded to indigenous communities, and problems in the implementation of the law limit the capacity of indigenous communities to truly benefit.

9 Self-delineation implies that designated and trained community representatives identify and survey, jointly with accredited geodetic engineers, cultural boundary markers.

As De Vera (De Vera, 2007) puts it, "problems are rooted in conflicting policies, capacity gaps and the government's questionable commitment to empower indigenous communities". He further argues that "the urgency of the problem is underscored by overt encouragement on the part of government of the entry of large-scale commercial investment into traditional lands to install extractive industries which include open-pit mining, palm oil plantations and industrial forest farms" (De Vera, 2007).

Thailand

Even though P3DM was used earlier in Thailand than in the Philippines, its evolution and impact on natural resource governance there has been constrained by a number of factors, including the rigid regulatory framework associated with the existing watershed classifications and the absence of a legal basis for community forestry and land tenure allocation in the highlands. These factors deeply conditioned the uses to which community-generated maps could be put, thus narrowing the outreach of PLUP and P3DM to localised decision making. Additional factors, which contributed in the early 1990s to the stalling of participatory mapping, included limited access to the official large scale (>1:50,000) topographic maps under the control of the military and limited attention paid by the development community to local spatial knowledge.

At present, the situation is likely to evolve under the 1997 and 2007 constitution and local governance reforms, and with the community forestry bill being debated in 2010 in Parliament. Article 46 of the 1997 Constitution recognises community rights on the conservation and use of natural resources, and spells out that "communities shall have the right to preserve and restore their traditional culture, knowledge and fine arts [...], and participate in the management, maintenance, preservation and utilisation of natural resources and the environment in a sustainable way, in accordance with the laws...". This clause is maintained in Article 66 of the 2007 Constitution. Article 79 of the 1997 Constitution and Article 85 of the 2007 Constitution further emphasise the duty of the State to promote and encourage public participation in the conservation and use of natural resources (Sreesangkom 2010).

In spite of the suspended Community Forestry Bill, community-based forest management involves local administrations (Tambol), user groups and the Royal Forest Department. This arrangement translates the Constitution into practice and gives local communities the right to design their own rules for managing, using and conserving some portions of the forest. Within these likely favourable conditions, many researchers and development workers believe that the use of P3DM – increasingly linked with GIS – will rapidly expand and add value in natural resource governance.

Vietnam

Over the past two decades, the government policy in Vietnam has gradually shifted away from a centrally planned economy with collective land tenure and management, towards a system aimed at decentralising the management of natural resources. The rights of individual households were introduced in 1988 and were further secured by the 1993 Land Law, where the State recognised customary land use as a prerequisite for issuing land-use right certificates that entitled the awardees to exchange, transfer, lease, inherit and mortgage such rights. Concurrently, the duration of land allocation was extended to 20 years for land under annual crops and 50 years for land under perennial crops and was renewable provided careful use of it was made. In 2003 the government revised the Land Law. The most important revision concerned "communities" which could obtain land-use right certificates for long-term leases. The 2004 Law on Forest Protection and Development recognises village communities as traditional owners and sets the conditions under which forests can be assigned to them in return for protection and sustainable use.

In 2010, community-based natural resource management (CBNRM) arrangements benefit from a policy framework that is generally supportive but not explicit. While the legal framework provides the basis for adopting multi-stakeholder natural resource management modalities, regulations can be both supportive and restrictive (Swan 2010).

Lessons learned

The most important lesson learned from the analyses is that the uses for the physical P3DM outputs depend on the degree to which government agencies (i.e. existing national regulatory frameworks) accept and recognise community-based mapping practices. In some countries, mapping activities have to be implemented or at least certified by licensed surveyors. Depending on the purpose of the map-making activity, these kinds of issues should be clarified in advance in order to be in compliance with the law.

From a technical point of view, the lessons learned include the choice of the scale and geographical scope of the single model (as detailed in TABLE 1 on PAGE 28) and the necessity to fully integrate P3DM with GIS and GPS to support initiatives transcending the local contexts and aiming to establish a peer-to-peer dialogue among communities and central institutions, agencies and projects.

PARTICIPATORY 3D MODELLING, STEP BY STEP

P3DM is a process that can be used to generate a series of physical outputs, the information from which may be stored in a database for use in a GIS. FIGURE 26 summarises a typical P3DM process.

The basic steps in producing a 3D model and derived maps comprise the following:

1. Conducting preparatory work
2. Assembling the blank model
3. Preparing the map legend
4. Depicting information
5. Handing over the model
6. Extracting data
7. Digitising and manipulating data
8. Cross-checking and validating

Each step is described in the following sections of this handbook.

The P3DM's main function is to generate, through a participatory process, spatially defined, georeferenced and scaled data. This is not the case with most sketch mapping techniques. The P3DM process requires thorough preparation in procuring supplies, discipline in adhering to colour coding and precision in conducting all steps.

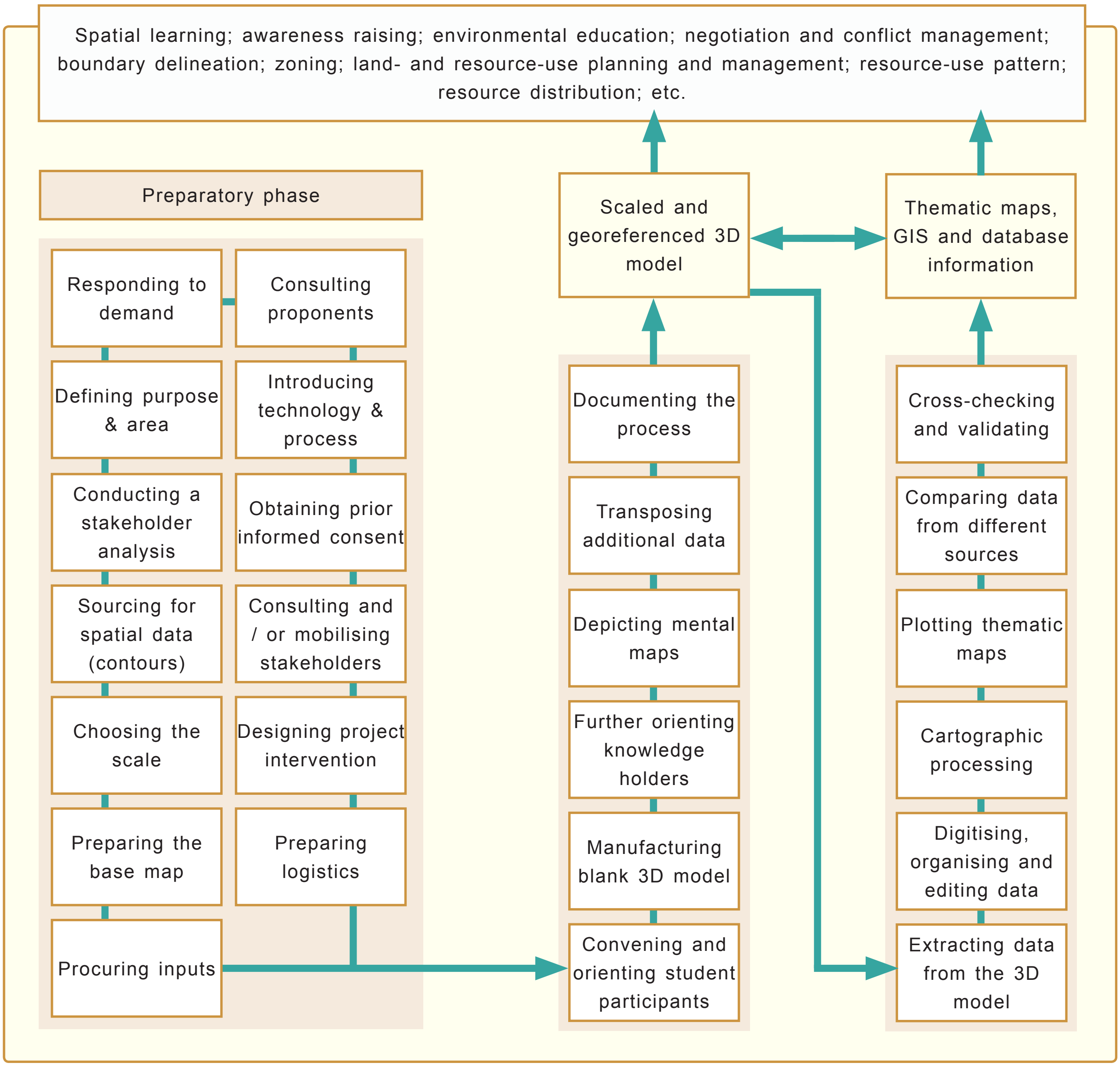


Figure 26. P3DM and its integration with GIS

Phase One: Preparatory Work

Selecting the area

Stakeholders may adopt a variety of criteria to define the geographical scope of the model, depending on the purpose of the exercise. The kinds of criteria may include:

- physical (e.g. topography, watershed, sub-watershed, location of infrastructure, roads);
- administrative (e.g. protected areas, buffer zones);
- environmental (e.g. ecosystems, habitats) ;
- cultural (e.g. ethnicity, ancestral rights, values, customary tenure);
- socio-economic (e.g. settlements with associated resource-use areas, harvesting or grazing areas);
- territorial (e.g. conflicts, disputes, causes and effects).

Stakeholders should identify the area on existing topographic maps using a combination of these criteria. Identifying an area is simpler if the guiding criteria are physical parameters (e.g. watershed) because these are relatively easy to identify. It is more complex to define areas when cultural and societal aspects are the lead selection criteria.

In the case of, for example, a national park, the area of interest may include the core, its buffer zones and its environs of ecological, cultural and economic significance. If the core of a protected area is a mountain, the area of interest should include the downhill catchments and possibly the settlement areas where most resource-dependent communities reside. If the core is a lake or coastal area, all catchments draining into the main water body should be represented. Selecting the geographical coverage is important for the analytical process, during which participants assess causes and effects.

As a general rule, all areas that could be the subject of discussion should be included in the model. This is particularly relevant where the model is meant to serve in defining or negotiating boundaries. This calls for the need to consider the pros and cons (see TABLE 1) of expanding the geographical coverage of the model to include several communities or villages.

Understanding social dynamics

As discussed on PAGE 3, technology intermediaries need to have a thorough understanding of the social dynamics in the area. When interactive processes bring stakeholders having different levels of power and interests together, apparent and latent conflicts often become an issue. Conducting a stakeholders' analysis (more details are provided in APPENDIX 3) and producing a stakeholders' map would be of great advantage. The stakeholder analysis implies doing a preliminary assessment of the different interests at stake and understanding if these embody latent or open conflicts and space for mutual cooperation. Such assessment will guide project implementers in defining the composition of the groups that could best collaborate during the process.

Groundwork at the community level

The next step in the preparatory phase is to introduce the concept of P3DM to the various stakeholders as a method that could help them address selected problems and aspirations. This interaction should lead to a consensus about the use to which the P3DM process is to be put. Particular attention has to be paid to the legal and regulatory environments, which would counter or support changes resulting from the process. Such decisions should lead to the preparation of an agenda that will provide the focus for the P3DM activity. The agenda for the 3D modelling exercise should be tailored to provide a tangible contribution to the overall intervention.

Table 1. Advantages and disadvantages of small and large model

Application	Village model including its traditional natural resource-use zones (Usually at 1:5,000 scale, 1 ha corresponding to 4cm²)	Model including several villages and the respective natural resource-use zones (Usually at 1:10,000 scale, 1 ha corresponding to 1 cm²)
Learning	Detailed but confined to the geographical coverage of the model	Expanded to include areas frequently beyond the usual cognition of the participants
Community cohesion, self-determination	Of limited use for self-determination if used in isolation; aggregating data from models representing adjacent villages that are part of the area of interest may overcome this limitation	Relevant, provided the geographical scope of the model has been chosen on the basis of kinship and cultural affinity
Awareness raising	Effective if causes and effects (e.g. uphill erosion and downhill sedimentation areas) are visible within the geographical scope of the model	Effective if causes and effects (e.g. uphill erosion and downhill sedimentation areas) are visible within the geographical scope of the model
Land-use planning	Allows detailed land-use planning at farm and plot levels.	Best for overall land- and resource-use planning, zoning, etc.
Collaborative research	Allows detailed localisation of resources	Useful for outlining the distribution of resources over larger areas; accommodates quite precise location of point information
Documenting traditional knowledge	Allows knowledge holders to accurately locate their spatial knowledge	Allows knowledge holders to locate their spatial knowledge, but with less accuracy
Protected area management	The use of the model is confined to village-based issues	Useful, provided the model includes a substantial portion of the protected area and its buffer zones
Participatory monitoring and evaluation	Of use mainly by the concerned village	Quite productive, because its geographical coverage is likely to expand beyond the collective cognitive boundaries of the single villages
Conflict management	Useful for dealing with territorial conflicts among villagers; of limited use for negotiating conflicts between neighbouring villages	Useful for dealing with conflicts among adjacent villages
Access to resources	Useful for defining zones within the geographical scope of the model; confines the identification of outer village resource-use boundaries to unilateral decisions	Useful for defining zones within geographical scope of the model; allows for conducting bilateral or multilateral boundary negotiations
Watershed management	Valuable, if the geographical coverage includes pertinent watershed or sub-watershed	Valuable, if the geographical coverage includes pertinent watershed or sub-watershed
Tenure	Useful for discussing both individual and community tenure	Best for defining community tenure (e.g. ancestral domains); the 1:10,000 scale is too small to discuss household tenure
Disaster risk reduction planning	The visualisation of details is extremely important when dealing with location-specific vulnerabilities	Of use when risk reduction planning concerns larger areas (e.g. flood-plains)
Fire management	Useful for village-based fire management	Broadens the scope of fire management to adjacent communities; likely to yield better results
Logistics	Model generally stored at village level; easily accessible to those who produced it	Because of its nature, this type of model is located at most within one village among those depicted. Requires displacement of users for consultation

Obtaining free prior and written informed consent[10]

Although there are many common ethical principles that are shared in different contexts, an operational definition of "free, prior and written informed consent" is not as straightforward as it may seem. Practitioners should be aware of certain questions that arise in the analysis of this concept.

"Free" means that people have a choice to participate. How can this be ensured in practice? What can be done to verify that consent was freely obtained? Who obtains consent? Who gives consent? Could a third party be designated by the community as responsible for obtaining consent?

"Prior" means advanced notice, which is necessary to allow time for deliberation and negotiations. How much time in advance is needed? Clearly understood and flexible schedules are essential for the participatory process.

"Written" means that the process is formally documented. The documentation of consent raises both legal and operational issues, which may vary depending on the project context. Is a written, legally binding document necessary? How can consent be negotiated and documented in an oral society? What if people are reluctant to be pinned down in writing?

"Informed" means open, understandable, two-way communication. What information must be provided? In what form should information disclosure take place? Information and concepts must be communicated in a language understandable to the community. Participants must understand the proposed activities and their relevant rights. Participants must also know and understand both positive and negative outcomes. In addition to discussing the types and purposes of the maps that will be created, it would be useful to review the basics of map reading and assess map literacy to ensure understanding.

"Consent" means general agreement among all members of the community. How is consent given and who gives the consent? How can negotiations maintain trust and legitimacy? How detailed should any statement or agreement be? Consensus should be achieved according to customary laws and practices. This follows the basic rule of "handing over the stick", or giving ownership and control of the process to the participants. However, we should not overlook issues of empowerment and potential exploitation.

While there currently are no standard protocols for FPWIC in participatory mapping, a suggested checklist of elements to be included in the design of FPWIC documentation is presented below. This is not an exhaustive list and FPWIC documentation should be tailored to meet the needs of each project and community. The suggested elements include:

- a statement on the purpose of the proposed project;
- an explanation of the type of maps and data to be produced;
- a description of the methods to be used to collect data and produce the maps;
- a statement on the expected time frame for the project;
- an explanation of the rights of participants, including voluntary participation, confidentiality, etc.;
- an explanation about custodianship of the outputs of the project;
- a description of any reasonably foreseeable risks of the project;
- an explanation of whom to contact for answers to pertinent questions about the project;
- a statement of agreement to participate in the project.

10 Castrence M, Fox J. and Miles W.. 2010. *Free, Prior and Written Informed Consent*. Module M02: Attitudes, Behaviours and Ethics; in "Support the spread of good practice in generating, managing, analysing and communicating spatial information", CTA, The Netherlands.

Preparation of the map legend[11]

Legend development is one of the most important steps in participatory map making. It releases tacit knowledge about the landscape onto a map, which is a primary goal of participatory mapping. The map is anchored in local knowledge, culture and values. By using a systematised coding system, the legend creates a language and reference system which allows people from outside the community to read, interpret, engage with and learn from the map. A map without a good legend is silent and not of much use to anyone.

As discussed in detail on PAGE 36, map symbols serve as a graphic code for storing and retrieving data in a two- or three-dimensional geographic framework. Map symbols should be designed or chosen according to principles of logic and effective intercultural communication.

It is preferable that legend preparation be conducted before the actual mapping exercise. This helps create a structure to the legend and gives the facilitator some idea of the proportion of points, lines and areas that will be required. If there are many types of point features, the facilitator will need a variety of codes (e.g. push pins and map pins for P3DM and graphic symbols for other types of maps). Preparatory work saves time and helps orient the informants and the facilitator; however, more information is elicited when the real map making begins. As participatory data gathering starts, the map legend will typically evolve and/or increase by as much as 30 percent.

Legend preparation is based on oral interviews and focus group discussions with knowledge holders (FIGURE 27). Some knowledge is "tacit", in that people know their territory but they may not have tried to explain it to an outsider before.

You have to practise interviewing for legend elicitation and categorising the information received so that it can be correctly added to the map legend. The key principles are:

- reducing ambiguity of meaning;
- getting at the underlying logic of how the land is perceived by the local community;
- rendering this in an intelligible manner.

Interviewing can be a sensitive activity. In some cultures it is considered rude for a younger person to ask an older person certain questions. Elders who are not used to being asked explicit questions about landscape information may become nervous, confused or irritated. Good legend elicitation requires careful selection of an interviewer. This should be a person who will respect the interviewees, have the right combination of respect, patience and intellectual curiosity and have the ability to get at deeper or hidden meanings and connections.

Figure 27. Legend preparation (Nessuit, Kenya)

Sometimes informants may disagree about terms. With languages that are not written or are only somewhat standardised, it is common for different informants to have different terms or different spellings for a landscape feature. Interviewees also may use dialect variations in describing legend terms. If a meaning is complex, the people working on the legend may need to draw out the distinction between the competing terms. If the two terms seem to be completely equivalent, the facilitator should note this but may want to use only one term on the legend.

Once the initial legend has been developed, the facilitator needs to work with the com-

11 Crawhall, 2010

munity to develop codes for the different features. Again, there may be sensitivities about what colours mean to a community.

One simple example is the colour white:

- In European culture, white is associated with purity, weddings and celebrations.
- In China, white is associated with mourning and loss, while red is associated with weddings and celebrations.
- In Hindu and Buddhist cultures, white is associated with purity (of lay people) and with visiting temples.
- In Gabon, white is used to paint men's ritual masks for secret cult activities.

Green can be associated with ecology or verdure, but this may not make sense in a desert culture. Green is also the colour of Islam. Green eyes are considered deceptive in some cultures and beautiful in others. Green is associated with sickness in some cultures and good luck in others!

In conclusion, do not make assumptions that a facilitator's colour associations are shared by other communities.

Place names (toponyms) are usually written in black on white strips of heavy paper or cardboard. Remember that whoever is going to encode the data at a later stage may need to read these from the photographs of the model. Community researchers may want to do some toponym research in advance and build an electronic database which can be added to later. This is particularly useful when the toponyms are important for understanding ecological characteristics (e.g. water quality, presence of wildlife, flora, caves or subterranean water).

