Participatory 3-D Modeling:
Bridging the Gap between Communities and GIS Technology

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- **Summary**

When brought at community level, Geographic Information System (GIS) applications are hardly manageable and replicable and strongly depend on outsiders' skills and facilities. As pointed out by Peter van Treffelen at the last GISDECO 2000 Conference held in Los Baños, Philippines, GIS facilities have been and still remain "islands of privilege". This paper focuses on Participatory Three-Dimensional Modeling (P3DM), which may effectively be considered as a bridge between the public and GIS. P3DM merges GIS-generated data and peoples' knowledge to produce stand-alone relief models. These provide stakeholders with an efficient, user-friendly and relatively accurate spatial research, analysis and decision making tool, the information from which can be extracted and further elaborated by the GIS. The 3D modeling process and its output (the scaled relief model) are the foundations upon which Public Participation GIS (PPGIS) can release its full potential increasing, among others, the capacity of local stakeholders to interact with national and international institutions. P3D Models provide local stakeholders and official policy makers with a powerful medium for negotiation, by easing communication and language barriers.

- **The power of maps**

In a recent publication, Janis Alcorn highlights 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." (Alcorn B. J., 2000)

The power of visualizing issues through cartographic means, particularly relief models has definitely ancient roots. During his reign (1661 to 1715) the Sun King, Louis XIV, commissioned more than 140 relief models of the cities that had recently been incorporated into the Kingdom of France, so that he could see for himself the bastioned fortifications proposed by his defense engineers Vauban and Louvois. The relief models manufactured during that period were both instruments of power and dissuasion. The gallery in Paris, where these models were stored was kept secret from the eyes of the public. Like a hidden vault, accessible only to a restricted elite, it contained spatially defined, visualized knowledge enshrining the entire power of the Kingdom. (Siestrunck R., 1980).

The maps produced by European explorers were another perfect expression of cartographic power: by ignoring indigenous names, and barely alluding to the presence of local settlements, in effect they declared the land to be empty and available (Poole P, 1998).

Aerial and satellite photography and the dawn of the digital era have yielded maps of unprecedented realism; today's Geographic Information System (GIS) technology allows earth surfaces to be portrayed in three dimensions with a precision unimaginable to previous generations of mapmakers.

In recent years there has been a strong drive towards integrating Geographic Information Systems (GIS) into participatory planning, particularly to deal with spatial information gathering and decision-making.

A strong debate has sprung out of the concern that the nature of and access to GIS simultaneously marginalizes or empowers different groups in society with opposing interests (Poiker T. and Sheppard E., 1995). A workshop on the matter took place in Durham (UK) in 1998. Researchers and practitioners debated the pros and cons of combining participatory research and GIS. The outputs of the event, well summarized in PLA Notes 33, 1998 (Abbot. J et al. 1998), counsel caution in using “community-integrated GIS”, especially in terms of final ownership and use of the generated information.

A follow-up “Empowerment, Marginalization and Public Participation Workshop” held in Santa Barbara (USA) in 1998 reminded us that the use of GIS in a genuine participatory context is still in its infancy. A number of cases presented as “participatory applications” of GIS, merely used demographic information or secondary data within a standard GIS environment (Jordan G., 1999). What has formally emerged is (a) the need to define "best practice", allowing for true participation in generating accurate spatial information; (b) the importance of determining the "added value" of using GIS and what the nature of participation should be, (c) the need to place emphasis on detailed monitoring and evaluation of processes, methods, accuracy and outcomes; (d) the fact that the use of GIS means that accuracy issues become important, which has profound implications for the classic spatial participatory tools such as participatory sketch mapping (Jordan G., 1999).

- **The Philippine Case**

In the Philippines for the past few decades biological and cultural diversities have been under great pressure by widespread conversion of forests into farmland, overexploitation of natural resources, population increase, movement of lowland communities into areas traditionally occupied by Indigenous Cultural Communities and the attempt made by various entities to “integrate” Indigenous Peoples into the mainstream of society.

Cognitive maps and peoples’ rights

Under present law, all land over 18 percent slope is deemed “public forest land” to which access is legally granted only in the form of limited-term agreements or concessions. Thus, while the Constitution (Art. XII, sec. 5) recognizes the “rights of Indigenous Cultural Communities to their ancestral lands,” until 1993 these were considered as “squatters" on public lands.

