Participatory 3-D Modeling for Climate Change Adaptation in India: Experience, Guiding Principles, Future Opportunities

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Preface

The Watershed Organization Trust (WOTR) has long recognized the value of public participation in sustainable rural development. Participation and governance at the stakeholder level are crucial for the success and sustainability of any grassroots resource management plan, as proven by WOTR's early Watershed Development projects in rural Maharashtra. The achievement of natural resource security through local governance requires effective communication between three main players: indigenous communities, project facilitators, and relevant governmental bodies. However, this level of communication is difficult to achieve in reality, for several reasons. For one, traditional indigenous knowledge is often ignored by policymakers in preference of quantitative spatial data collected remotely, interpreted, and applied without the consideration of local experience, land use or cultural identity. Secondly, natural resource scarcity is a complex issue, with many interrelated contributing factors that are not always recognized or controlled by indigenous communities. To empower stakeholder communities with the understanding of this complexity and the capacity to engender plausible solutions mandates a significant input of time, a well-established relationship of trust between stakeholder communities and community organizers, and a set of effective tools for local capacity-building and communication with relevant external parties (i.e. policymakers, academic researchers, and development agencies).

For over half a century, participatory mapping has been commonly used as a tool in rural development for communicating indigenous spatial knowledge. Community "sketch" maps, for example, convey local human relationships with the surrounding landscape, but are used principally for internal project purposes rather than for collaboration with external interest groups. These maps often lack a precise geo-location and/or consistent scaling. They are useful for temporary, localized purposes, but are not usually acknowledged by research scientists or governments as "credible" spatial information. Because rural indigenous communities traditionally lack access to modern geographic information technologies (GIT) used by government bodies, development agencies, and research institutions, they have been historically excluded from decision-making processes regarding the development and management of their local landscapes and resources.

So, while participatory mapping for development is not a new concept, the application of GIT at the grassroots level, especially for indigenous peoples, has only emerged in the last two decades. Participatory Geographic Information Systems, or PGIS is a set of various methods that attempt to convey indigenous experience and spatial knowledge in a digital form that is communicable to researchers and policymakers, theoretically empowering indigenous communities with a voice in the legislative planning and management of natural resources. A PGIS method called Participatory Three-Dimensional Modeling (P3DM) has surpassed the benefits and overcome the drawbacks of other PGIS methods. Through the construction and demarcation of a geo-referenced, scaled relief model, Indigenous communities can extract and display indigenous knowledge in a way that is meaningful not only for policymakers and academics but also to the communities themselves. P3DM was conceived in the late 1980's in Thailand, and has since been developed and used as a spatial communication and planning tool for resource-dependent communities across Southeast Asia and other parts of the Global South, where local access to computers is virtually impossible.

To date, WOTR has completed two trials of P3DM, one for exposition at the Shiswad Biodiversity Festival in December 2011, and the other as an educational tool for a capacity-building workshop on Climate Change Adaptation, held in February 2012 in Madhya Pradesh for a new project village cluster. Each trial informed potential improvements to our methodology, and we are continuing to adapt P3DM to fit WOTR's specific project objectives. The purpose of this manual is to provide important guidelines for the implementation of Participatory 3D Modeling (P3DM) for WOTR's Climate Change Adaptation (CCA) project. After experimenting with P3DM within the CCA context, we believe that this method can be highly effective for the following:

1. The improvement of local capacity to understand and address the conceptual complexity of climate change
2. The enhancement of participation by project villages in their own resource planning, disaster risk reduction (DRR), and other programs associated with the CCA project
3. The communication of indigenous spatial knowledge concerning land use, cultural identity and environmental history among local villagers and WOTR staff, which pinpoints vulnerabilities and refines development objectives
4. The effective transfer of indigenous spatial knowledge to relevant government officials and other development agencies via geographic information technologies

It is important to mention that this is a "working manual" on P3DM, as WOTR's particular adaptation of the tool remains in its nascence. This document is intended to represent our interpretations of and ambitions for P3DM based on two trials. In order for full effective incorporation into WOTR's CCA project, this tool must be continually expanded, edited, and ratified. We believe that P3DM is an inherently adaptive tool, and therefore encourage future practitioners to consider specific village needs while following these basic guidelines. We anticipate that P3DM will become an important element of our goals to further empower and capacitate our project villages for increased involvement in resource management and climate change adaptation at the village level.