Organising the logistics

Logistical aspects vary from project to project. The more complex the initiative the more demanding are the logistical arrangements. All projects, whether they involve single or multiple communities and ethnic groups scattered over a large area, must handle logistical details for field activities, workshop venues, travel, accommodation and catering for community members and technical staff. Other matters to be arranged include contracts for a venue sufficiently large and possibly with electric power – to allow the manufacture of the model, board and lodging, equipment rental or purchase and procurement and safe storage of supplies including the base maps. Additional staff may be hired and vehicles made available – in short, a variety of logistical arrangements are required for the project to run smoothly. All of these arrangements must be made in a timely fashion, and many must be in place during the earliest stages of the project and before project activities get underway (Chapin, 2010).

Selecting participants and making follow-up arrangements

In an ideal situation, there are two groups of participants who can best contribute to constructing the model. One includes students (from about 10-14 years of age) from local schools who will be responsible for assembling the "blank" model. In doing this, they will learn a lot about topography and local geography. The second category includes representatives of groups having vested interests in the area to be mapped, who are identified by means of the stakeholder analysis as discussed on PAGE 27. These may include indigenous groups, various economic sectors (e.g. farmers, fishers, tour operators), government and non-government organisations and others. Their participation – particularly when dealing with conflicts – may occur at different stages of the process. Each stakeholder group should nominate its representatives. This is best done once all stakeholders have been thoroughly briefed about the method and its strengths, weaknesses, opportunities and threats and after they have agreed to pursue the initiative.

Once the participants have been identified, their participation in the P3DM exercise should be scheduled based on their residence, economic endeavours, cultural affinity or other criteria. The maximum number of participants in one mapping session should

Participation is frequently described as the panacea for all problems, under the assumption that the mere act of people getting together would generate consensus. On the contrary, enlarged participation may surface an increased number of interests, which may in turn ignite new conflicts. An inclusive participatory approach (i.e. the one which brings all relevant stakeholders together) only makes sense during the final stages of a conflict cycle (Leeuwis, 2000).

In this respect, minority groups who are asserting their rights on resources or struggling for the preservation of their cultural identity, may wish to include only those people with similar concerns and aspirations when constructing the model. This group activity then may lead to preparing tailored means of communication (e.g. maps, written documents, photographs, multimedia) to exert pressure on or dialogue with a broader audience or selected institutions at a later stage of the process.

be dictated by the perimeter of the 3D model. In other words, the number of participants should not exceed the number of people who could stand or sit and work on the model at the same time. For example, a model composed of two units (1.2m x 2.4m) can accommodate approximately 25 people working at the same time. Experience has shown that it is best to schedule the participation of groups in shifts each lasting approximately 1 ½ days and to provide a couple of hours of overlap between groups. This will allow newcomers to cross-check and cross-fertilise the work done by the outgoing group. Good practice suggests that a representative from the first group introduces the second group to the task, and so on. This will ensure that the knowledge holders gain increasing ownership of the process. Facilitators should make their best effort to ensure that women[12] and elders are adequately represented.

Gathering geo-coded data

To conduct a P3DM process cost-effectively requires having cheap and easy access to digital contour lines. If that is not possible, they can be digitised from existing maps, but the costs are relatively high. An alternative solution is to enlarge topographic maps by using digital copiers. While this is a cheaper process, it sacrifices accuracy. Additional data that needs to be gathered includes information regarding demography, land use, vegetation cover, resource tenure, the existing regulatory framework and whatever else might be relevant for the facilitators to understand the physical and socio-economic characteristics of the area.

The base map[13]

A matter of scale

In order for a map or 3D model to be most useful, it must accurately show locations, distances and elevations on a given base of convenient size. This means that everything featured on the map or model (e.g. land area, distances, elevation) must be shown in proportion to its actual size. This proportion is the scale of the map (FIGURE 28). Scaling exceptions include symbols like lines and points used to depict things such as roads, rivers and households. All these have to be drawn sufficiently large to be visible.

Figure 28. 1:10,000 scale (reference)

The scale of a map can be defined simply as the relationship between distance on the map and the distance on the ground, expressed as a proportion, or representative ratio.

This "representative ratio" means that 1 cm on a map is equivalent to:

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

12 Women's participation may vary, depending on the cultural background of the participating communities.

13 References on "map reading" are provided in Appendix 2.

- 100 m on the ground at a 1:10,000 scale;
- 50 m on the ground at a 1:5,000 scale.

Why do we need to adjust the planimetric scale?

Maps with smaller scales can accommodate fewer feature classes. Maps with larger scales are more comprehensive and more able to be useful. Considering that P3DM aims to provide a visual aid, the larger[14] the scale the better.

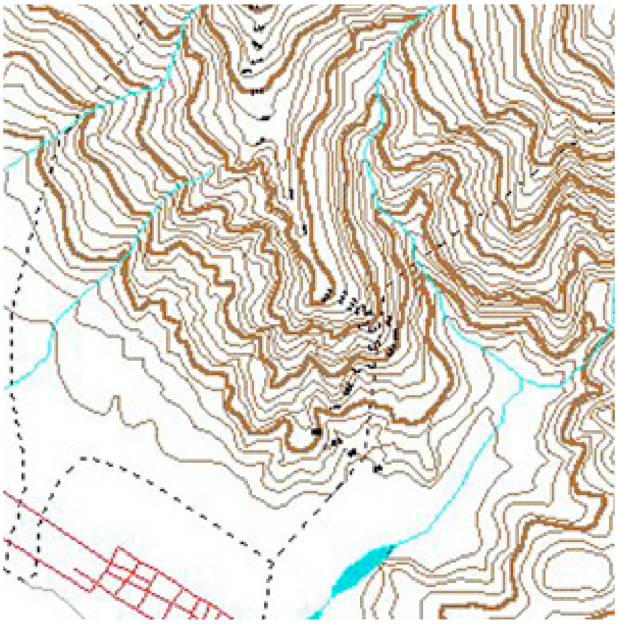
The choice of the scale, and hence the size of the model, should take into account the need for accuracy as well as the need for enough space in which to physically construct and store the model.

The ideal scale for 3D modelling is 1:10,000 or larger. If the reference map is at a 1:50,000 scale, it needs to be re-scaled to 1:10,000, where one centimetre on the model corresponds to 100 metres on the ground; this is a scale that is pretty comfortable for people to locate data.

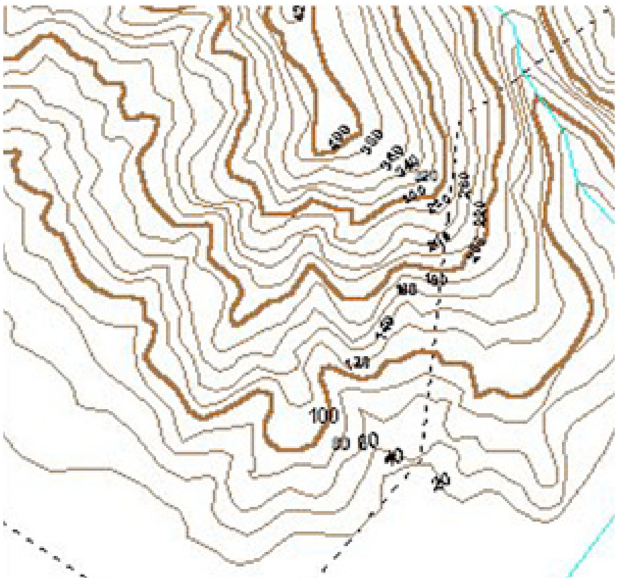
TABLE 2 illustrates the simple arithmetic of rescaling smaller scale maps (e.g. 1:50,000) to larger scale maps (e.g. 1:10,000) and the relationships between the physical dimensions of the model and the represented geographical area.

Several factors influence the options for rescaling. First, concerned stakeholders have to identify and measure the area they want to reproduce. For ease in manufacturing, it is best to select a rectangular shape. Once the area is defined, the next step is to select the scale in which it will be reproduced. The scale should allow the depiction of the desired level of detail on a model of manageable size.

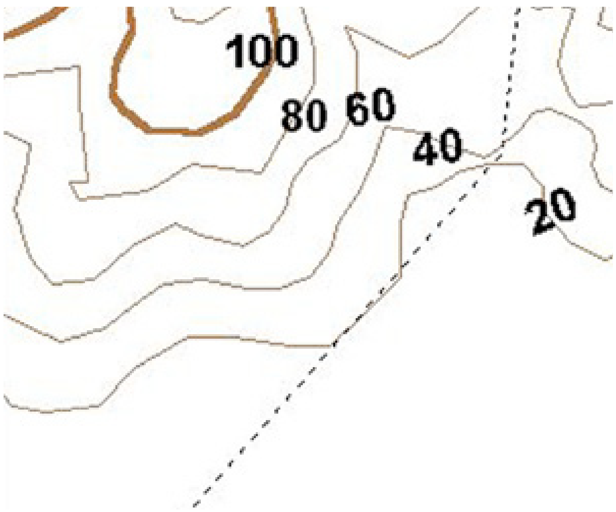
A scale of 1:10,000 is the limit beyond which individuals start having difficulties in locating point data (e.g. their household) with sufficient precision. Larger scales (e.g. 1:5,000) allow for quite accurate location of feature classes. A one-hectare plot would measure 4 cm² at a 1:5,000 scale, which is



1:50,000 scale



1:25,000 scale



1:10,000 scale

14 N.B. 1:10,000 is a larger scale than 1:50,000.

Table 2. Examples of scales

On the reference map		On the 3D model		
Scale	Area (cm x cm)	Selected scale	Resulting size (cm x cm)	Total area represented
1:50,000	48 x 96	1:10,000	240 x 480	576 km^2
1:50,000	40 x 50	1:20,000	100 x 125	450 km^2
1:50,000	40 x 50	1:10,000	200 x 250	450 km^2
1:50,000	40 x 50	1:5,000	400 x 500	450 km^2

a pretty comfortable size in which to depict single plots and associated crops.

The physical size of the model will dictate the time and resources needed for its construction and the space needed for its display and storage. Usually, 3D models are constructed and stored at the same location. The model's dimension should be discussed in advance with the prospective caretaker, which could be the local government, a school or a people's organisation.

For 3D models, scaling has to be applied both horizontally and vertically. The vertical scale (vertical exaggeration) may differ for the purpose of enhancing the perception of slope. Vertical exaggeration is often dictated by the availability of construction materials and contour intervals.

More details on how to select the geographical scope of a 3D model are provided on PAGE 27.

Last but not least, as models become larger, more time is needed for their manufacture and more resources (human and financial) need to be mobilised.

The vertical exaggeration

Vertical exaggeration simply means that the vertical scale is larger than the horizontal scale.

On a 1:10,000-scale 3D map, a 1,000-metre high mountain will be 10 cm tall. To enhance the visual perception of the ruggedness of the landscape or to highlight erosion hazards or accessibility, the vertical scale could be increased, say to 1:5,000.

The concept of vertical scale is closely associated to the contours because these are the lines that join points of equal elevation on the earth's surface. The smaller the scale, the greater will be the interval between contours. A 1:1,000,000-scale map may feature 200-m contour lines, while a 1:10,000-scale map can accommodate up to 4-m contours. What makes the difference is what we discussed before: a small-scale map accommodates less information!

The contour intervals that are shown on maps depend on the technologies used to generate them. The closer the intervals, the more accurate the process has to be.

Considering the scope of this handbook, the discussion will be limited to how to choose the contour interval when manufacturing a scaled 3D model.

What contour intervals should we use?

Assuming a 1:10,000 scale (horizontal and vertical), decide what contour interval to use.

Generally, 1:50,000-scale reference maps feature 20-m contours, which conveniently may be applied to a 1:10,000 model.

If you intend to produce the 3D model of an island which has, for example, the lowest elevation (seabed) at -40 m, and the highest (mountain peak) at 2,400 m above sea level, you would need 122 layers to reproduce a difference in elevation of 2,440 metres using 20 m contours [(2,440/20)=122]. This would involve a work group of 12 people to trace, cut and paste approximately 15 layers

Table 3. Three-dimensional mapping variables

Difference in elevation between the lowest and highest point (metres)	Contour intervals (metres)	Scale of the 3D model	Vertical exaggeration	Thickness of the layer representing the contour interval	Number of contour intervals (layers)	Height of the peak on the model (cm)
1800	20	1:10,000	1.0 X	2 mm	90	18.0
1800	20	1:10,000	1.5 X	3 mm	90	27.0
1800	20	1:10,000	2.0 X	4 mm	90	36.0
1800	40	1:10,000	1.0 X	4 mm	45	18.0
1800	40	1:10,000	1.5 X	4 mm	45	27.0

per day, and would take about seven or eight days to complete.

But if you use 40-metre contour intervals, you would be able to prepare and assemble 61 layers [(2,440/40)=61] in three or four days.

TABLE 3 illustrates the impact of varying selected variables (i.e. vertical exaggeration and the thickness of the material used to construct the model) on the workload (i.e. the number of layers to cut) and the actual height of the highest peak on the model.

Often, the availability of the materials used to construct a model dictates which vertical exaggeration to apply. In some countries, for instance, single-wall corrugated carton board is available only in 3 mm and 4 mm thickness as detailed in APPENDIX 8. The use of EVA offers more flexibility in this context.

Preparing a customised base map

GIS technology has become a standard for storing and manipulating georeferenced information. It plays an important – although not central – role in constructing a P3DM and in converting local spatial knowledge into a mobile, negotiable format. For further discussion of this topic, please refer to PAGE 11.

Once scale, size and contour intervals have been defined, a customised topographic map, or base map, has to be generated. The Terms of Reference for preparing a base map should include the desired scale, contour interval and grid. Elevation labels should be inserted along contour lines. Contour lines should be drawn in a sequence of at least five different colours to facilitate the work of the tracers as discussed on PAGE 40. More details on preparing a base map are found in APPENDIX 4. It is necessary to prepare at least two copies of the map.

What to do in the absence of digital contour lines

In some countries, digital topographic information at scales greater than 1:50,000 is hardly available to the public, either because it does not exist or because it is treated as confidential for national security reasons. Nonetheless, access to this type of data has been rapidly increasing because of the recent diffusion of online databases offering free digital elevation model (DEM) data and because of access to free or low-cost remote-sensed imagery. However, acquisition of digital data at sufficiently large scales may still be a challenge in many developing countries. For this reason, a common technique used by practitioners in southeast Asia for preparing base maps consists of blowing up 1:50,000-scale topographic maps – usually available on the open market – to the desired scale with the use of digital copiers. To ease work at the village level and to remove information that could bias[15] participants, these enlarged maps are transferred to tracing pa-

15 Typically, cartographic data that have some bearing on the way people would depict or describe their cognition include boundaries and borders.

per. This adds to the workload, but favours quality and precision.

The Quick Reference Guide

P3DM can generate scaled and georeferenced data. The fact that 3D models display the vertical dimension definitely helps informants identify landmarks and organise data spatially. Field experience has shown that scale translations between the real world and a map, or vice versa, are difficult. While the presence of the vertical dimension does facilitate locating point and line data, blatant inaccuracy may occur in sizing areas.

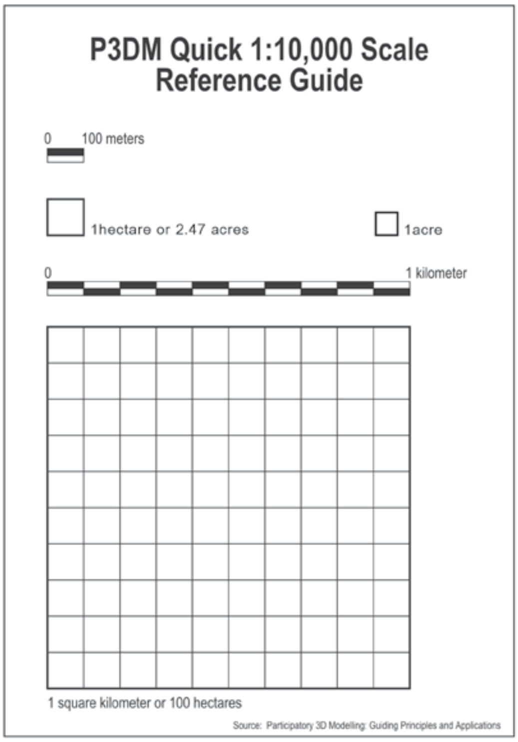


Figure 29. Example of 1:10,000 Quick Reference Guide

As an example, farmers delineating the boundary of a woodlot of 3 ha (3 cm^2 on a 1:10,000-scale model) may erroneously portray it larger (e.g. as a 25-hectare, or 25 cm^2, plot). In fact, the natural tendency of informants would be to size an item according to perceived importance rather than to its scaled dimensions.

While perceptions are of paramount importance, P3DM is meant to support the generation of georeferenced and scaled qualitative and quantitative data. Therefore, people's perceptions and values may be better recorded by choosing a particular colour or symbol or simply by noting them as part of the process documentation.

The "Quick Reference Guide" has proved to be a useful tool when estimating distances and areas.

It is recommended that *ad hoc* quick reference guides be distributed to informants. Measurement units in use (e.g. hectares, acres) vary from country to country and frequently also within a particular country. Quick reference guides should match the system in use. A sample is found in APPENDIX 5.

Procuring materials

One of the most critical tasks in manufacturing a 3D model is procuring the needed materials. APPENDIX 6 provides a sample inventory of materials needed for manufacturing one model. Various map symbols should be available in sufficient quantity to accommodate the many variables that participants may want to record on the model. Different coloured map pins of various shapes, a rich array of water-based colours and matching yarns are vital to the exercise (FIGURE 30 and FIGURE 46). Supplies have to be procured well in advance of the mapping exercise and delivered on site at the users' earliest convenience. Storing the supplies in a safe place is strongly recommended.

Map symbols

Map symbols and their categories (i.e. points, lines and polygons) serve as a graphic code for storing and retrieving data. Models and derived maps generally include a combination of all three. These categories can be further differentiated – particularly on maps – by variations in colour, grey-tone value, texture, orientation, shape and size (Monmonier, 1996).

When using colour to characterise areas, decoding is made simpler when darker means "more" and lighter means "less". Colour conventions allow map symbols to exploit idealised associations of water with blue and forested areas with green. This implies that dense primary forest is dark green, secondary forest is mid-green and grassland is light green, and that deep waters are dark blue and shallow waters are light blue (Monmonier, 1996).

Size is well-suited to show differences in quantity and variations in grey tone are preferred to distinguish differences in rate or intensity. Symbols varying in orientation are useful mostly for representing directional occurrences like winds or migration streams. Line symbols best portray watercourses, roads, trails and boundaries and they may integrate additional variables like colour and size (thickness). A heavy line suggests greater capacity or heavier traffic than a thin line (Monmonier, 1996).

Each symbol should be easily discernible from all others to clearly distinguish different feature classes and provide a sense of graphic hierarchy. A poor match between the data and the visual variables may frustrate and confuse the map user.

While choosing symbols for two-dimensional maps is limited only by imagination and logic, selecting symbols in 3D modelling frequently depends on the availability of materials, particularly push and map pins that generally represent point features. Colour-coded yarns and different colour paints can easily represent lines and polygons.

As discussed on PAGE 30, it is important to pay attention to the significance of colour in a given socio-cultural context. Once cultural implications have been considered, standardised symbols allow users to unambiguously recognise features. Standardisation within diversification[16] also promotes efficiency in exchanging and comparing data and in producing and using 3D models and derived maps. Sometimes 3D models are manufactured at separate locations and assembled later. In these cases, it is essential to use codes consistently. Maps or models that share a common graphic vocabulary are definitely more powerful in conveying the intended message and are easier to decode. APPENDIX 7 provides a draft guideline for coding data on participatory 3D models.

Figure 30. The range of coding items

In obtaining materials, the quantity and shape of pins and other items should be related to the quantity of features that needs to be depicted. For example, be aware of the approximate number of households in the area. This will guide you in determining, for example, the number of white bullet-headed pins required. In the same area, you may expect to find a certain number of schools and day care centres. Make sure that you have enough colour-coded pins to identify these two items independently.