The first significant steps towards fulfilling this constitutional promise were taken with the issuance of the Department Administrative Order No. 2, series 1993 (DAO 2, S. 1993) by the Department of Environment and Natural Resources (DENR). This order established the Certificate of Ancestral Domain Claim (CADC). DAO 2 stipulates a process through which Indigenous Peoples (IPs) can delineate, document, and gain “recognition” of their “claim” to territory in the form of a certificate, or CADC. In order to avail of the legal stewardship entitling IPs to live, manage and utilize their ancestral domain, an applicant group has to meet a series of requirements including providing proof of use and occupation of given portions of the territory for times immemorial.

In this context maps exerted all their power in eroding a consolidated land tenure and resource access pattern and in influencing national policy making: cartography resulting from two and three dimensional community-based mapping supported by GIS applications[1] formed the foundations upon which Indigenous Peoples filed numerous applications.

As of June 1998, these resulted in the issuance of 181 ancestral domain certificates covering 8.5% of the national territory.

Furthermore the appeal and communication power of well presented maps produced for substantiating the majority of the claims, has been instrumental in building public support for the passage of the Indigenous People's Rights Act (IPRA), which provides indigenous groups tenurial rights on their ancestral domains. (Alcorn B J 2000).

The third dimension in conserving biodiversity

In June 1992, at the Rio Earth Summit, the Government of the Philippines signed the Convention on Biological Diversity and adhered to Agenda 21, thereby endorsing the concepts of conservation through participatory resource management, and environmental protection as the basis for sustainable development. Concurrently the Philippine Congress enacted the National Integrated Protected Areas System (NIPAS) act aiming at conserving biodiversity through – among others - the full participation of local communities.

In this context the European Union and the Government of the Philippines[2], initiated and co-financed the National Integrated Protected Areas Programme (NIPAP), a six-year (1995-2001) intervention aimed at establishing eight protected areas within the NIPAS framework. The challenge faced by the Programme has been how to give due weight to the interests of local communities in delineating protected area boundaries, identifying resource-use zones and formulating policies on protected area management.

- **Visualizing information**

NIPAP started action research in 1996. Protected area dependent communities were introduced to participatory approaches in data collation, analysis and interpretation. Spatial methods such as transect diagramming and participatory resource mapping were readily adopted, yet with reservations about "translating" sketch maps into more precise, useable information. In 1997, with the objective of generating durable, true-to-scale and "meaningful-to-all" information, the Programme developed a method, called *Two-Stage Resource Mapping* (Rambaldi et al.1998). Communities produced sketch maps. Thereafter, they transferred the information to blown-up topographical maps. After a final community validation, the outputs were extracted and transferred with minimal distortion to a GIS environment. Plotted data were then returned to the communities for validation and were used in subsequent consultations on zoning within the protected area.

While the method integrated people's knowledge and perceptions with additional resource management information, and returned the output to the communities for further use, it was observed that the basic input - the participatory resource maps - were spatially confined to the social, cultural and economic domains of those who had produced them.

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[1] As early as November 1993, the Environmental Research Division of the Manila Observatory assisted the Mangyan Alangan community in Mindoro Oriental in generating cartographic information to support the filing of an ancestral domain claim and for preparing the related domain management plan. (Walpole P. et al. 1994)

[2] Protected Areas and Wildlife Bureau, Department of Environment and Natural Resources.

Thus, in the case of protected areas and their buffer zones, covering hundreds of square kilometers and numerous *barangays* (the smallest unit of local government), the production of a sufficient number of community-specific sketch maps became unrealistic from both practical and financial points of view. Furthermore, the Programme had to acknowledge that a consistent part of the comprehensive analysis was done far from the field. Communities were presented, after several months, with GIS outputs for their comments, rather than being provided from the onset with a tool enabling them to do a comprehensive analysis of the protected area and its environs as a whole, locally. These were the limitations the Programme experienced in integrating people's knowledge and GIS capabilities, but all this was linked to the nature of the areas, covering extensive terrestrial and marine components and diverse ecosystems.