Introduction: Participatory 3-D Modeling for Sustainable Rural Development

When GIS meets Participatory Learning and Action: Participatory GIS

Participatory GIS (PGIS) was conceived in the mid 1990's as an attempt to incorporate emerging GIS technologies into international development initiatives by involving stakeholder communities into local mapping processes and environmental decision-making. PGIS transcends the limitations of earlier Participatory Learning and Action[1] methods for community mapping (such as sketch maps) towards a more technical approach using the same technology employed by governments and academic researchers for resource management. PGIS, by contrast, uses GIT to produce maps based on stakeholder perspectives of their environment, which include sociocultural and behavioral elements of human landscapes that are often ignored in governmental or research-based GIS analyses. PGIS is grounded on the assumption that the creation of digital, geo-referenced maps by marginalized communities (such as rural indigenous peoples in developing countries who have been historically excluded from environmental decision-making), encourages the recognition of local indigenous knowledge by governmental bodies and research institutions as credible forms of spatial information. Access to GIS technology, according to PGIS practitioners, allows marginalized communities to effectively voice their development concerns across a wide geographic extent and at local, regional, national, and international levels for the purposes of awareness-raising, advocacy and collaboration among other interest groups.

However, several well-documented challenges arise when a highly expensive, complex technology such as GIS is introduced to indigenous communities in developing countries. The most prominent concerns the issue of governance. If the goal of a PGIS initiative is to establish complete community ownership over a map and its contents, the stakeholder community must have full control over 1) data collection and ownership, 2) establishment of the map legend (i.e. decision-making concerning the maps contents), 3) data processing and map production. The implication here is that stakeholder communities must learn how to implement GPS and GIS independently and sustainably. This has worked well in Western contexts, where communities generally have an understanding of cartographic principles and easy access to computers. For isolated, rural communities in developing countries who are not proficient in English and have never been introduced to computer science, complete stakeholder governance of PGIS is virtually impossible. Many PGIS initiatives for rural indigenous communities therefore employ external GIS practitioners to collect relevant spatial data from stakeholder communities, after which the data is then processed and finalized outside of the community. While GIS has the ability to store and display large amounts of high-resolution spatial data, the software also greatly facilitates, and intentionally so, the manipulation of such data by the user. Without a system of complete accountability for adequately expressing indigenous perspectives in digital form, PGIS initiatives can emulate the predominant top-down management models they were designed to neutralize. The misinterpretation or misuse of such knowledge, should it fall into the wrong

[1] Participatory Learning and Action (PLA) is an overarching term for various approaches to international development from the grassroots level, which seek to empower local communities with maximal ownership over development goals by encouraging stakeholder participation. Many of these methods are documented and available online by the International Institute for the Environment and Development (IIED).

hands, can lead to intentional or unintentional exploitation of indigenous communities or their environments. There seem to be a lesser degree of community empowerment and a greater possibility of continued community marginalization when the spatial data and resulting map do not remain in stakeholder control, and for this reason many PGIS projects in developing countries are criticized for not being as "participatory" as they should be.

Participatory 3-D Modeling: Development and Design

Participatory 3-D Modeling is a community mapping tool that combines indigenous spatial knowledge with topographical and other geophysical information to produce a scaled-relief model of the local domain. The process is carried out over multiple days in a workshop-fashion, amongst a group of representative participants from the indigenous community and several external facilitators. The group assembles around a common purpose pertaining to the local environment, to which P3DM will contribute. Then, using enlarged topographic maps of the local area, participants construct the model by superimposing layers of corrugated cardboard – each traced from a single topographic contour line – and demarcating the model with relevant spatial features stored in the community psyche. The complete model can be transposed into GIS via manual tracing techniques or digital photography, thus producing a digital, geo-referenced map that can be used for collaboration with governmental bodies and research institutions. The model itself thus remains with the community for internal use and future modification.