It is best therefore to make first an assessment of the features that may be encountered in the area of interest before purchasing materials. This is done by drafting a preliminary map legend as discussed on PAGE 30. The legend will be revised during the conduct of the mapping exercise to accommodate additional features and to fine-tune the definitions of single items. The draft legend will

16 Standardisation of symbols and terms should not be imposed by outsiders but should be agreed upon by the participating community members. Standardisation of symbols and terms in a participatory context does not conform to international data standards. If imposed in a participatory context, such standards would suffocate genuine participation and free expression.

Table 4. Features and the means to code and display them

Feature classes	Features	Displayed by means of
Points	Water points (springs and waterfalls); mountain peaks; social infrastructures (municipal/district halls, administrative centres, day-care centres, schools, rural health centres, hospitals, bus stops); cultural places (religious sites, burial caves, cemeteries, sacred sites, etc.); tourist establishments; human settlements (households); scenic spots, diving spots; docking sites and others	Map and push pins of diverse colours, shapes and sizes
Lines (also perimeters)	Watercourses (rivers and canals); communication ways (roads, bridges, trails); rural water supplies, boundaries and perimeters (e.g. protected areas, ancestral domains, areas where destructive methods are employed, fish breeding and spawning areas, fishing grounds, features of the seabed like coral reefs differentiated into "intact" and "damaged", seaweed areas); coordinates (grid)	Yarns of different colours
Polygons	Water bodies (lakes, sea); land uses (rice fields, vegetable gardens, sugar cane, orchards, reforestation sites, residential areas, resettlement areas, etc.); land covers (forest, grassland, mangrove, etc.); landslides and bare land; and others	Acrylic paint in different colours
Attributes	Names, annotations	Text on labels

serve as a guide for compiling the procurement list.

Construction materials

Makers of 3D maps have used a variety of materials including plywood, corrugated or solid carton board, polystyrene sheets and foam mats. Corrugated carton board should be used in custom-cut sheets of single-wall corrugated carton – inner and outer liner and flute 180 g/m^2. To know more on the topic, please refer to APPENDIX 8. Solid carton board is a good alternative because it is strong and durable and is available in a relatively wide assortment of thicknesses. Its relative disadvantages are its higher cost and weight. Also, because of its firmness, the board has to be cut with coping saws. Non-scaled 3D models are frequently made with soil, sand, concrete, sawdust, papier-mâché and other materials.

It is also possible to use foam sheeting (see FIGURE 31) (i.e. expanded EVA/PE closed cell foam or sponge – usually a blend of ethylene vinyl acetate [EVA] copolymer and polyethylene [PE]) which is cut, assembled and covered with epoxy paint or paper cut-outs. The sponge is a lightweight foam material which has a smooth surface and does not absorb water. Generally EVA sheeting is priced competitively with other blown materials and is available in different densities, thicknesses and colours. It is one of the materials most popularly known as expanded rubber or foam rubber sheeting. It is used to produce mouse pads, flip flops and sports mats. Three-dimensional models made out of this material are well-suited for humid tropical environments where carton board would deteriorate rapidly.

Figure 31. Participants cutting out layers of EVA/PE foam sheets to manufacture a 3D model in Nepal. Image courtesy Ms. Apoorva© ENRAP/IDRC

Making a 3D model with expanded EVA/PE closed cell foam sheets is slightly more costly than using carton board and produces non-biodegradable debris, but it ensures a more durable output and a consistent vertical scale/exaggeration. The assembly process remains unchanged (materials do vary).

For ease of reference, the remainder of this document refers to using carton board, although expanded EVA/PE closed cell foam sheets could be used instead.

Phase Two: Assembling the Model

Orienting participants

Orienting participants to the mechanics of construction (FIGURE 32) should include some information about map reading (APPENDIX 2) and the materials being used. For example, “We are going to use a three-millimetre thick carton board for each layer because – at a 1.5 vertical exaggeration – 3 mm represents a 20-metre contour interval or a 20-metre difference in altitude”.

Figure 32. Prepare visual aids to support your presentation

Organising work

To assemble a 3D model, divide participants (usually students) into four working groups as shown in TABLE 5, coached by facilitators. In three days, a team of 20 students guided by three facilitators can construct a blank 1:10,000-scale model that measures five square metres (500 km² on the ground) and involves cutting approximately 60 layers.

The base table

It is necessary to have one solid, purposely-constructed wooden table, 60-70 cm high, which exactly matches the size of the base map. The table top should be reinforced (FIGURE 33) to avoid bending while the wet carton board and papier-mâché are drying.

Figure 33. Details of the base table

Table 5. Work groups & facilitators

Working group	Assemblers	Tracers	Cutters	Gluers
No. of participants	3	4	4	4
Facilitators		1	1	1

One side of the base table should measure less than 1.8 m, to allow easy access to otherwise hard-to-reach sections. It may sometimes be easier to work on two or more units and join them on completion of the exercise.

Assembling the base maps

Prepare two copies of the base map ahead of the exercise, usually in A 0 continuous format. These need to be composed to match the size of the base table. In doing this pay careful attention to joining the sheets correctly (FIGURE 34). Use the existing grid as a reference.

> Base table, base map, carton board and carbon paper should all be exactly the same dimensions.

Figure 34. Map makers at work

After completing this exercise, glue one map on top of the table. Bond the second one to a large carbon paper purposely assembled (FIGURE 35) with staples and some adhesive tape.

Figure 35. The carbon paper is assembled

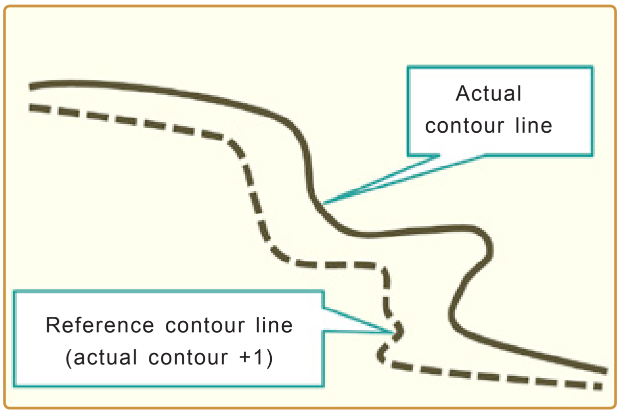
Tracing, cutting and pasting

The first group, "the Assemblers", prepares carton sheets, exactly corresponding to the size of the wooden table and base map. In a well-organised exercise, the carton board should have been cut to the desired size at the factory.

A second group, "the Tracers", fastens a second base map with carton boards, one at a time, by using binder clips as shown in FIGURE 36.

Figure 36. Tracing sandwich

They select one corner of the map as a reference. They begin by identifying and tracing the lowest elevation contour (please refer to APPENDIX 4) on the map with a pencil and then



mechanically transferring the outline to the carton board.

After tracing the selected contour line with a plain line, tracers should use a dotted line to trace the next one (identifying a higher elevation) on the same carton board. The first contour serves as a guide for cutting, and the second contour serves as a reference for pasting the succeeding contour layer.

Once the first contour is traced, the carton board is handed over to the third group, "the Cutters", who cut out the layer using scissors, cutters or coping saws. Each elevation contour is traced on a separate carton board (FIGURE 37) and cut out independently (FIGURE 38).

Figure 37. Each contour line is traced on a separate carton board

Figure 38. Contour layers are cut

For clear identification, each layer is marked with a directional arrow indicating the North and an annotation about the elevation.

The fourth group, "the Gluers", pastes the carton layer on top of the previous layer (see FIGURE 39), making sure that it matches the reference contour.

The various layers are then consolidated with crêpe paper and water-based glue (FIGURE 40). A strong and resistant papier-mâché can be constructed from small squares of crêpe paper measuring approximately 5 x 5 cm.

Figure 39. The single layer is pasted

Figure 40. Layers are consolidated

Figure 41. Different elevation contours are traced sequentially

Figure 42. A complete hill is joined to the model

The higher the elevation, the more segmented each layer will be, particularly when reproducing mountain areas. It may be desirable to independently assemble the selected portions of the model, as shown in FIGURE 41 and FIGURE 42, depending on the complexity and segmentation of the layers.

The "blank" 3D model

The outcome of the first phase is a scale 3D model that follows the bare contours of the landscape (FIGURE 43).

Figure 43. The "blank"

In the process of assembling the model, the participants learn about scaling, contour intervals, slopes, gradients and other cartographic concepts. Already, the blank model provides a bird's-eye view of the area.

The subsequent phases progressively enrich the model with georeferenced information, most of which reflects the mental maps of community informants.

Phase Three: Depicting Information

Composing people's knowledge

Once the basic 3D model is completed (see FIGURE 44), key informants work on it for a period of time, depending on its size and complexity and the number of participants.

Figure 44. Residents of Ovalau Island in Fiji familiarise with the blank model

The venue should not be overcrowded. A model measuring 2.4 m x 1.6 m can accommodate approximately 20-25 participants at a time. If 100 informants have been invited, they should be convened in groups, as discussed on PAGE 31. The exercise should last for five to six days. Informants' sessions should overlap to encourage cross-checking of depicted data.

Orienting key informants and updating the legend

When the group is standing close to the blank model, it is a good time to explain the process of depicting mental maps on the model and to remind participants of the importance of using the map legend in choosing colours and symbols. This is a good opportunity to invite the participants to revise the legend (FIGURE 45) and to ensure that all understand its definitions and associated symbols. *Primary forest* is a term that may have a different meaning for a scientist than

Figure 45. The legend is updated

for a farmer, or it might mean nothing at all. Establish common ground and understanding. It helps to use local definitions for "land use" and "land cover" and to use vernacular translations.

Who decides on what is important?

A 3D model is meant to distinguish the territory with the use of coded polygons, lines and points. Each feature needs to be identified, defined and associated to a particular symbol. All these symbols and their descriptions are summarised in the form of a map key or legend, which is the graphic vocabulary that allows users to decode and interpret displayed data. The preparation of the legend, particularly the listing and description of the different items, is a key factor that determines the usefulness of the model as a means of communication and the final intellectual ownership of the output.

While for practical reasons it is important to prepare a draft legend ahead of the event, it is even more important to solicit its thorough revision during the course of the exercise.

In updating the legend, the features to be depicted should be matched with available symbols (e.g. push pins, yarn and water-based paint).

Depicting mental maps

Maps and models elicit strong alignment effects and can be confusing if improperly oriented (May 1995). A model needs to be oriented North-South with a compass.

Arrange and display all the codes (FIGURE 46), and make sure that each one is clearly associated with the real-world feature it represents. Prepare several copies of the legend to be distributed among the participants.

Humans tend to relate to maps better if the maps are aligned with the environment they represent. A correct alignment (or orientation) allows for maps (and 3D models) to be interpreted more rapidly and accurately.

Figure 46. Coding means are displayed

Recall that humans organise spatial knowledge by initially looking for landmarks, then by establishing links among them and finally by developing a broader, encompassing understanding of landforms. For more details, please refer to PAGE 5. Invite informants to locate and name in sequential order the mountain peaks, islets, water courses, roads, trails, social infrastructure and other features they use to orient themselves when moving around within their domains (FIGURE 47).

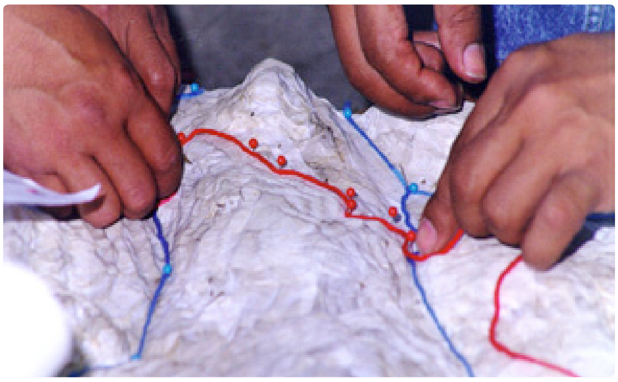


Figure 47. Landmarks are identified

This is a critical process that follows human's inborn orientation and learning mechanisms and allows participants to progressively deepen their grasp of their whereabouts in relation to the model. Informants should be invited to use colour-coded yarns to delineate vegetation types, land use and other relevant features (FIGURE 48).

Informants should initially use yarn and dress maker's pins to identify areas instead of immediately painting or drawing; this allows them to negotiate the distribution, location and extent of any particular feature. During this process, the facilitators should call attention to the scale of the model, which is best done by using the Quick Reference Guide, as discussed on PAGE 36. Water-based colours (FIGURE 49) should be applied only once informants have agreed upon the location and extent of single features.

Figure 48. Land uses and land cover are identified

After the paint has dried, invite participants to locate point data and their descriptions with colour-coded push pins and paper tags (FIGURE 50).

Figure 49. Water-based colours are applied after validation

This process calls for the concurrent participation of groups of people from neighbouring locations for cross-fertilisation of information and data validation.

Figure 50. Point data are located with the use of colour-coded pins

During the process, participants may add new features to the legend. Select the appropriate colour code and medium (pin, yarn or paint) and add the definition and corresponding symbols to the legend.

Figure 51. Group dynamics are enhanced

The use of a well-articulated coding system allows 3D models to serve as rudimentary community-based GIS, accommodating overlapping layers of information and facilitating analysis of spatially defined data.

Placing the grid

For a 1:10,000-scale model, it is advisable to use a 10 cm-interval grid. Each resulting square corresponds to 100 hectares or one square kilometre.

The grid should be placed on the model to match the grid on the base map. A strong, fine yellow thread may be used to intertwine the grid above the model (see FIGURE 52).

To ensure correct positioning, measure the intervals starting always from the same corner (i.e. the reference corner, see FIGURE 53),

Figure 52. The grid is intertwined

and proceed as shown in FIGURE 54. The grid should form – as far as possible – a horizontal plane above the model by eventually fitting a wooden frame at the edges of the model.

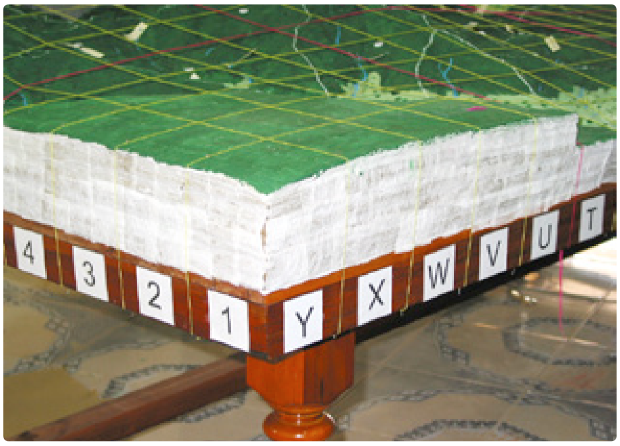


Figure 53. The grid is placed with the use of letter/ figure coordinates

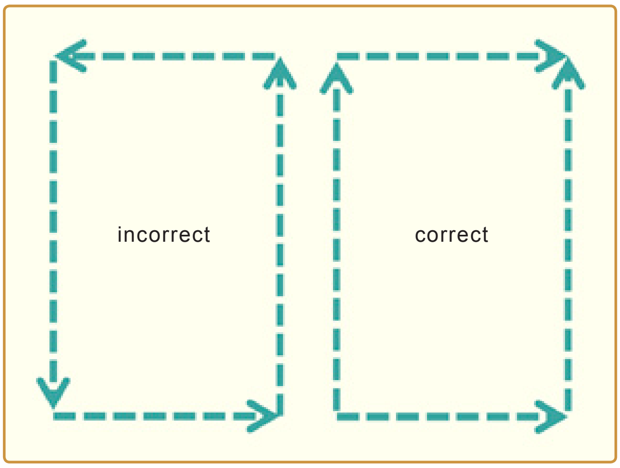


Figure 54. Path for marking intervals

Additional data

Once the grid is in place (FIGURE 55), additional data obtained from a range of sources may be added. Boundaries and borders are cases in point:

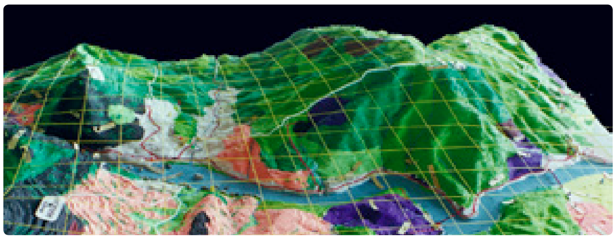


Figure 55. Model with a 10-cm grid

Figure 56. Boundary negotiation in the Cordillera, Philippines, 2001. Image courtesy Dave de Vera, PAFID.

Boundaries

Resource distribution, tenure and access are focal issues when it comes to management of natural and cultural resources. They are all spatially defined. Among many societies in developing countries where common property is still in use, the concepts of boundaries may be fuzzy because they may be overlapping, seasonal, blurred or vary according to gender, age or other local conventions and traditions.

In Western terms, boundaries are usually indicated by lines which represent the borders of political entities or legal jurisdictions. In some cases (e.g. protected areas, logging concessions, mining operations, etc.), boundaries may have been set without undergoing consultative processes. Adding them to a 3D model may help broaden the basis for negotiation by making sources of conflicts visible, hence setting the basis to address them (FIGURE 56).

To add "official" boundaries to a model, one has to establish a spatial relationship between a reference map (i.e. repository of the data) and the 3D model. This is done by super-imposing a georeferenced grid on top of the model.

Adding boundary lines on maps is a delicate exercise. Boundaries usually define the borderline between being allowed and being restricted from doing or owning something. Boundaries are frequently sources of territorial disputes. How many wars have been fought over lines drawn on maps?

When facilitating a participatory mapping exercise, it is recommended to refrain from inviting participants to outline dividing lines – except if boundary disputes are at stake and need to be visualised to start a negotiation. If some participants would like to visualise boundaries, facilitators should carefully monitor the process because this could lead to unexpected heated discussions with participants standing for neighbouring communities. The use of colour-coded yarns in lieu of permanent marker pens is strongly recommended. Yarns can be placed on the model, moved and removed and thus do not represent a permanent trait which could be perceived as the legitimisation of a claim.

Transposing data

Latitude and longitude coordinates of the boundary corners are identified on the reference map (FIGURE 57) by making use of its corresponding grid and transcribing it to the 3D model (FIGURE 58).

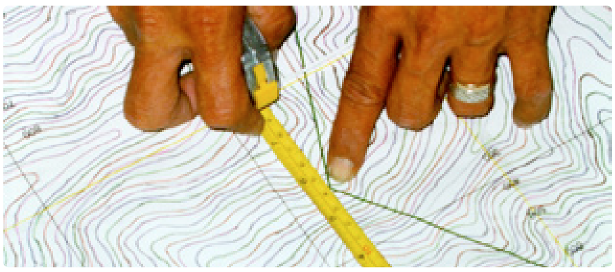


Figure 57. Coordinates are identified on the base map

Figure 58. Coordinates are replicated on the 3D model

Each corner is then connected to the next using a coloured yarn (FIGURE 58).

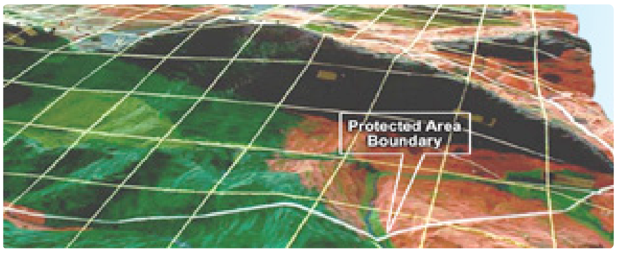


Figure 59. Model with visible protected area boundary

At the end of this exercise, the boundary is visible to everyone (FIGURE 59).

Finishing touches

Figure 60. Embedded elements of the map key

The prerequisite of a 3D model is that everyone should understand it.

Therefore, once the model is complete, finalise and lay out the legend which should include both the numerical (e.g. 1:10,000) and graphic versions of its scale. Additional necessary attributes are a North-labelled arrow and an acknowledgement plate (see APPENDIX 9). Do not forget to credit those who input data on the model and the date at which the model was last updated. The legend is best colour-printed, plastic-laminated and embedded into the model (FIGURE 60).

Phase Four: Handing Over the Model

A handing-over ceremony formally transfers ownership of the model to the custodian nominated by the participating communities.