Committed to involving protected area-dependent communities in the planning process, the Programme was faced with the challenge on how to provide all stakeholders the opportunity to portray their domain as they view and know it and to avail themselves of an accessible medium understood by all.

- **Making information tangible through Participatory 3-D Models**

An answer suggested itself in the collation and plotting of data on scale relief models through a process outlined in Figure 1. The methodology is based on the integration of participatory spatial research tools and scaled spatial information (contour lines) provided through a GIS.

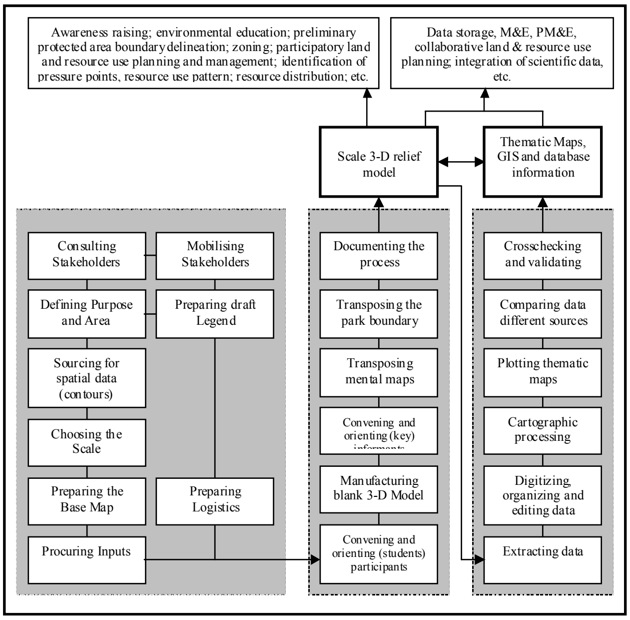

Figure 1 The Participatory 3-D Modelling process

Stakeholders are consulted on their interest in availing of a locally based 3-D model for planning, management and monitoring purposes. A consensus obtained, mobilization starts: the GIS produces a contour map at the desired scale (e.g. 1:10,000) including the protected area, buffer zones and other features of economic and ecological relevance. Facilitators procure the necessary inputs and mobilize the community for the phase where research, analysis and diagnosis are done sequentially.

High school students are best involved in assembling the scaled blank relief model where key informants are later assisted in transposing their mental maps. Informants include elders, indigenous people, other community representatives from the various activity sectors (fisherfolk, farmers, forest dwellers, etc.) national and local government officials, non-governmental organizations, etc, all contributing in a voluntary capacity. A legend is prepared according to an array of colours and various media (pushpins, yarn and paint) (see Table 1).

The process facilitates concurrent participation of men and women, people from different neighborhoods, social, educational, cultural and economic backgrounds allowing for *on-the-spot* validation of the displayed information.

Table 1 “Features” and the means to code and display them

	Features	Displayed by means of
Points	Water bodies (springs and waterfalls); mountain peaks; social infrastructures (municipal halls, barangay centers, day-care centers, schools, rural health centers, hospitals, bus stops); cultural places (churches, burial caves, cemeteries, sacred areas, etc); tourist establishments; human settlements (households l); scenic spots, turtle nesting sites; diving spots; docking sites, and others.	**Map and push pins of diverse color, shape and size.**
Lines	Water bodies (rivers, lakes); communication ways (roads, bridges, trails); social infrastructures (rural water supplies), boundaries (administrative units, protected area, Ancestral Domains, land status, etc); coordinates (grid)	**Yarns of different colors.**
Polygons	Water bodies (rivers, creeks, lakes, springs and waterfalls); cultural places (cemeteries, sacred areas, etc); tourist establishments; land use (rice fields, swidden, vegetable gardens, sugarcane and coconut plantations, orchards, reforestation sites, residential areas, etc.); land covers (mossy, dipterocarp and pine forest, grassland, brushland, mangrove, etc.); land slides and bare land; fish breeding and spawning areas; feeding grounds of endangered species; fishing grounds (differentiated as squid and pelagic fisheries); areas where destructive methods are employed, coral reefs (differentiated into "intact" and "damaged");	**Acrylic paint – different colors.**
Attributes	Names, annotations	**Text on labels**.