Unlike other spatial tools, a 3D model is never completed. Like a living organism, it needs to be nurtured by regularly updating and enriching its information.

The model has to be entrusted to an entity with the means and the commitment to safeguard and maintain it, and which will make it accessible to those who would like to use, update, integrate or correct previously input data. 3D models ensure that accurate, meaningful-to-all information is kept among the people who generated it.

Gathering dust?

I came across some comments stating that some 3D models were "gathering dust" in a corner of a village without being used.

A 3D model is like a book. How many times do we read the same book? What happens to it after use?

It is shelved and gathers dust until we need it and get back to it.

3D models are like books, handwritten notes, picture libraries, maps or even digital files on hard disks. All these are data repositories and are consulted when the need arises.

What is essential is to be able to decode the displayed graphic vocabulary. This is the reason that acknowledgements are important – to know the source of the data, legend, ratio scales, directional arrow and date in order to allow users to decode and interpret the displayed information and place it in clearly-identifiable, socio-cultural, geographic and historic contexts.

Representatives of concerned stakeholders should be present at the handing-over ceremony.

For the purpose of monitoring, the custodians of the model should keep a visitors' book in which visitors are asked to record their contact details, purpose of visit and comments.

Phase Five: Extracting and Digitising Data from a 3D Model[17]

Once the model is completed, data can be extracted and entered into a GIS. While transferring from one medium to the other, the main concern should be minimising data loss or erroneous georeferencing.

Those who will be extracting the data should familiarise themselves with the model as annotated in the process documentation and in the map legend.

Extracting the data with digital photography

In order to capture the model with fewer shots, the camera has to be placed at a sufficient distance from the model. This requires moving the camera at the set distance to capture the model in sections. The model is tilted by 90 degrees (FIGURE 61) to allow photographs to be shot perpendicularly to its surface.

To reduce radial and relief displacements, parallel camera movement shooting is recommended for models that cannot be captured in one shot. This technique is described below.

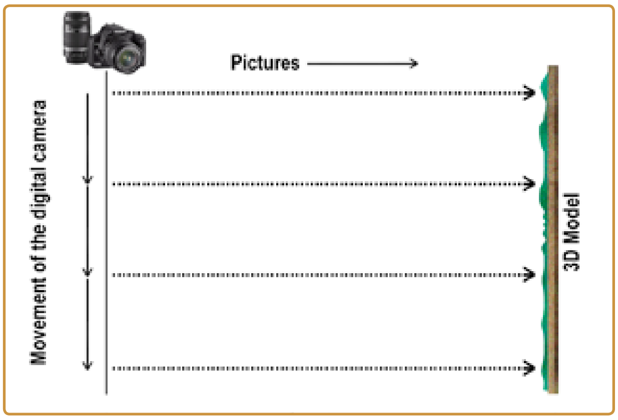


Figure 62. Parallel camera movement

Figure 61. The model is tilted by 90 degrees

Draw lines on the floor perpendicularly to the model's horizontal plane at selected intervals (FIGURE 62). Draw a reference line at the end of the orthogonal lines to serve as a guide in moving the camera from one position to the next. Use a plumb line to position the camera exactly above the intersection of the orthogonal and reference lines (FIGURE 63).

Figure 63. Lines on the ground guide the photographer

Place a high-resolution digital camera (preferably a single-lens reflex (SLR) with a man-

17 Rambaldi and Verplanke, 2010

ually adjustable zoom lens) set to mid-range zoom[18] on a tripod at a 4 metre distance[19] from the base of the tilted model (FIGURE 63).

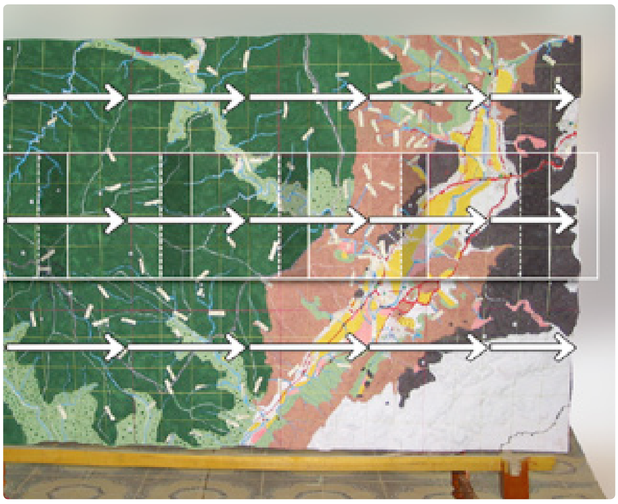


Figure 64. Sequential high resolution pictures are taken

Any mainstream digital camera provides sufficient image resolution (i.e. > 6 megapixels).

The camera needs to be set to capture images at its maximum resolution. The flash should be turned off. Pictures should be shot in diffused daylight. Avoid taking pictures under direct sunshine or fluorescent tube light illumination as these either intensify contrast or alter colour patterns.

Select the height of the camera above ground, which has to be constant throughout the first passage. Make sure that the camera is perpendicular to the model, and that there is at least 60 percent overlap between the images taken (FIGURE 64 and FIGURE 65)

Figure 65. Shooting sequence

The number of pictures needed to capture the entire model may vary, depending on the size of the model and the camera used. As an example, approximately eight photographs are needed to capture the details of a model (1:10,000 scale) measuring 2.4 m x 1.2 m when capturing sections of 75 cm x 100 cm with sufficient image overlap (FIGURE 66).

The photographs taken are "raster[20] images" saved in either TIFF (recommended) or JPG/JPEG format. No ortho-rectification will be necessary, provided that images were shot at a sufficient distance and perpendicularly to the model plane.

After georeferencing, the images can be converted to vector[21] format through on-screen digitising.

Figure 66. Picture sequence

18 If the camera has 10x zoom, it should be set at 5x zoom to remove lens distortion.

19 Four metres at a 1:10,000 scale correspond to 40,000 metres - in other words, the model landscape if recorded from a virtual altitude of 40 km. This definitely reduces radial displacement, due to relief, to a minimum.

20 A raster image file is generally defined as a rectangular array of regularly sampled values, known as pixels. Each pixel (picture element) has one or more numbers associated with it, generally specifying a colour in which the pixel should be displayed.

21 A vector image is generated through a sequence of commands or mathematical statements that place lines and shapes in a given two-dimensional or three-dimensional space.

Georeferencing photographs

Georeferencing is about establishing the correct position of an image on the world's surface using a predetermined coordinate system.

Preparing for on-screen digitising

It is not necessary to scan maps or photos if digital images of the 3D model are available. These photos can be opened as raster images in a GIS. Most importantly, the photos must be provided with geographic coordinates. This can be done by georeferencing these in a GIS. Once the different features (i.e. legend items) of the 3D model are digitised, the derived data sets can be added to a geo-database containing other GIS data (e.g. digital versions of the base map of the model).

Images taken from 3D models, aerial photography and satellite imagery will not align properly with other data until they are georeferenced. Thus, to use the photographs that have been taken of the 3D model in conjunction with other spatial data, it may be necessary to align, or georeference, them to a map coordinate system. A map coordinate system is defined using a map projection, a method by which the curved surface of the earth is portrayed on a flat surface. In the case of P3DM, it is necessary to refer to the map projection of the base map used to manufacture the model.

When georeferencing a raster dataset, it is important to define its location using map coordinates and to assign the coordinate system of the data frame. Georeferencing raster data allows it to be viewed, queried and analysed with other geographic data.

To georeference an image, establish control points, input the known geographic coordinates of these control points, choose the coordinate system and other projection parameters and then minimise residuals. Residuals are the difference between the actual coordinates of the control points and the coordinates predicted by the geographic model created using the control points. They provide a method for determining the level of accuracy of the georeferencing process.

Georeferencing procedure

Establish control points from the base map of the model. At least four points (corners) with known coordinates should be marked on the map. Because the 3D model is based on a north-oriented map (using GIS software such as QGIS[22]), it is a straightforward process to georeference the image based on control points. When the map grid is placed on the model, the coordinates of four grid intersections at the corners and one in the middle will probably offer accurate georeferences. Because the coordinates of the grid intersections are known from the model base map, this should be a straightforward exercise. The procedure is as follows:

- Write down the x, y coordinates of each point (see FIGURE 67). Open/import an existing raster layer (photo) into the GIS program. Use the software's georeferencing tools to select and add control points.
- Click the mouse pointer over a corner point on the raster layer for which the x and y coordinates are known (FIGURE 68).
- After at least four points are added, evaluate the transformation. In most GIS software, the "residual" error for each point and the "RMS" (Root Mean Square) error can be examined.
- In an ideal situation, the RMS error should not be greater than 1 pixel (FIGURE 69).
- The actual procedure for georeferencing is different for each software package.
- The software help function should be checked for guidance in this process.
- Once the single images have been properly georeferenced, they can be "glued" or "stitched" together to represent the entire model.

22 GRASS and ILWIS are other open source GIS software packages which can be used for the same purpose. ArcGIS is a commercial solution – in most cases too elaborate or expensive for grassroots practitioners.

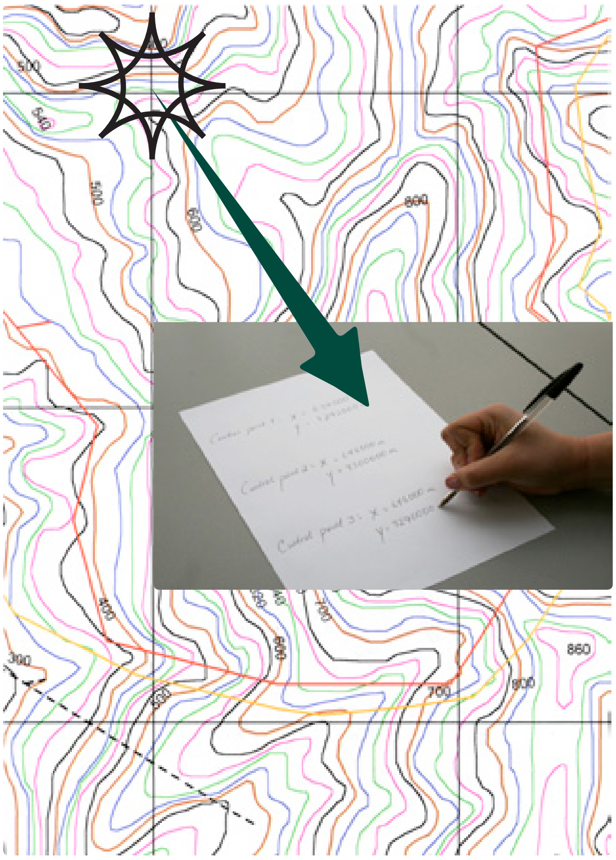


Figure 67. Control point coordinates are recoded from the base map

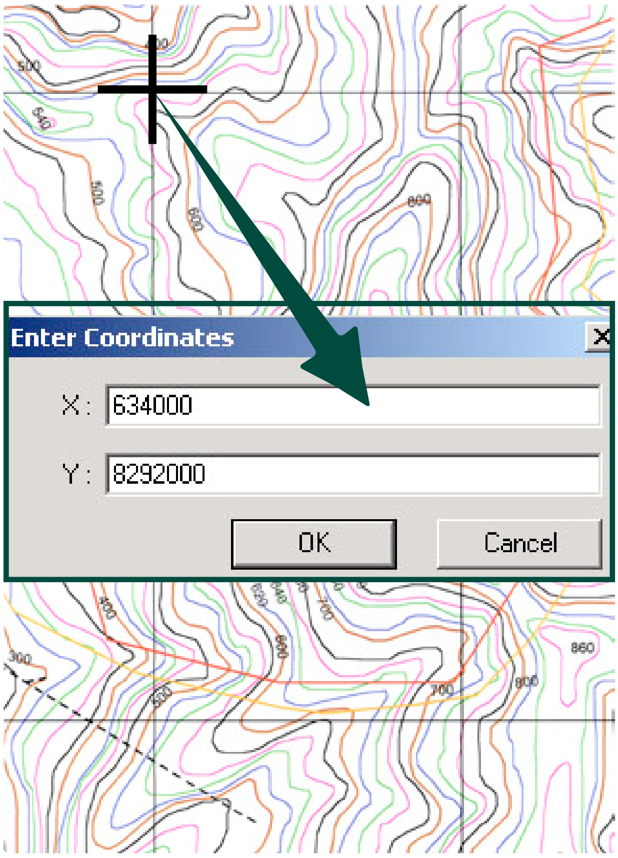
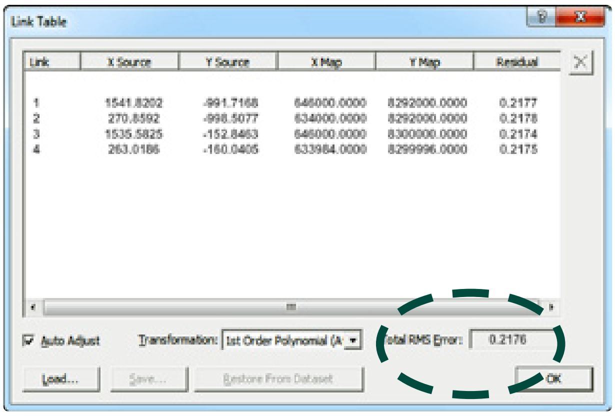


Figure 68. Coordinates of selected control points are added into the GIS

The output of this process is a georeferenced raster image which is ready for onscreen digitising.



Link Table

Link	X Source	Y Source	X Map	Y Map	Residual
1	1541.8202	-991.7168	646000.0000	8292000.0000	0.2177
2	270.8592	-998.5077	634000.0000	8292000.0000	0.2178
3	1535.5825	-152.8463	646000.0000	8300000.0000	0.2174
4	263.0186	-160.0405	633984.0000	8299996.0000	0.2175

Figure 69. Residual errors of control points resulting in an RMS error smaller than 1 pixel

On-screen digitising

Manual on-screen digitising (FIGURE 70) with a mouse cursor on the computer screen is currently the most practised method. In principle, digitising can be done in any image and photo-editing software; however, it is essential to use GIS software (e.g. QGIS, ILWIS, ArcGIS) to derive a geographically referenced map with embedded coordinates.

Phase Six: Data Elaboration and Manipulation

Once the data extracted from the 3D model are digitised, information obtained from official and other sources, like administrative and political boundaries, can be integrated. Attributes are ascribed to points, lines and polygons. The entire output is subjected to cartographic processing wherein colours, symbols and lines are chosen to represent the different attributes of the model. Customised thematic maps are produced at predetermined scales (APPENDICES 10, 12, 14, 16, 17, 18, 19, 20 AND 21).

A legend is prepared and joined to other cartographic information like scale, title, source of information (including date), coordinates, directional arrow and others as shown in APPENDIX 9.

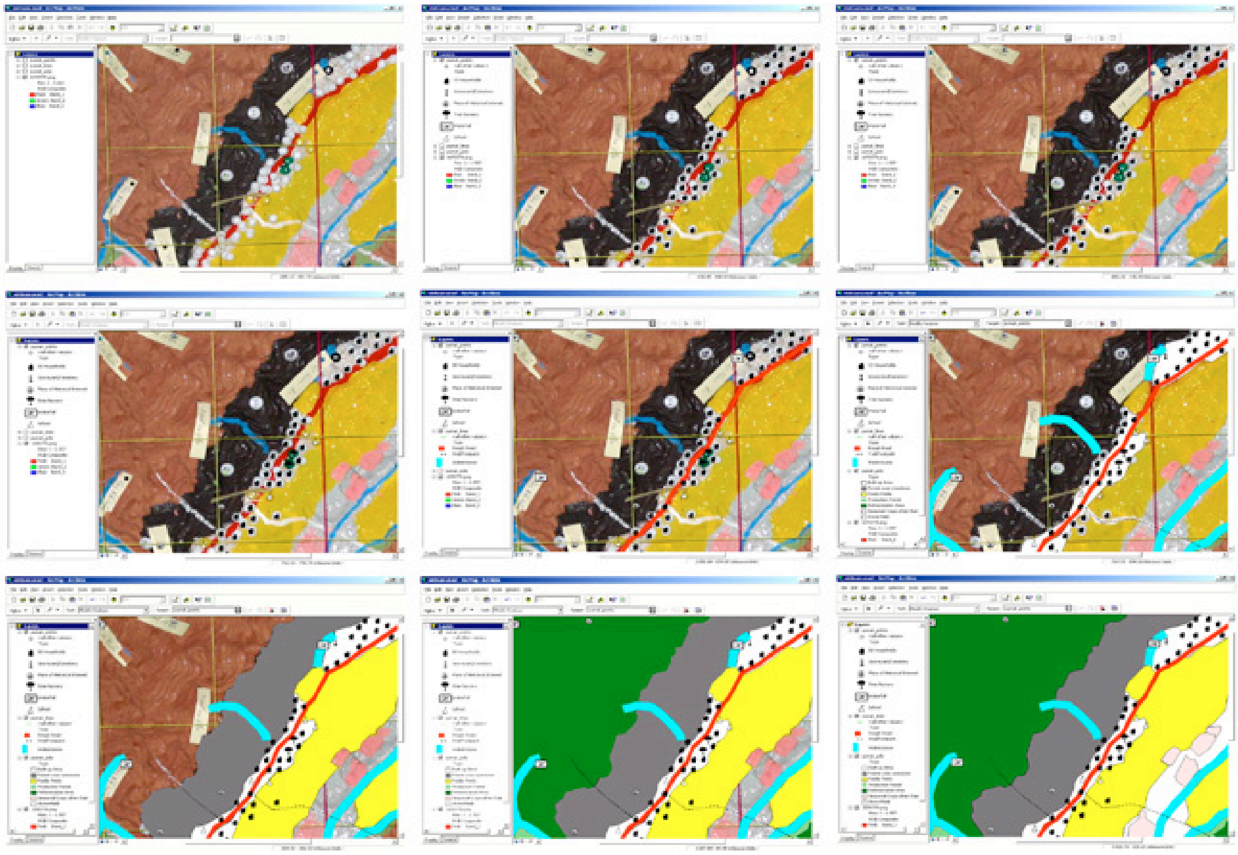


Figure 70. On-screen digitising sequence

Using standardised coding to produce thematic maps is important for sharing information, comparing data sets from different sources or comparing data collected from the same source but at different dates – especially when 3D models are used as a means for conducting participatory monitoring and evaluation (PM&E).

Phase Seven: Field Verification

GIS translation of the model's data can be compared with other existing spatial information, like maps produced from satellite-interpreted imagery (APPENDIX 11) or other cartographic information obtained from institutional sources. Examples are shown in APPENDIX 12 vs. APPENDIX 13 and APPENDIX 14 vs. APPENDIX 15.

Inconsistencies between data sets need to be verified. This should be done through reconvening around the 3D models with a sufficient number of informants and through community-based on-field investigation.

FREQUENTLY ASKED QUESTIONS (FAQ)

Can P3DM be used for reproducing large areas (e.g. >100,000 km^2)?

The geographical coverage of a model is influenced by its final size. Key-informants' knowledge can be successfully collated on 3D models made at 1:10,000; models at larger scales would be even better. Reducing the scale (e.g. to 1:50,000) in order to cover larger areas limits accuracy and the ability of informants to internalise the model and transpose their knowledge. A solution is to produce a series of models – to be made and displayed at different locations – each one covering a portion of the desired area. Obviously this process would require more time and financial and human resources.

Do participants get paid?

The essence of participatory approaches is the full participation of people in the processes of learning about their needs and opportunities, and in the action required to address them. Informants and representatives from all stakeholder groups generally work in a voluntary capacity. It is important to limit to a minimum the amount of time that participants are requested to stay away from their homes and obligations. Usually participants inputting data onto a 3D model need 1½ days to complete their work. The project should cover the costs of transport, lodging and catering.

How many participants (informants) are required for a 3D model?

The number of participants working at one time should allow everyone to physically access the model. An overcrowded venue causes distraction and loss of motivation. It is best to split informants into groups of 20-25 and to make provisions for brief overlapping of groups to allow cross-fertilisation and cross-checking of information.

Who does the community mobilisation?

Ideally a participatory mapping activity is demand-driven. Therefore, community mobilisation should be done by representatives from the community itself. In a project context involving technology intermediaries, community mobilising brings all concerned communities to a common level of awareness concerning the purpose of the initiative, the mapping methodologies involved and the tasks assigned to community representatives and technology intermediaries.

How do I deal with conflicting information?

What is the truth? Whose knowledge counts? These are recurrent questions that surface while doing community-based work. A 3D model accommodates a blend of information collated by knowledge holders. Outsiders may inject additional information (e.g. from remote-sensed imagery) to start further community-based discussion and analysis. GPS-based field verification supported by skilled mediation may help in addressing disputes.

How do I best make use of the outcomes of the P3DM exercise?

Outcomes of a P3DM exercise include a lot of non-tangible elements like individuals' increased awareness and knowledge about bio-cultural aspects of the territory which was mapped, enhanced community identity and social cohesiveness. Technology intermediaries may assist community members in building on this to communicate, advocate and plan more effectively. Considering the fact that 3D models are bulky, extracted data should be used to produce thematic maps which could then be used by representatives of the community as media in negotiation processes. P3DM should be seen as a means to enhance community-based awareness and local analytical skills

Remember that P3DM has been conceived to be part of a broader intervention, aimed at full participation by people who are in the process of learning about their opportunities and are ready to take action to address them.

Thus, in order for outsiders to apply this process, they must fulfil two preconditions: The first is to be trusted by the participating communities and have a thorough understanding of the socio-economic setting of the area. The second is to have the resources to support communities in implementing strategies and actions to follow-up the P3DM process.

To what extent is P3DM feasible in densely populated areas?

Densely populated areas can be reproduced in 3D format at a scale which meets the purpose of the exercise. A 1:2,000 scale or larger would be ideal to generate household-level information. Densely populated areas are generally located in alluvial plains. Small-interval contour lines should be used to depict as many landmarks as possible. Vertical exaggeration should be applied to enhance the perception of slope and evidence landmarks.

How long does it take to complete the process from community mobilisation to the production of the model and derived digital information?

Depending on available information (including digital contours, socio-economic and land-use data, etc.) and community preparedness: three to six months of staggered inputs.

What skills are needed?

Organising and facilitating a P3DM exercise requires a multidisciplinary team with at least three facilitators covering – as an example – the following disciplines: geography/cartography/GIS; natural resource management/ environment; and social sciences.

GLOSSARY

Attribute	A characteristic of a geographic feature described in numbers or text.
Base map	A map containing geographic features, used for locational reference. Also, the source map of a P3DM process.
Mental maps	Represent the perceptions and knowledge that an individual has of an area. Mental maps allow us to know "what is out there, what its attributes are, where it is and how to get there". Mental maps are distinctive to individuals. They are not inclusive like a cartographic map with a constant scale, but consist of discrete, hierarchically-organised pieces of information determined by physical, perceptual or conceptual boundaries. (source: Wikipedia http://tinyurl.com/ycguun2)
Depiction	Meaning conveyed through pictures, drawing or symbols.
Digitise	To convert an image, such as a map, into a form that a computer can store and manipulate by using special software (a computer programme). Digitising is usually done manually, with a digitising tablet, but simply scanning the image may be suitable for some purposes (Flavelle, 2002).
Facilitator	Someone who helps a group of people understand their common objectives and assists them to plan to achieve them without taking a particular position in the discussion. Wikipedia: http://en.wikipedia.org/wiki/Facilitator
Feature classes	Homogeneous collections of common features, each having the same spatial representation, such as points, lines or polygons, and a common set of attribute columns. The four most commonly used feature classes in the geo-database are points, lines, polygons and annotations.
Georeferenced	Refers to a map or photo that has been geographically corrected so that every point on it shows an absolute location. For example, air photos and satellite images are georeferenced to correct for scale distortions inherent in the process of collecting data through remote sensing.
Grid	A raster-based data structure composed of cells of equal size arranged in columns and rows.
Layer	A logical set of thematic data described and stored in a map library. Layers organise a map library by subject matters (e.g. soils, roads, households, land use).
Modelling	The act or art of making a model of something; rendering into solid form.
Perception	The active acquisition of knowledge about the self and the world through the senses.

PLA Participatory Learning and Action (PLA) is an umbrella term for a wide range of similar approaches and methodologies to involve communities in self-help and development projects. The common theme to all these approaches is the full participation of people in the processes of learning about their needs and opportunities, and in the actions required to address them.

Topographic map A contour map that shows human-made and natural physical features (Flavelle 2002).

Zoning Dividing an area into zones having different objectives and uses.

APPENDICES

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Department of Environment and Natural Resources
Visayas Avenue, Diliman, Quezon City, 1100
Tel. No. (632) 929-66-26 to 29 (632) 929-62-52
929-66-20, 929-66-33 to 35
929-70-41 to 43

KALAYAAN

January 4, 2001

JAN 04 2001

DENR MEMORANDUM CIRCULAR

NO. 2001- 01

SUBJECT: **Participatory Three-dimensional Modelling as a Strategy in Protected Area Planning and Sustainable Natural Resource Management**

Pursuant to Chapter IV Section 8 of DAO 25 Series of 1992, DENR Circular Nos. 3 and 4 Series of 1993, the Participatory Three-dimensional Modelling is hereby recommended as one of the strategies in protected area planning and sustainable natural resource management.

The Participatory Three-dimensional Modelling integrates participatory resource mapping and spatial information to produce a stand-alone and user-friendly scaled 3D model which has proven to be relatively accurate for spatial research, planning and management. The model contains information which can be extracted and further elaborated by the geographic information system.

A *Manual on Participatory 3Dimensional Modelling* has been developed for the guidance of all Regional Executive Directors and concerned Assistant Regional Executive Directors.

ANTONIO H. CERILLES
Secretary

Grow a Tree for Legacy

Appendix 2 Reading Maps

A map is a representation of the Earth, or part of it. Traditionally, maps have been printed on paper. When a printed map is scanned, the computer file that is created may be called a digital raster graphic.

The distinctive characteristic of a topographic map[23] is that the shape of the Earth's surface is shown by contour lines. Contours are lines drawn on a map to represent points of equal elevation on the surface of the land above or below a reference surface, such as mean sea level. On conventional maps, they are usually printed in brown, in two thicknesses. The thicker lines are called index contours, and they are usually marked with numbers, giving height in metres. The contour interval – a set difference in elevation between the brown lines – varies from map to map; its value is given in the margin of each map. The closer the contour lines, the steeper the slope is. Contours make it possible to measure the height of mountains, depth of oceans and steepness of slopes.

A topographic map shows not only contours, but various other natural and man-made features, each represented by colours and symbols.

Colours 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 printed in solid or dashed, red or black lines, depending on its size and surface.

Symbols include variously weighted line styles, fonts and icons to improve appearance and readability of a map.

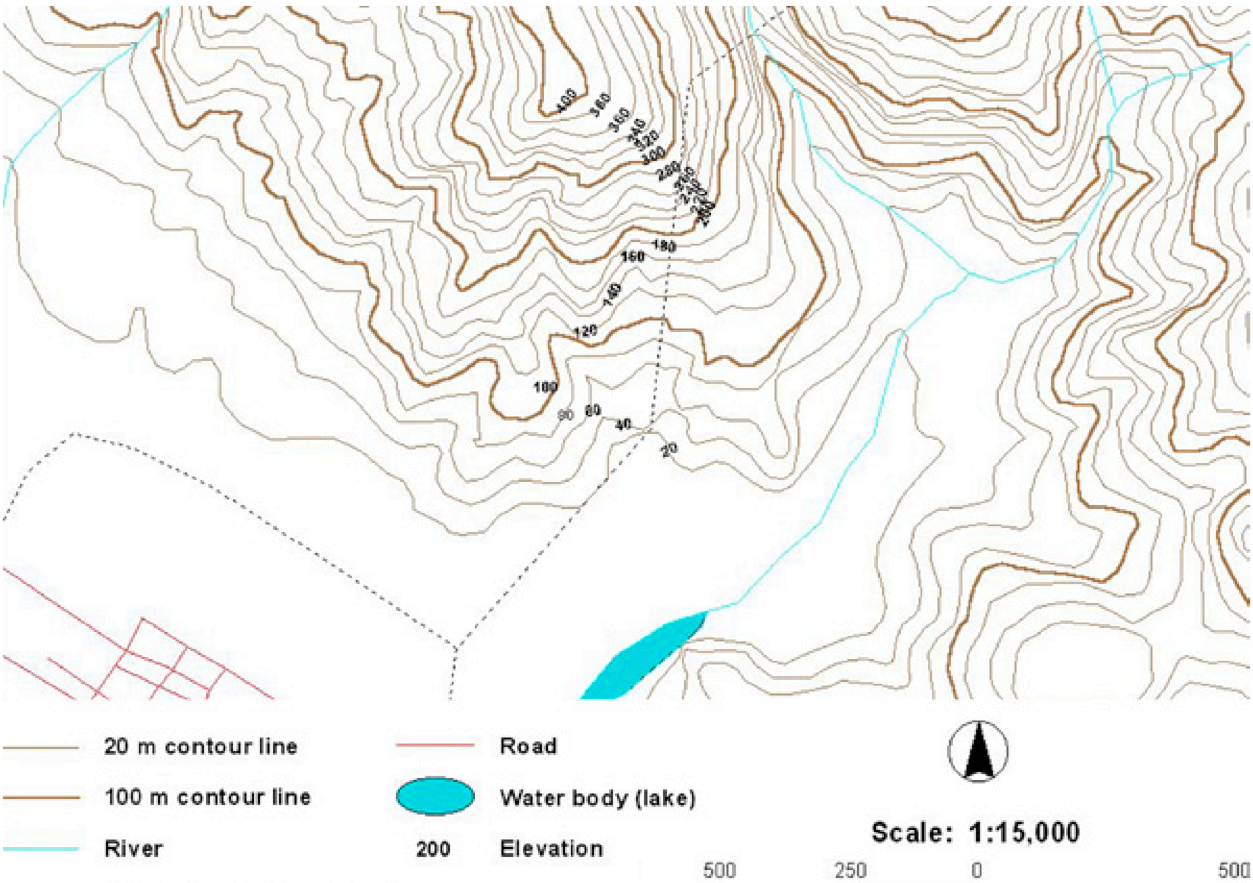


Figure 71. Sample of contour map

23 Topographic maps are maps that present the horizontal and vertical positions of the features represented; distinguished from a planimetric map by the addition of relief in measurable form.

Appendix 3 Stakeholder Analysis

A stakeholder analysis is done to identify all groups, institutions and individuals having interests in or control over a particular situation or deriving benefits or suffering consequences from that situation or from one which may materialise as a consequence of change. The analysis is meant to list these stakeholders and determine their level of power and relationships. The analysis has to identify local decision-making structures, the way decisions are made and the holders of relevant specialist knowledge (e.g. resource user groups) and assess the effects change may have on them.

It could also help to identify those who could help organise P3DM activities and deal with follow-up arrangements.

A stakeholder analysis is more appropriate than an inventory when the communities affected are complex and the stakeholders and their relationships to the resources are not easily identifiable. A stakeholder analysis requires more time and resources than an inventory, since the analysis is usually carried out in the field and involves participatory exercises (e.g. a Venn diagram) and the collection of new data.

The use of natural resources is typically characterised by diverse and conflicting interests. For instance, many local communities are socially stratified; knowing the different interests of the various members will help in organising their participation in the initiative as well as in developing local resource management institutions. Undertaking a stakeholder analysis will also provide a frame of reference for further steps in the initiative and for dealing with various consequences and conflicts which may emerge.

A possible constraint to this exercise is that it requires expertise in social analysis and community consultation techniques. Undertaking an analysis can also be costly and time-consuming and, as with inventories, the end product will need to be updated to maintain its relevance to the initiative.

References and recommended readings:

Overseas Development Administration. July 1995. Guidance Note on How to Do Stakeholder Analysis of Aid Projects and Programmes. Social Development Department Mimeo. London: ODA. http://tinyurl.com/y38r9a5

Borrini-Feyerabend, 1997. *Beyond Fences: Seeking Social Sustainability in Conservation*, IUCN, Gland (Switzerland), 1997.

If digital contours are available, the recommended format for the base maps includes the following features:

- Scale: 1:5,000 to 1:10,000
- 20-m contour lines coloured in a recurrent sequence: e.g. brown (100m), blue (120m), green (140m), purple (160m), black (180m); brown (200m), blue (220m), green (240m), purple (260m), etc.
- Format of the contour lines: 1 pt., except for the "index contours" (100m, 200m, 300m, 400m, etc.), which should be 2 pt. thick.
- 40-m contours are a valid alternative. The colour sequence could be the following: e.g. brown (0m), blue (40m), green (80m), purple (120m), black (160m); brown (200m), blue (240m), green (280m), purple (320m), etc.

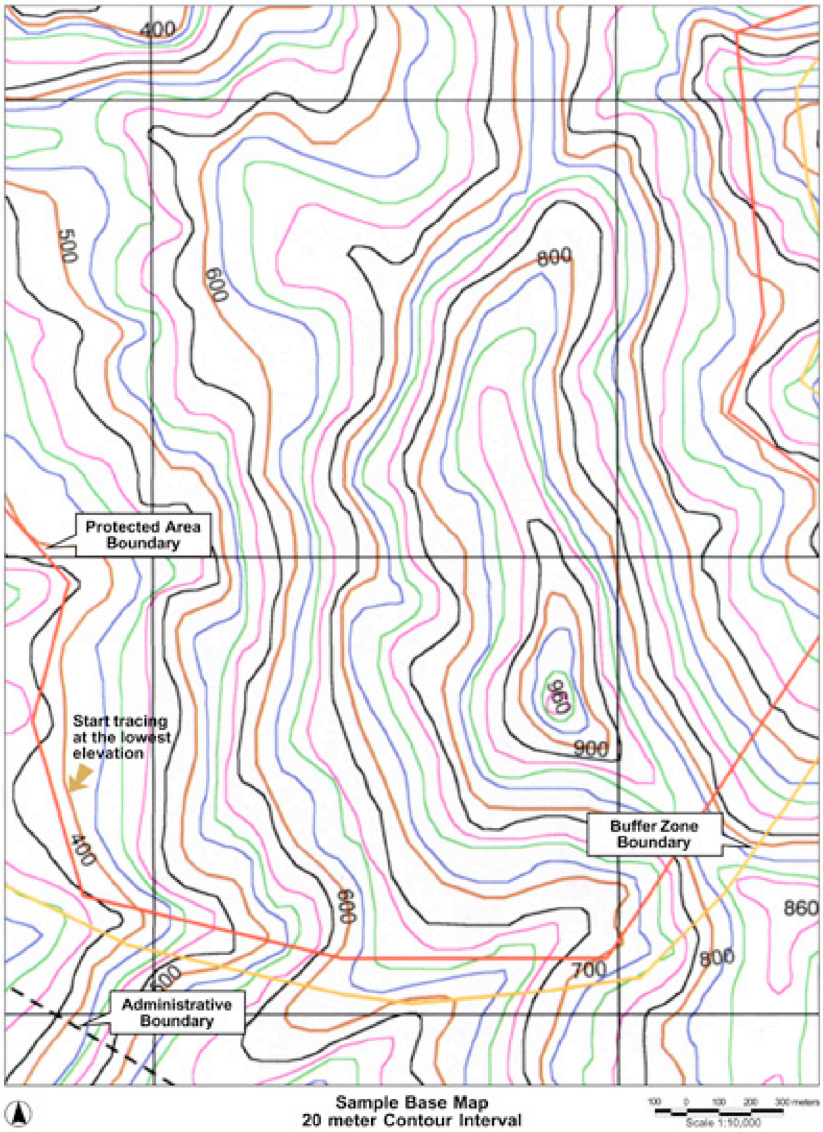


Figure 72. Sample of base map for 3D modelling

- Elevation labels: Many, to facilitate identifying the elevation of each contour during tracing. In addition, elevation labels should be placed at all hilltops, mountaintops and bottoms of depressions.
- Grid (10 cm = 1 km on the ground for a 1:10,000-scale model) format: Solid line, black, 1 pt.
- Contour line expressing the lowest elevation: To be identified with a mark, e.g. an arrow. This allows locating the first contour line to be traced and cut out.
- Administrative boundaries (e.g. national boundary) format: Dashed line, black, 2 pt.
- Protected area boundary format: Solid line, red, 2 pt.
- Buffer zone boundary format: Solid line, orange, 2 pt.


Quick 1:10,000 Scale
Reference Guide
5m16FT
Top-Stop

Appendix 6 Supply list for the manufacture of the 3D model of Pu Mat National Park, Nghe An, Vietnam. Area coverage 700 km^2; scale 1:10,000; year 2001. Model size: two units each measuring 1.4: m x 2.5m.

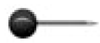
QTY	Unit of measure	Article specification	Unit cost (USD)	Total cost (USD)
2	lit	Alcohol	0.67	1.33
200	pc	Attendance certificates	0.07	14.00
1	pc	Banner	32.00	32.00
1	set	Base maps: editing and attributing contour lines (700 sq km, 1:10,000 scale; 20 m contour interval)	333.33	333.33
4	pc	Base maps: plotting base map on A0 paper (2 copies each)	26.67	106.67
2	unit	Base table (1.4m x 2.5m x 0.6m) plywood (1/4”) with reinforcements	26.67	53.33
3	pc	Blade cutter	0.43	1.30
5	pc	Blade for coping saw (steel)	0.33	1.67
5	pc	Blade for coping saw (wood)	0.33	1.67
20	box	Blades for above cutters	0.47	9.40
8	pc	Bucket (1 litre capacity)	0.20	1.60
1	pc	Bucket (10 litre)	0.47	0.47
2	box	Carbon paper (hand writing)	2.67	5.33
6	pc	Colour markers, black, blue and red	1.33	7.98
1	no.	Compass	1.33	1.33
4	pc	Coping saw	13.33	53.33
1	bag	Cotton	0.33	0.33
1	roll	Cotton yarn (fine); yellow	0.80	0.80
40	rims	Crepe paper (white)	0.50	20.00
24	pc	Double clip (25 mm)	0.07	1.68
5	box	Dressmaker pins	0.67	3.35
1	pc	Egg beater	3.33	3.33
4	rolls	Film Kodak ASA 200 (36p)	2.40	9.60
4	kg	Glue powder	2.67	10.67
1	pc	Hammer	0.60	0.60
1	kg	Hand-knitting yarn no. 8; 18 colours	4.00	4.00
1	pc	Labels (craft paper)	1.67	1.67
8	no.	Laminated north arrow	0.13	1.04
1	no.	Laminated plate (commemorative)	0.13	0.13
1	no.	Laminated plate (legend)	0.13	0.13
4	series	Letters (alphabet) font 72	0.00	0.00
1	no.	Logbook	1.60	1.60
1	bag (100 pc)	Pins (map pins) (13 mm long; 10 mm head; white)	5.00	5.00
4	bag (50 pc)	Pins (map pins) (13 mm long; 10 mm head; yellow, red, green, blue)	2.23	8.93
2	bag (1000 pc)	Pins (map pins) (13 mm long; 4 mm head; white)	5.00	10.00