Once completed, the relief model contains spatially defined detailed information on land use and land cover, settlements, communications, social infrastructure, sacred places and many other features. The output is self-contained and can be used as it stands for the desired purpose. Nonetheless, discussions centered on use of and access to resources located within a protected area can be initiated only after visualizing the protected area boundary.

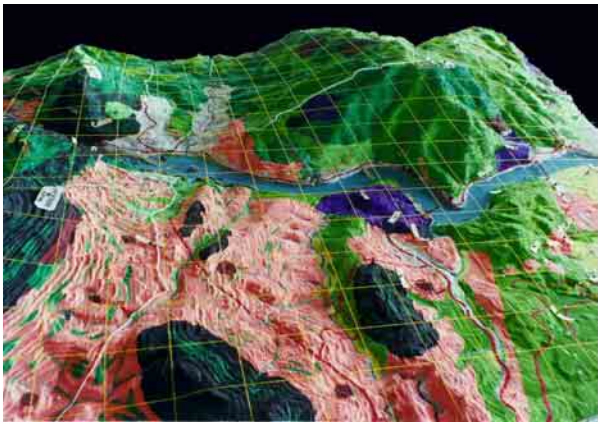

Figure 2 Three-D model with geo-referenced grid

At this stage, GIS-generated information comes back onto the scene.

Based on the outline of the source map, a geo-referenced scaled grid is placed on top of the relief (Figure 2). For 1:10,000 scale models, the grid has 10-cm intervals. The resulting squares correspond to 100 hectares. Latitude and longitude coordinates of the boundary corners are identified on the source map and reflected on the relief model. The corners are connected by the use of a color-coded yarn. At the end of the exercise the outline of the protected area boundary is visible to everybody.

The relief model is now ready to be used for any type of discussion on resource use, distribution and access, for participatory problem analysis and for planning.

- **Linking People's knowledge to the Geographic Information System**

In order to use the 3-D model for Participatory M&E or for combining thematic layers of different sources, the information has to be extracted and stored. In practice, whatever is displayed on the model is transferred to transparent, grid-referenced plastic sheets (Figure 3) in the form of points, lines and polygons. Attributes (non-graphic information like names, descriptions of land use or cover) are consigned to a legend. Plastic sheets and accompanying notes are handed over to the GIS, which digitizes, stores and edits the data. Administrative boundaries are integrated and attributes are assigned to points, lines and polygons. Colors and symbols are allocated to the different attributes. A legend is prepared and joined to other cartographic information like scale, title, source of information (including date), coordinates, directional arrows, etc. Customized thematic maps are produced at the desired scale. Outputs are then compared with other existing spatial information, such as satellite-interpreted imagery. In the cases examined by the Programme, cognitive maps contained more features and were more precise than satellite interpreted information.

Figure 3 Information is extracted

Inconsistencies among data sets were encountered in almost all sites. Validation has been done in the field by reconvening around the P3-D Models with a sufficient number of residents or through direct on-field investigation.

Experience has shown that "pooled people's knowledge" merged with traditional spatial information (contours) is not only accurate but more detailed and updated than that maintained in official circles.

- **The use of P3-D Models in Protected Area Planning and Management**

Figure 4 1:10,000-scale relief model of Mt. Malindang National Park and environs

On January 4, 2001 the Philippine Department of Environment and Natural Resources institutionalized Participatory 3-D Modeling by virtue of Memorandum Circular No. 1, S. 2001 as a process to be adopted in protected area planning and management.

The technique has been rapidly spreading and as of June 2001 about 7% of the initial 209 components of the Philippine National Protected Area System (NIPAS) have been reproduced in the form of scaled 3-dimensional models. The models include inland and coastal ecosystems. Most of these are home to indigenous groups and contemporary migrants.

Once completed, the models (and the GIS-generated maps) have been entrusted to the Protected Area Management Boards or to the concerned Protected Area Offices. The physical outputs of the process are therefore two: the relief model and the GIS-generated maps. Both are permanently displayed within the proprietor community.

- **P3D Models and GIS**

The 3D modeling process and its output (the scaled relief model) are the foundations upon which Public Participation GIS (PPGIS) can release its full potential increasing the capacity of local stakeholders to interact with national and international institutions.