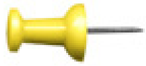
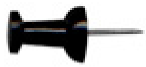
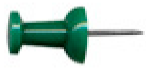
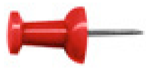
QTY	Unit of measure	Article specification	Unit cost (USD)	Total cost (USD)
1	bag (1000 pc)	Pins (map pins) (13 mm long; 4 mm head; yellow, blue, black, red, violet, white, orange)	5.00	5.00
0	bag (1000 pc)	Pins (map pins) (13 mm long; 6 mm head, white)	7.00	0.00
10	pc	Masking tape (2”)	0.93	9.33
3	pc	Measuring tape (3 metres long)	1.00	3.00
1	kg	Nails (0.5”)	0.67	0.67
1	kg	Nails (2.5”)	0.53	0.53
1	kg	Nails (5”)	0.53	0.53
4	series	Numbers (1 to 35) Font 72	0.00	0.00
24	kg	Office glue (water-based)	1.20	28.80
2	set	Overhead projection markers (six colours)	4.67	9.33
3	pc	Packing tape (2’)	0.33	1.00
4	pc	Painting brush # 0	0.27	1.07
20	pc	Painting brush # 10	0.13	2.67
20	pc	Painting brush # 12	0.20	4.00
20	pc	Painting brush # 2	0.07	1.40
20	pc	Painting brush # 7	0.10	2.00
20	pc	Painting brush 25 mm	0.07	1.40
2	pc	Painting brush 63.5 mm	0.27	0.53
36	pc	Pencil mongol # 2	0.17	6.12
1	pc	Pencil sharpener	4.33	4.33
50	pc	Plastic jar (1 litre capacity)	0.10	5.00
10	pc	Plastic jar (3 litre capacity)	0.33	3.33
8	pc	Plastic-laminated Quick Reference Guide	0.33	2.64
1	pc	Pliers	1.33	1.33
2	pc	Plumb line weight	0.67	1.33
1	kg	Powder colour (black)	1.00	1.00
1	kg	Powder colour (blue)	2.33	2.33
1	kg	Powder colour (brown)	1.00	1.00
4	kg	Powder colour (green)	2.33	9.33
1	kg	Powder colour (light brown)	1.00	1.00
0.5	kg	Powder colour (red)	6.67	3.33
3	kg	Powder colour (white)	1.00	3.00
2	kg	Powder colour (yellow-lemon)	2.33	4.67
1	kg	Powder colour (yellow-orange)	2.33	2.33
1	bag (100 pc)	Pins (push pins), (flat head; white)	5.00	5.00
4	box (100 pc)	Pins (push pins), (white)	1.00	4.00
2	box (100 pc)	Pins (push pins), (yellow, blue, black, green, red)	1.00	2.00
2	pc	Scaled ruler	8.33	16.67

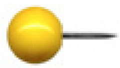
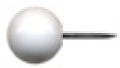
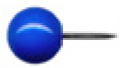
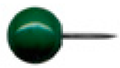
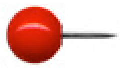
QTY	Unit of measure	Article specification	Unit cost (USD)	Total cost (USD)
10	pc	Scissors (for hair cutting)	0.53	5.33
18	pc	Scissors (small)	0.27	4.86
3	pc	Scotch tape (2')	0.33	1.00
150	sheet	Single-wall corrugated carton (1.4m x 2.5m) sheets. Inner and outer liner 175 g/m^2, B flute 175 g/m^2	1.30	195.00
1	box	Staple wire #35	0.13	0.13
1	pc	Stapler	1.93	1.93
50	m	Transparent plastic sheet (1.2 m wide)	0.50	25.00
40	pc	Weights (bricks, rims of paper, tiles, pieces of lumber, etc.)	0.00	0.00
		TOTAL		**1091.85**

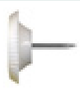
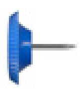
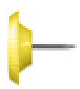
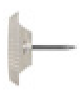
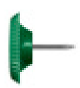
EXAMPLES OF MAP SYMBOLS USED ON PARTICIPATORY 3D MODELS

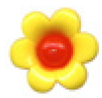
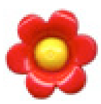
Point data

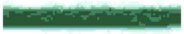
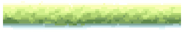
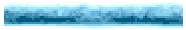
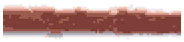
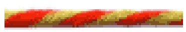
Map pin (head diameter: 5 mm)	Feature
	Single household
	Elementary school
	Water source (1)
	Water source (2)
	Forest-related data
	Ranger station
	Religious establishment
	Cave
	Place name (with label)
	Sports field

Push pin	Feature
	10 households
	High school
	Docking site
	Burial ground
	Tree nursery
	Protected Area Office

Map pin (head diameter: 10 mm)	Feature
	Unallocated
	Unallocated
	Diving site
	Unallocated
	Unallocated

Flat pins accommodate text	Feature
	e.g. wildlife species
	Unallocated
	e.g. fish species
	Unallocated
	Unallocated
	e.g. plant species

Push pin (Flower)	Feature
	Scientific research station
	Extension station
	Market
	Unallocated

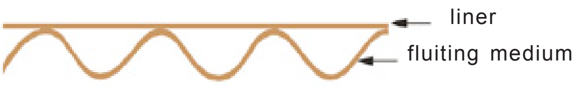
Linear or area data			
Line (yarn)	**Feature**	**Line (yarn)**	**Feature**
	Forest (1)		Vegetable garden
	Forest (2)		Rice field (paddy)
	Forest (3)		Watercourse
	Grassland		Trail or footpath
	Limestone		Mangrove area
	Landslide		Protected area boundary
	Swidden		Boundary (1)
	Reforestation area		Boundary (2)
	Road		Boundary (3)

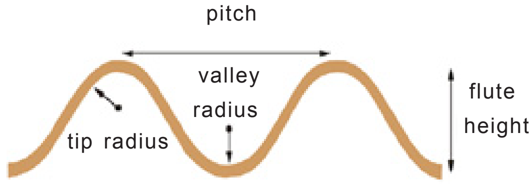
Note: Most yarns are used as temporary markers for features during discussion. Once informants have agreed on the different features, the yarns are removed and replaced by a matching paint. Administrative and management boundaries are best maintained as yarns to allow easy adjustments.

Appendix 8 What 3D Map Makers Should Know About Corrugated Carton Board[24]

Corrugated board is made largely of recycled paper and most commonly comprises three components: an outer "liner", an inner "liner" (i.e. the flat surface components) and a "corrugating medium", the "fluting", which is glued between the liners. It is this sandwich-type construction that gives corrugated board its excellent rigidity and structural strength as well as its unique cushioning characteristics.

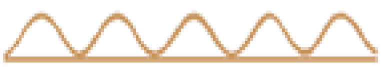
Over the decades, corrugated board has evolved and developed to provide a wide range of products for different applications. Standard and non-standard categories of corrugated board are based on the type of flute – whether coarse, fine or extra fine – and the number of fluted walls – whether single-, double- or triple-layered.





For the purpose of 3D modelling, options include single face, single wall and double wall corrugated board, each of which can be made in a variety of weights and thicknesses.

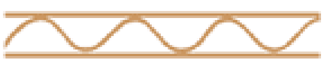
The standard range includes the coarse 'A' and 'C' flute, fine 'B' and extra fine 'E' and 'F' flutes. The 'B' flute is the most widely used. It is very robust (i.e. difficult to crush) and has good compression strength. The 'C' flute is larger with greater compression strength but offers less crush resistance and requires more space.



Single-face corrugated board is manufactured in standard widths ranging from 56" to 36". It is easily transported in rolls. Its ability to withstand compression (an important factor for the stability of a 3D model) is determined by the quality and thickness of the liner and the corrugating medium. For 3D modelling, the liner and the corrugating medium should be at least 185 g/m^2 and 150 g/m^2 respectively. The best solution is to request a specially manufactured corrugated board making use of a liner (175 - 185 g/m^2) and a kraft liner (175 -185 g/m^2).

The thickness of corrugated board (an important dimension in respect to scaling 3D models) is conventionally measured as detailed in the following table.

If transport is not a constraint, consider procuring single- or double-wall corrugated board, making sure to get the best possible quality in terms of strength, as discussed above. Single- and double-wall corrugated boards are classified as detailed in the following table and offer additional resistance to compression.

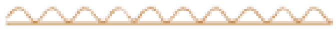
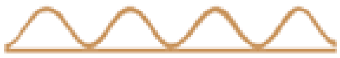
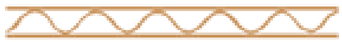
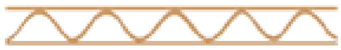
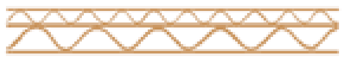
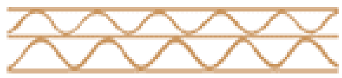
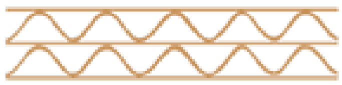


Provided you order a minimum quantity, and depending on the goodwill of the manufacturer, corrugated board sheets can be cut to the desired size ahead of the modelling exercise. If that is possible, the size of the board should match the size of the base table and the base map (see PAGE 39).

The choice among the various media will depend on their availability or the readiness of manufacturers to produce them according to the desired specifications and to the transport facilities available to haul the material to where the model will be assembled. Rolls of board

24 This Appendix has been prepared with the assistance of Dr Martin Oldman, Director, Corrugated Packaging Association Northampton, United Kingdom. http://www.corrugated.org.uk

Different types of corrugated carton board

Standards	Typical calliper (mm) (i.e. thickness)	
Single-face corrugated board		
E Flute	1.1 – 1.8	
B Flute	2.1 – 3.0	
C Flute	3.2 - 3.9	
A Flute	4.0 - 4.8	
Single-wall corrugated board		
B Flute	2.95	
C Flute	3.78	
Double-wall corrugated board		
EB flute	4.06	
BC flute	6.50	
CC flute	7.33	

are easier to transport, as they can easily fit into the back of a pick-up truck. Large carton board sheets are placed on the roof of a vehicle or in a truck obtained for this purpose.

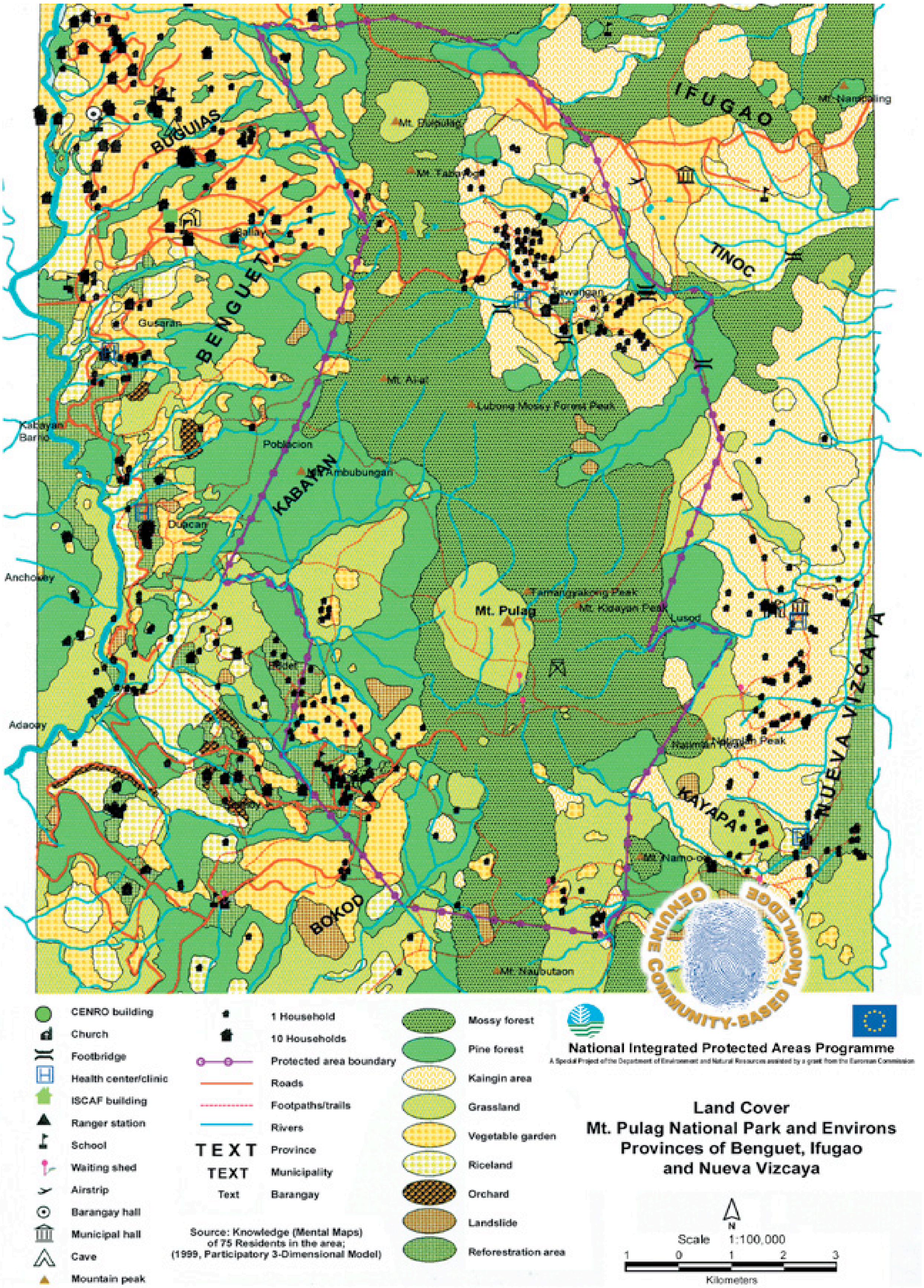
Compared with other supplies used for making 3D models (e.g. polystyrene or other petroleum-derived materials), corrugated board is environmentally friendly, being recyclable and ultimately biodegradable. As a matter of fact, 70 percent of the board produced each year is made from recycled fibres.

Corrugated board is not made from paper derived from tropical forest hardwoods –they are entirely unsuitable for the process. In fact, the paper industry uses fast-growing softwoods, which are being replanted faster than they are being used.

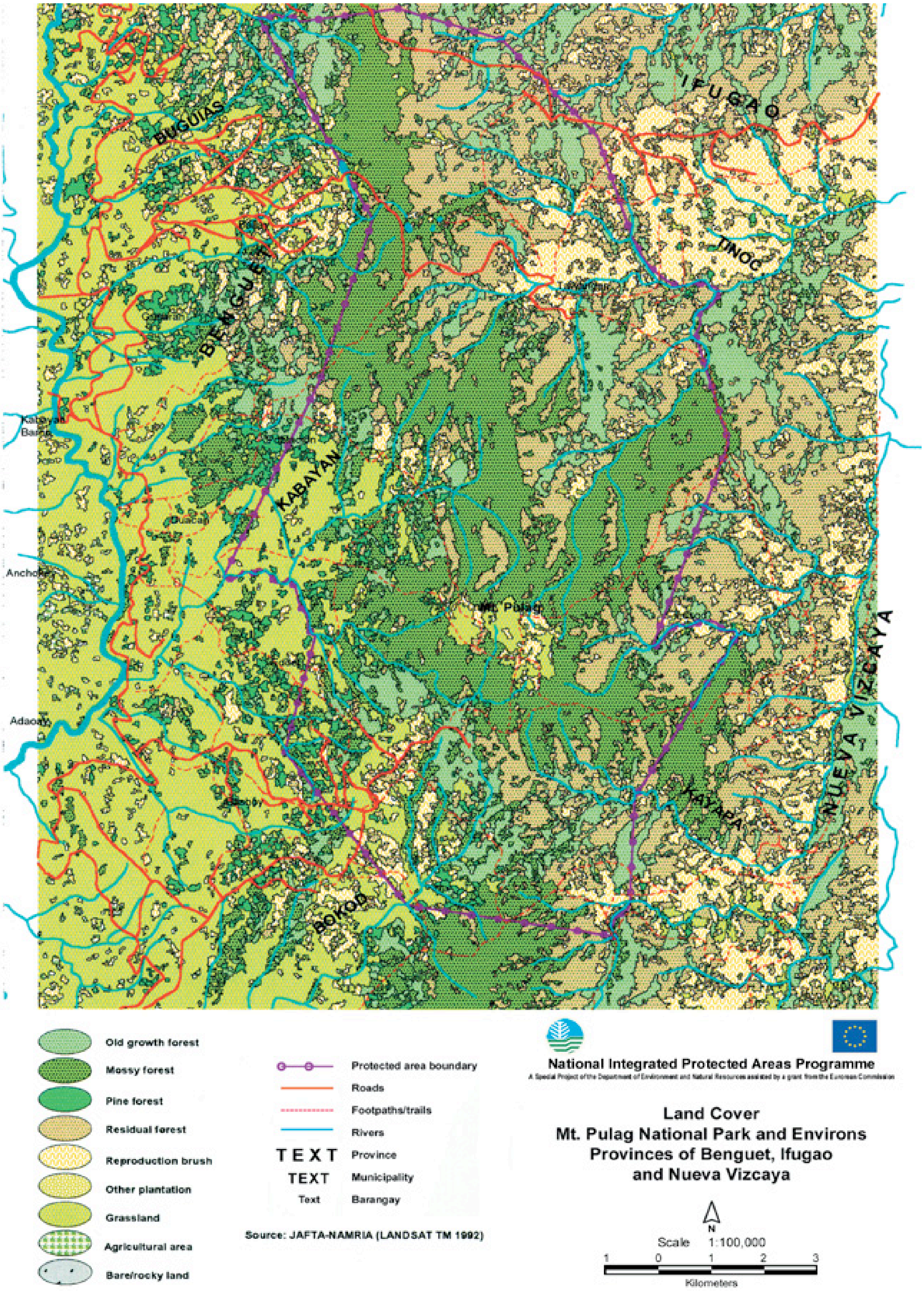
Corrugated carton is a reusable material made from a renewable resource.


National Integrated Protected Areas Programme
Participatory 3-D Model of Mount Guiting-Guiting Natural Park and environs
November 12-17, 1999
LEGEND (Relief Model of Sibuyan Island and Mt. Guiting-Guiting National Park)
Water bodies
Primary forest (Kaguvanan)
Mossy forest
Secondary forest
Reforestation site
Grassland (Kakugnan)
Orchards
Swidden (Kaingin)
Barangay Hall
Health Unit / Hospital
Chapel / Religious Institution
Mangroves
Rice field
Residential Area
Rock Formation
Beach
Coconut (Kaniyogan)
Landslide
Road
Trail or Footpath
Protected Area Boundary
CBFM Area (DENR)
CBFM Area (actual)
N
W
E
LEGEND
Water bodies
Dipterocarp Forest
Mossy Forest
Reforestation Sites
National Integrated Protected Areas Programme
Participatory 3-D Model of Mt. Isarog National Park and Environs
May 17-30, 1999 and January 23-25, 2001
Model resulting from an exercise organised and facilitated by the "Protected Area Office" with the active participation of the following:
LGU representatives
Representatives from the Barangays encompassing portions of the Park
PAMB members
CARE Philippines, Inc.
Haribon Foundation, Inc.
BURDFI, Inc.
PhilDHRRA
PagBICOL, Inc.
Students of the Camarines Sur State Agricultural College (CSSAC)
Students of the Bicol College of Arts and Trade (BCAT)
CARE
Participatory 3-D Mo
Đá vôi (Limestone karst)
Rừng nửa rụng lá (Shifting cultivation)
Rừng sản xuất (Production forest)
Rừng giang nứa (Bamboo forest)
Rừng kín lá rộng thường xanh (Evergreen broadleaved forest)
Rừng lá kim (Conifer forest)
Cây bụi (Bush/Brushland)
Đồng cỏ (Grassland)
Vườn cây ăn quả (Orchard)
Chè (Tea field)
Bãi đá (Stone field)
Chợ (Market)
10 Hộ dân cư (10 Households)
Trường học (School)
Vườn ươm (Tree Nursery)
Nghĩa địa (Graveyard/cemetery)
Trạm xá (Health Station)
Cây cổ thụ (Old tree)
Hộ dân cư (Household)
Thác nước (Waterfall)
Hang động (Cave)
Ranh giới quốc gia (National boundary)
Đường rải đá (rough road)
Sông/khe/suối (Watercourse)
Cầu (Bridge)
Horizontal scale 1:10,000
Meters
Vertical scale 1:7,500
Meters

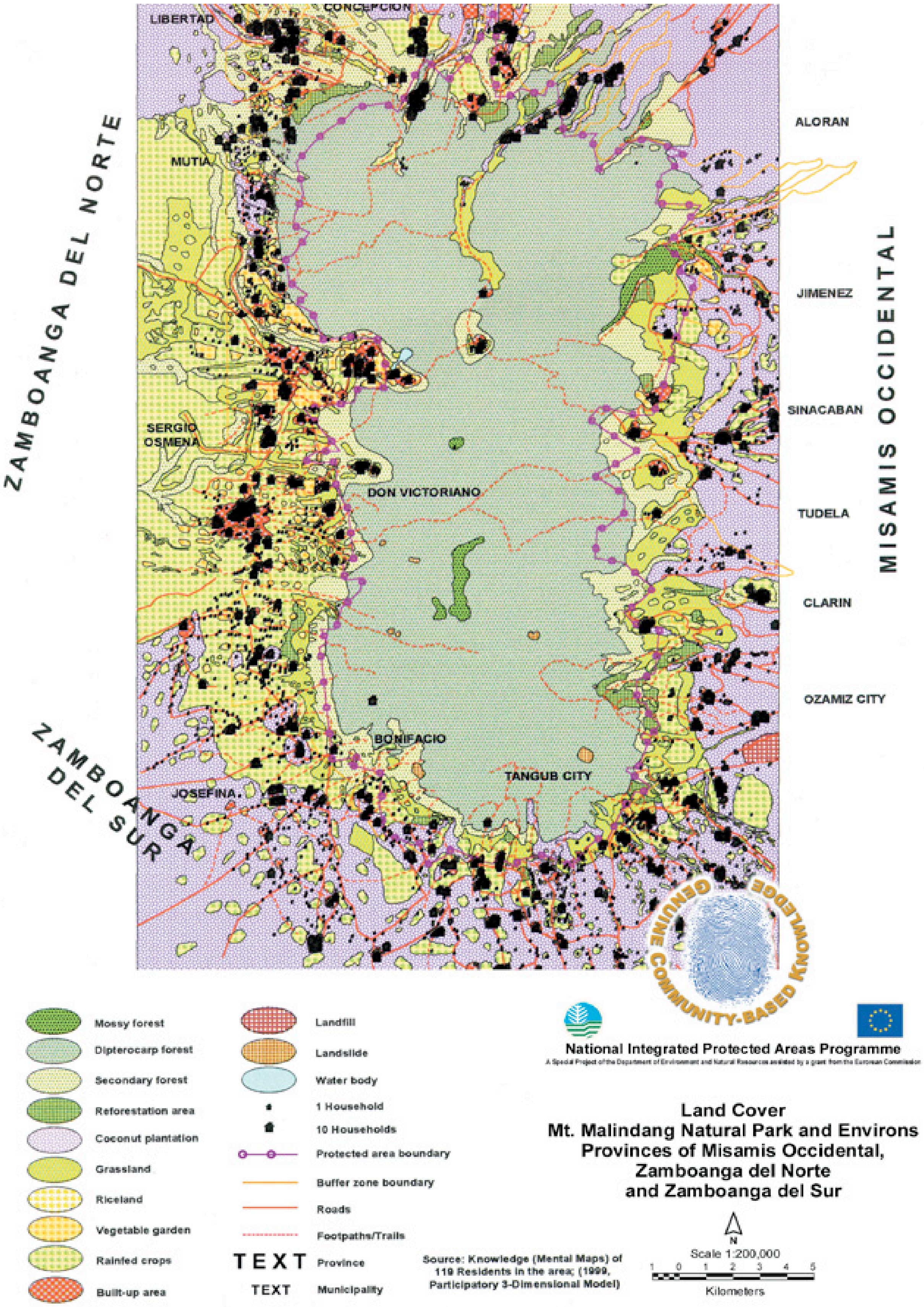
Appendix 10 Land Use and Cover. Mt. Pulag National Park and Environs. Provinces of Benguet, Ifugao and Nueva Vizcaya, Philippines (Source: P3DM, 1999)



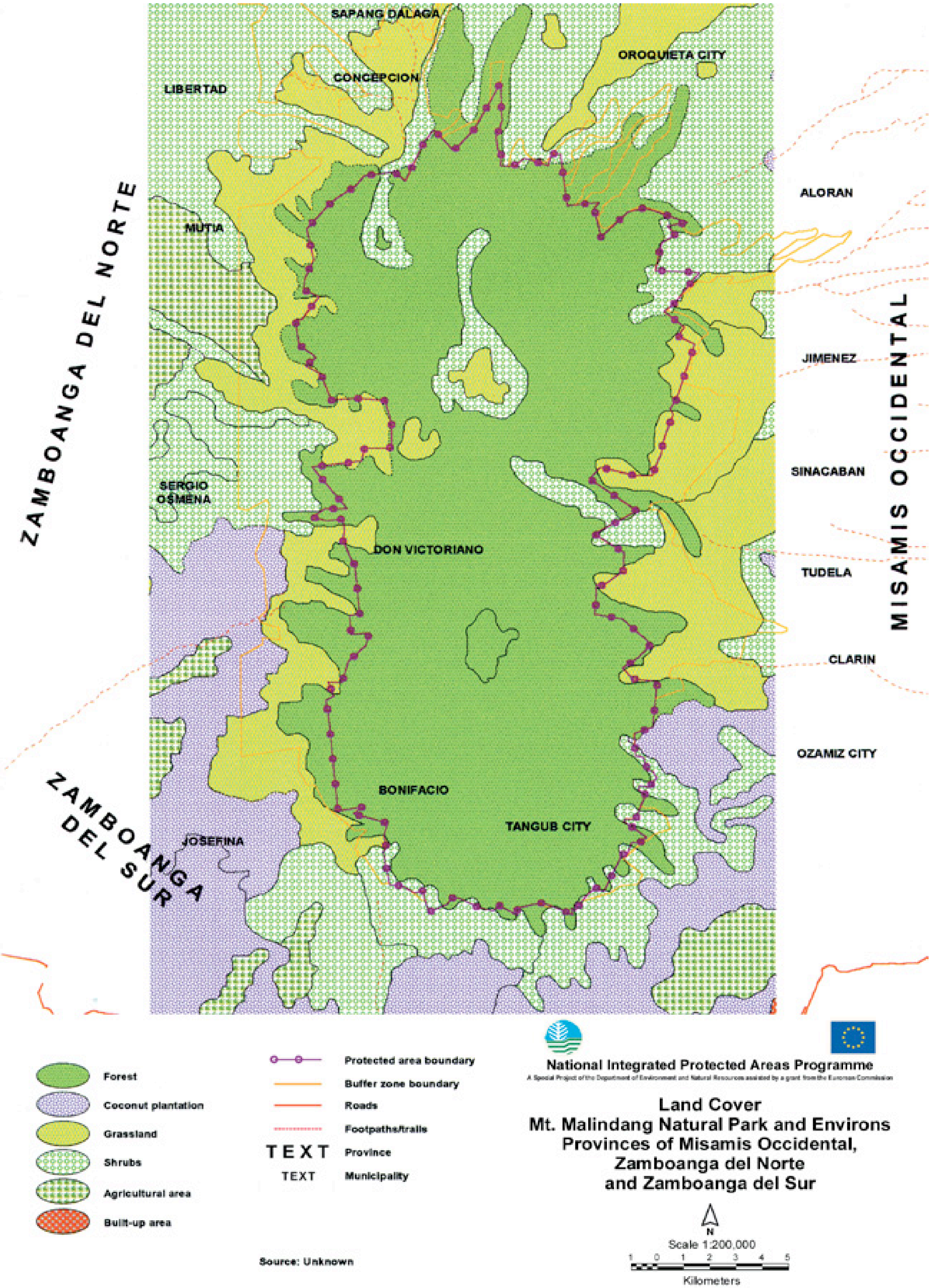
Appendix 11 Land Use and Cover. Mt. Pulag National Park and Environs. Provinces of Benguet, Ifugao and Nueva Vizcaya, Philippines (Source JAFTA-NAMRIA; LandSat TM, 1992)



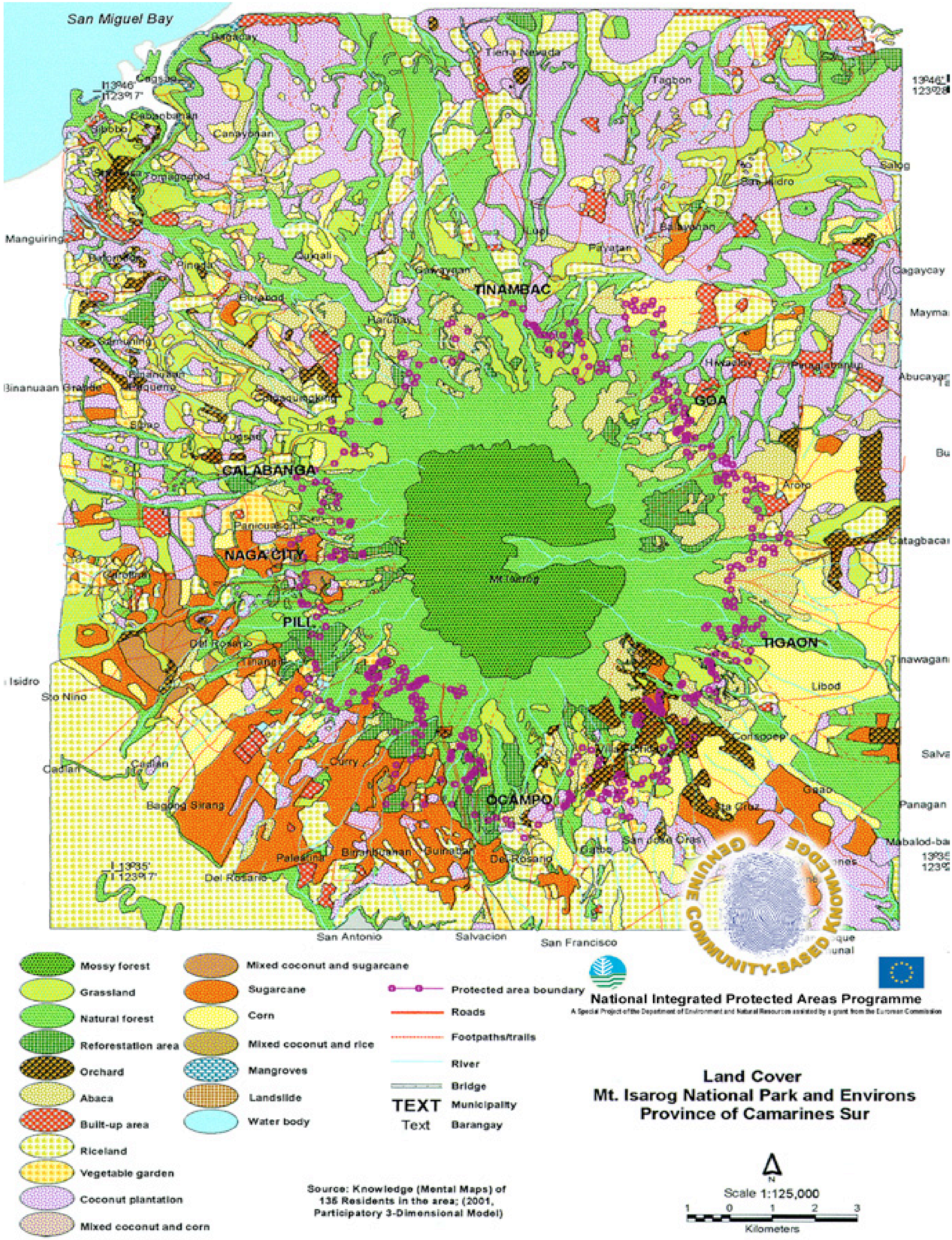
Appendix 12 Land Use and Cover. Mt. Malindang Natural Park and Environs. Provinces of Misamis Occidental, Zamboanga del Norte and Zamboanga del Sur, Philippines (Source: P3DM, 1999)



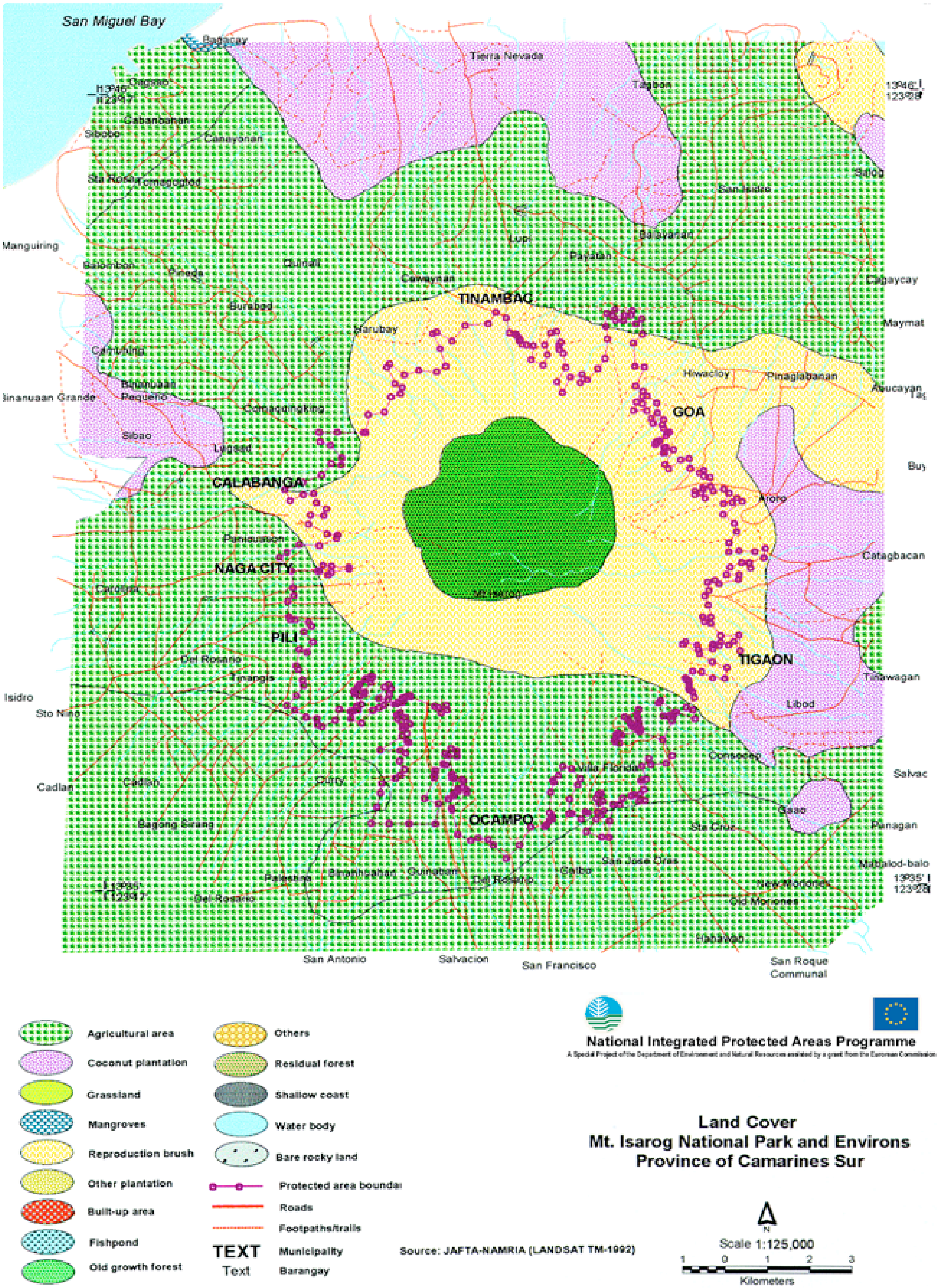
Appendix 13 Land Use and Cover. Mt. Malindang Natural Park and Environs. Provinces of Misamis Occidental, Zamboanga del Norte and Zamboanga del Sur, Philippines (Source: DENR, undated)



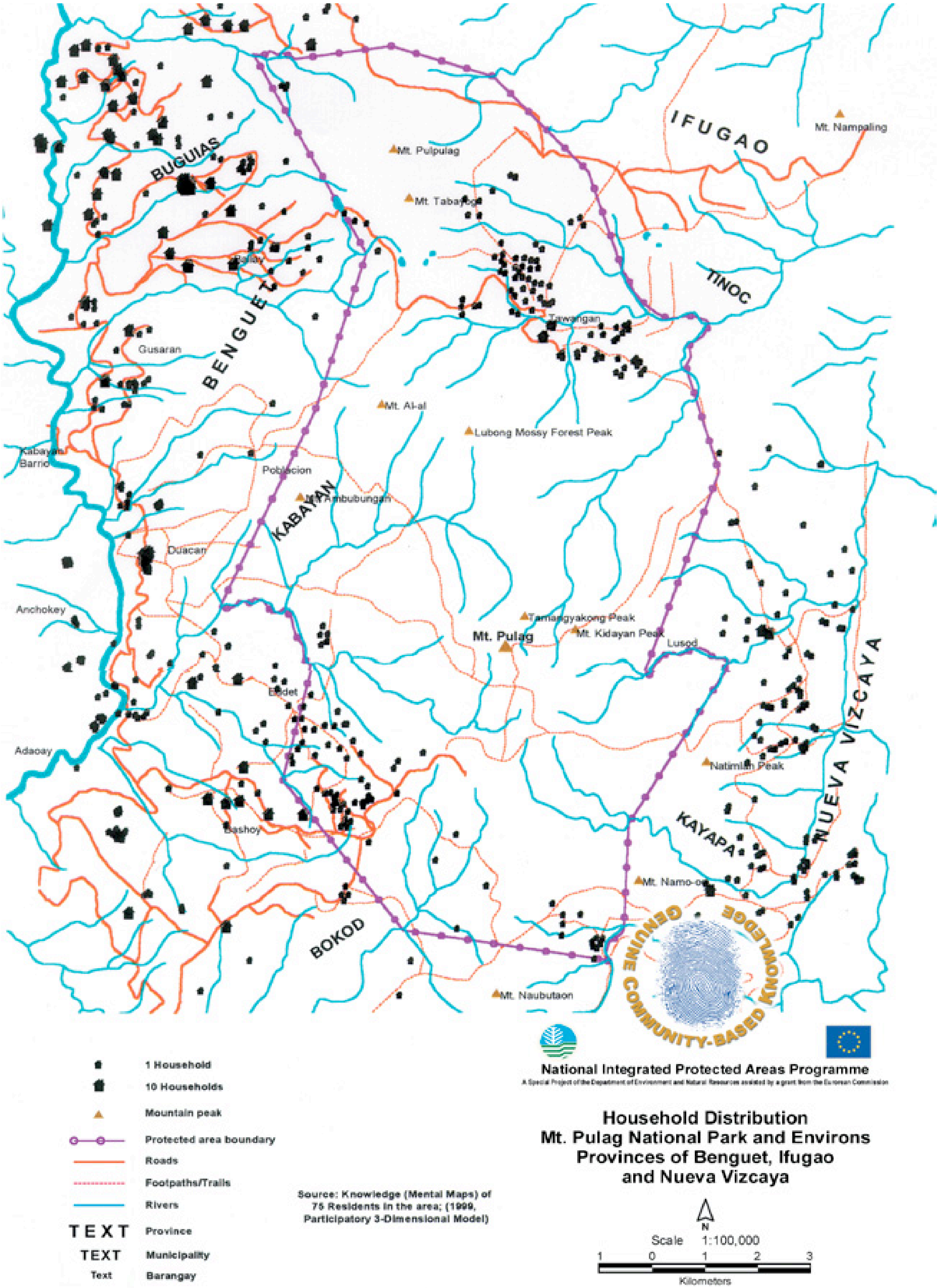
Appendix 14 Land Use and Cover. Mt. Isarog National Park and Environs. Province of Camarines Sur, Philippines (Source: P3DM, 1999)