In fact the models and derived maps allow local stakeholders to:

  - Use geo-referenced cartographic information – based on people's knowledge - in official and legal contexts, to assert rights over land and waters;
  - Use the models and the maps as a means to communicate with external agencies, geo-coding their priorities, aspirations, concerns and needs;
  - Play an active role in developing management, zoning and resource use plans and lead in delineating boundaries;
  - Conserve and reinforce local/traditional knowledge;
  - Teach local geography and enhance the interest of younger generations in conserving and/or restoring natural resources;
  - Discuss environmental, land tenure, ancestral rights issues and resolve internal conflicts;
  - Monitor changes in settlement pattern, land use and vegetation cover;
  - Introduce visitors to the area.

- **Lessons learned**

  - Relief models are excellent visual aids capturing the ruggedness and details of the territory. Users can see and feel the contours of every mountain range and river valley. Information portrayed through shape, coded materials and colors is made tangible and meaningful-to-all. It eases communication and language barriers. Two-dimensional maps cannot match their impact and appeal. Compared to data appearing on a planimetric map (e.g. contour lines), a relief model enormously facilitates their assimilation, interpretation and understanding.
  - Process and output have proven to fuel self-esteem, awareness of interlocked ecosystems and intellectual ownership of the territory.
  - Especially when dealing with relatively extensive and remote areas, P3D modeling bridges logistical and practical constraints and facilitates public participation in land/resource use planning and management.
  - Participants and users get a "*bird's eye view*" of their environment. This enhances analytical skills, broadens perspectives on interlocked ecosystems and helps in dealing with issues and conflicts associated with the territory and resource use.
  - Relief Modeling has many positive edges, but it is a demanding process entailing initial and final services of a Geographic Information System, accurate procurement of supplies, thorough groundwork to mobilize participants, skilled facilitators, space for storage and display, and caretakers. 3-D models are hard to move around. Digitizing the information and plotting it on paper maps, helps overcoming this.

- Because of their accuracy, P3-D Models, alone or combined with GIS, turn local knowledge into public knowledge and conceivably out of local control. This can be used by outsiders to locate resources and development needs, or merely, to extract more resources, or to increase control from the outside. (J. Abbot et al. 1999). Planners should be aware of these realities and be careful in applying this process. Thus, plotting endangered species, hardwoods, and other resources in demand on the black market, should be done with caution and invariably behind closed doors in the course of focus group discussions. This sensitive information should be removed from the model before displaying it to the public.
- A P3D model is never completed. Like any dynamic system, changes are constant and the model (like a GIS) can accommodate regular updating. Unfortunately a relief model cannot memorize past scenarios. This is the context where GIS "adds value" and becomes a vital ingredient for Participatory Monitoring and Evaluation (PM&E) [3]..

Conclusions

In the context of the Philippines, P3DM is now institutionalized and has gained tremendous interest. It has proved to be an extremely efficient community-based management and communication tool.

With some additional improvements it may be viewed as "best practice" for allowing true participation in generating, storing and analyzing geo-referenced information.

As distinct from sketch maps or sole GIS outputs, a well-displayed and properly stored 3D model is appealing, fuels community-esteem and sense of intellectual ownership. An enormous amount of information is collated and permanently displayed at community level, where it is readily accessible to local residents and outsiders. A model becomes finally part of the local cultural landscape.

Participatory three dimensional models can be considered as rudimentary community-based Geographic Information Systems: in fact the use of different coding means allows for the composition and storage of thematic information layers; this in turn facilitates community-based analysis of spatially-defined information and the display of results. The 3D modeling process and its output (the relief model) are the foundations upon which Public Participation GIS can release its full potential in displaying multiple realities and conflicting interests through the eyes of all concerned stakeholders.

The synergy derived from combining P3DM and GIS results in a powerful communication medium which bridges the gap between Indigenous Technical Knowledge and Information Technology, and increases the capacity of local stakeholders and policy makers to interact locally and with external agencies and central governments.

NOTES

Additional information and updates on P3DM are available on the web site **Participatory Avenues** at http://www.iapad.org

[3] Updated at regular 2-3 year intervals, a 3-D model allows for actual PM&E. This is based on the assumption that data contained in the model are dutifully updated and periodically extracted, digitised and plotted in the form of thematic maps.

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