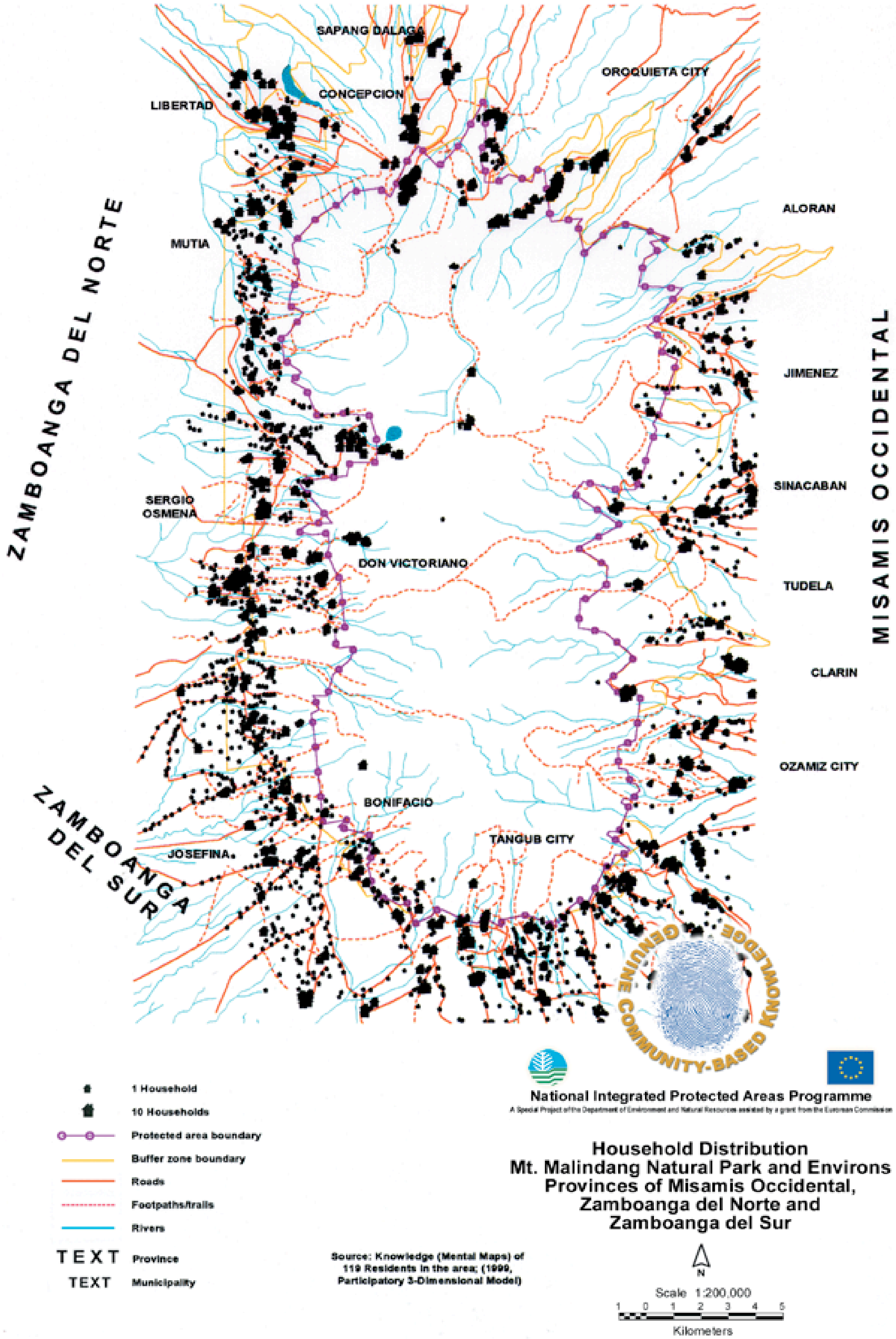
Appendix 15 Land Use and Cover. Mt. Isarog National Park and Environs. Province of Camarines Sur, Philippines (Source: Bureau of Soils and Water Management, date: unknown)



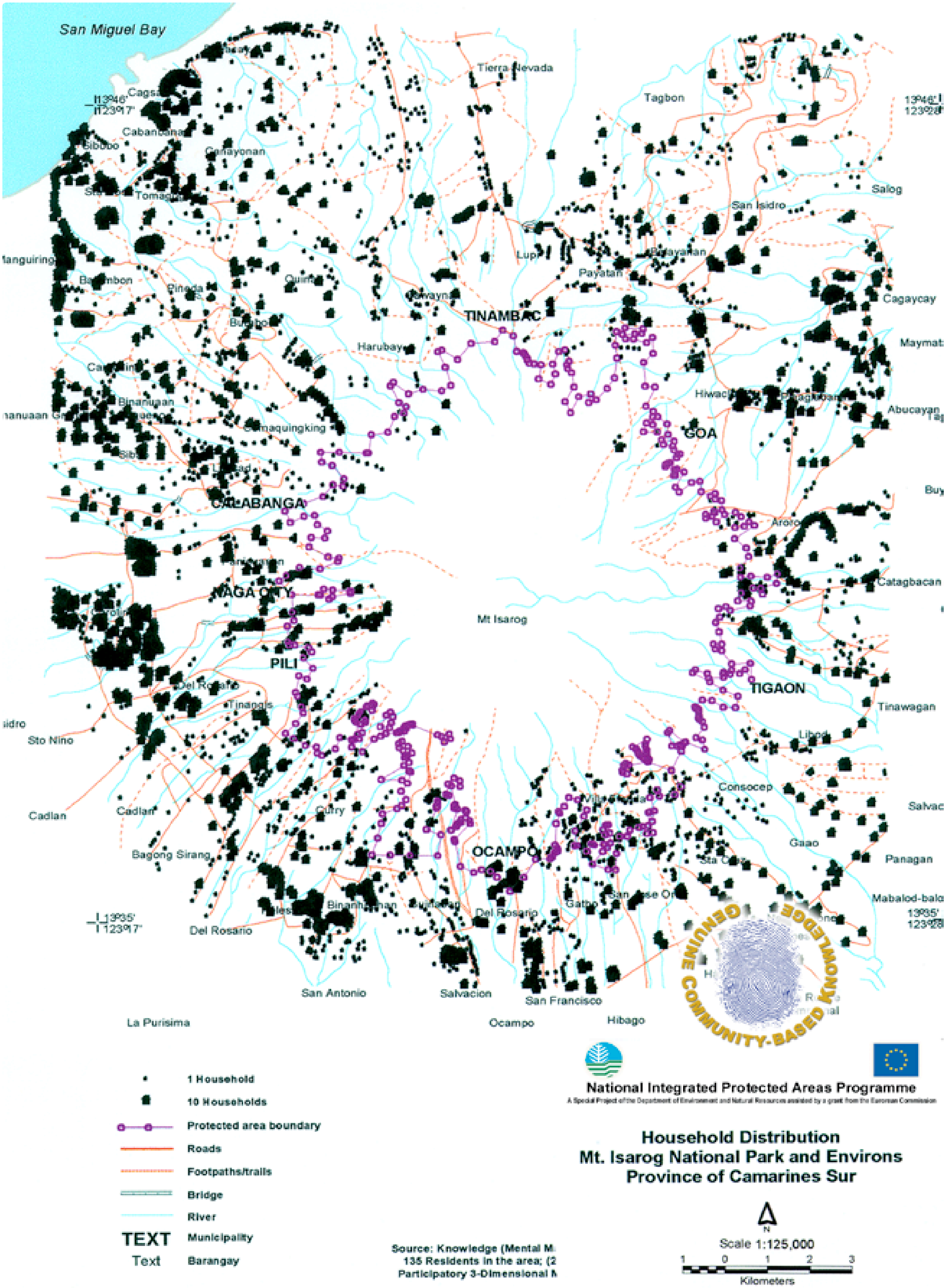
Appendix 16 Population Distribution Map. Mt. Pulag National Park and Environs. Provinces of Benguet, Ifugao and Nueva Vizcaya, Philippines (Source: P3DM, 1999)



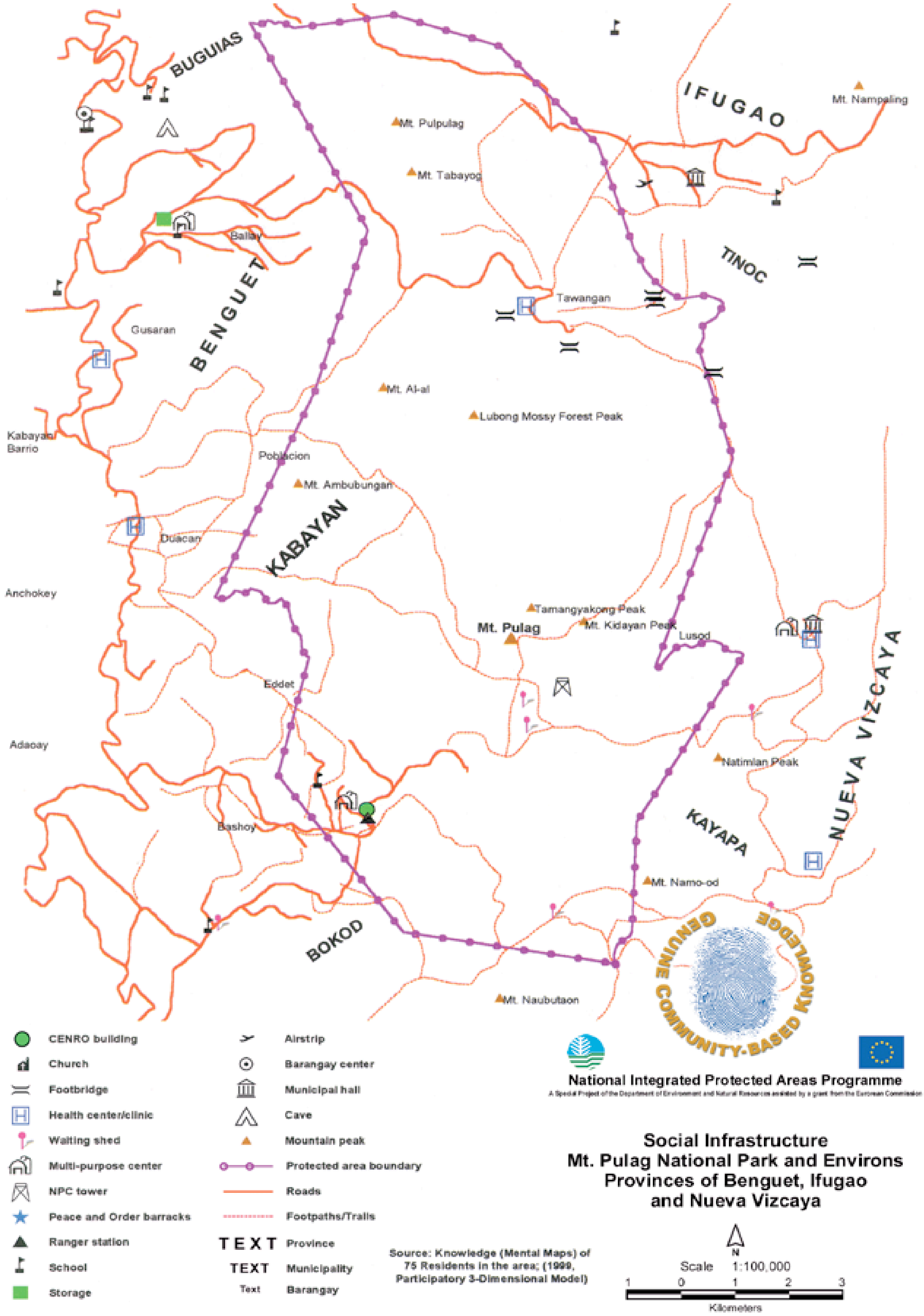
Appendix 17 Population Distribution Map. Mt. Malindang Natural Park and Environs. Provinces of Misamis Occidental, Zamboanga del Norte and Zamboanga del Sur, Philippines (Source: P3DM, 1999)



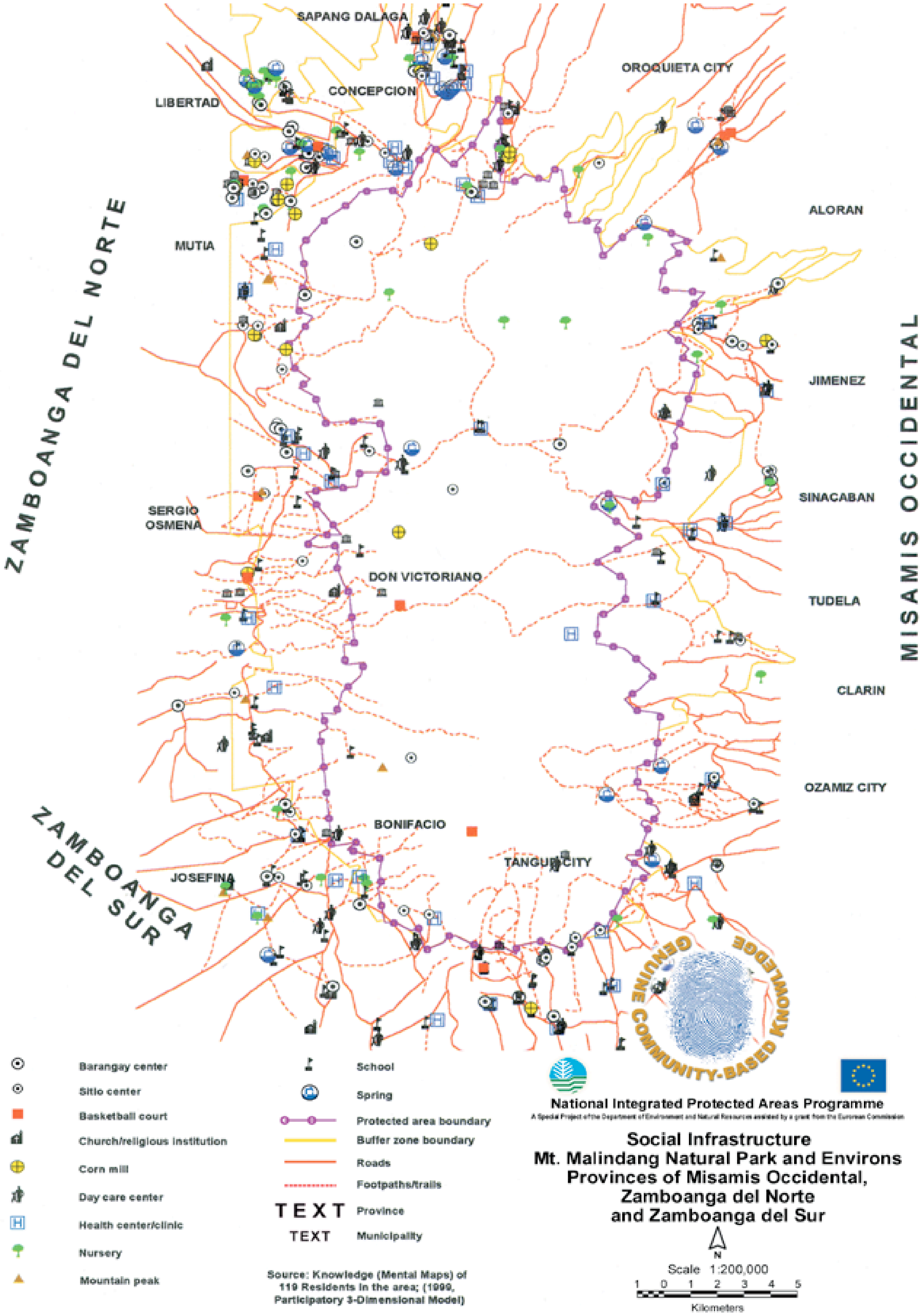
Appendix 18 Population Distribution Map. Mt. Isarog National Park and Environs. Camarines Sur, Philippines (Source: P3DM, 1999)



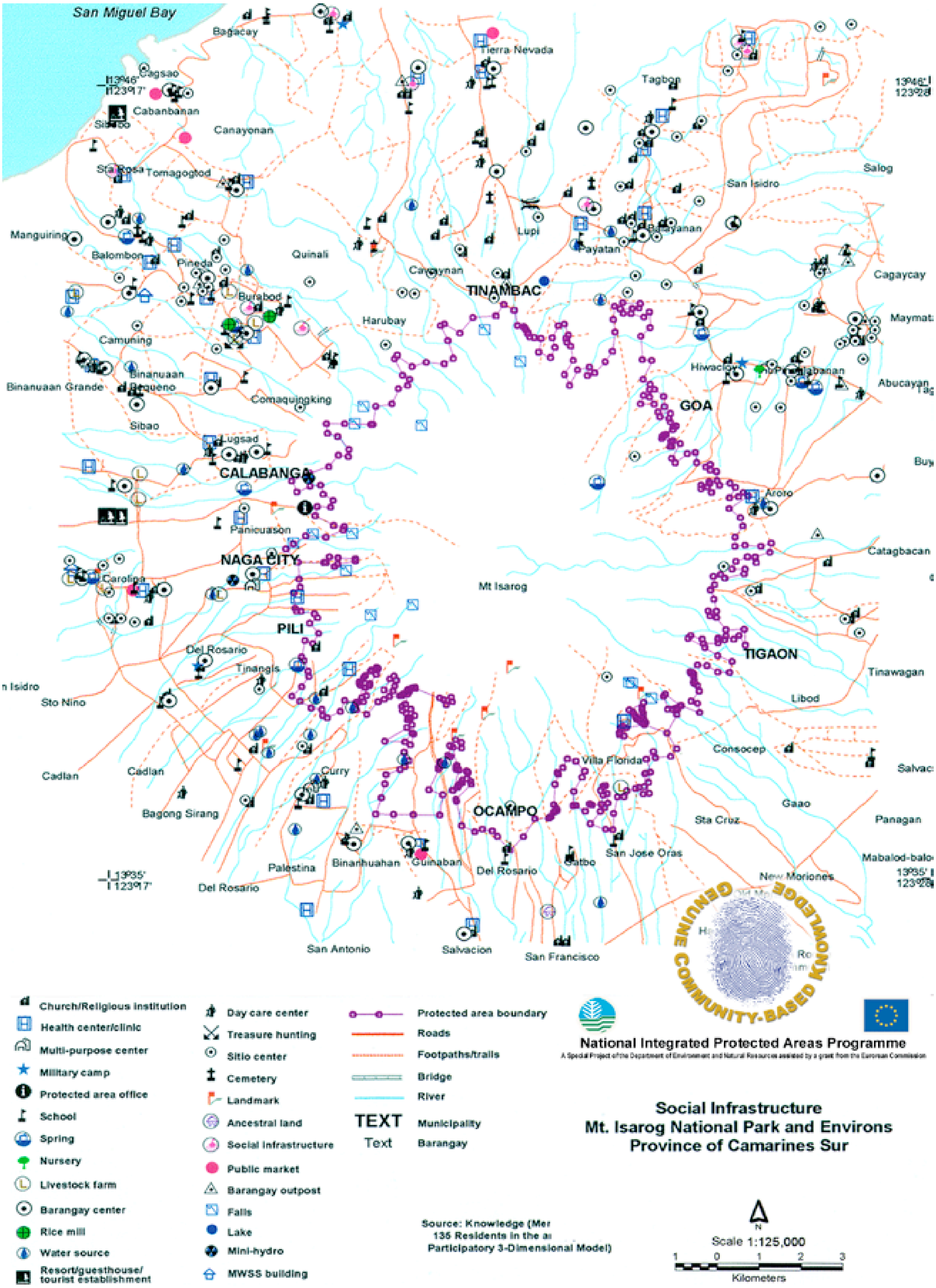
Appendix 19 Social Infrastructure Distribution Map. Mt. Pulag National Park and Environs. Provinces of Benguet, Ifugao and Nueva Vizcaya, Philippines (Source: P3DM, 1999)



APPENDIX 20 SOCIAL INFRASTRUCTURE DISTRIBUTION MAP. MT. MALINDANG NATURAL PARK AND ENVIRONS. PROVINCES OF MISAMIS OCCIDENTAL, ZAMBOANGA DEL NORTE AND ZAMBOANGA DEL SUR, PHILIPPINES (SOURCE: P3DM, 1999)



Appendix 21 Social Infrastructure Distribution Map. Mt. Isarog National Park and Environs. Camarines Sur, Philippines (Source: P3DM, 1999)



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