Since its origins in Southeast Asia in the late 1980's, P3DM has emerged as an effective tool for indigenous community-based resource conservation and planning, territorial conflict mediation, and disaster risk reduction, among other uses pertaining to land and natural resources in developing countries.[2] It has also presented itself as an excellent alternative to previous PGIS methods, in that P3DM inherently places relevant spatial data under the complete control of stakeholders, reduces the risk of data corruption, and

Potential Benefits of Participatory 3D Modeling for Indigenous Peoples

- Enhanced **visual recognition** of important spatial features and boundaries
- Improved **understanding** of ecological complexities, vulnerabilities and the consequences of human behavior on the landscape
- **Community cohesion** and **collaboration** over indigenous perceptions, needs and concerns a collective space of knowledge-sharing
- Increased **self-esteem** and **motivation** amongst stakeholders to participate in development interventions
- Effective **communication** of indigenous knowledge, development needs, and planning strategies amongst indigenous communities, NGO's, government bodies, academic researchers and international development agencies

[2] A comprehensive list of P3DM applications, case-studies, handbooks, and other PGIS publications can be freely accessed at www.iapad.org, a not-for-profit venture of *Participatory Avenues*.

Applications of Participatory 3D Modeling Across the Global South

- **Protected Areas Management** (Philippines)
- **Watershed Management** (Philippines)
- **Securement of Legal Right to Resources** (Ecuador)
- **Ancestral Heritage and Cultural Sustainability** (Philippines, India, Uganda, Fiji)
- **Territorial Conflict Resolution** (Philippines)
- **Disaster Risk Reduction**
- **Community Forestry** (Nepal)
- **Participatory Land Use Planning** (Thailand, Nepal, Ghana, Ethiopia, Kenya, Sri Lanka, India, Honduras)
- **Education and Communication** (Nepal, Morocco, Guatemala, Philippines)
- **Collaborative Research** (Thailand, Vietnam, Philippines, Colombia)
- **Climate Change Adaptation** (Papua New Guinea, Philippines, Solomon Islands)

These examples have been gathered from www.iapad.org, an official website of P3DM, PGIS and other Participatory Mapping documentation. See this website for details.

reveals geographic information and indigenous spatial knowledge in forms that are accessible to both stakeholder communities and policymakers.

Rather than depending exclusively on GIS technologies and abstract maps, P3DM employs a precisely scaled, physically and mentally tangible model using locally available materials. Participants control the spatial data displayed on the model by establishing a consistent legend using various colors of pins, yarn and paint for points, lines, and polygons[3]. In a typical PGIS process, these features would be inserted digitally into a map from GPS data, which is less intuitive and less participatory. It can therefore be assumed that the resulting map is less meaningful to those who provided the spatial data. By contrast, P3DM engages participants in the mapping practice from cradle to grave: from the construction of the base model to the digitization of the complete demarcated model. Establishing complete control of the model and its legend by a group of community members rather than a single or few GPS/GIS users engenders a sense of community ownership that is an important motivator in expanding participation in environmental decision-making processes. Indigenous communities may not be able to take part in the full GIS digitization of the model, for the same reasons mentioned earlier. However, this becomes less of a concern in P3DM because the points, lines, and polygons reflecting collective indigenous knowledge are already secured in the model by the participants. The risk for data corruption or misinterpretation is therefore significantly less than if the data was collected and processed by one or a few external GIS experts.

Also significant are the distinctive cognitive processes that occur within indigenous communities when working with a three-dimensional model as opposed to a two-dimensional map. The addition of a precise and consistent vertical scale to a map is unique to P3DM, and can greatly enhance spatial recognition by indigenous communities because spatial knowledge is three-dimensional, rather than two-dimensional. Landmarks are easily identified when observers can visualize the terrain. Once participants can precisely locate themselves, they can then move towards identifying other important features that pertain to their

[3] Points, lines, and polygons are the forms by which spatial features are logically presented in GIS. Points represent discreet locations, like village dwellings or wells, lines represent single continuous features, such as rivers and boundary lines, and polygons represent features with larger areal extents, such as a forests and reservoirs.

relationship with the environment. Thus the physical tangibility of P3DM increases the accessibility of indigenous spatial knowledge.[4]

Participatory 3D Modeling emphasizes the means as much as the ends. While other PGIS initiatives have focused largely on the resulting maps, many advantages of P3DM lie in the process of constructing and demarcating the model. The construction of a three-dimensional model from a two-dimensional topographic map is both a labor and time-intensive endeavor, but in this time participants engage together in a critical space of collective learning and knowledge-exchange. Older generations may share stories with younger generations. Men and women discuss and compare their distinct relationships with the land, and critical environmental concerns and vulnerabilities are allowed to freely emerge.[5] It would be incorrect to assume that the cognitive spatial perspectives of each individual participant are identical, and sometimes this process may lead to disagreement and require compromise amongst participants, which in itself is a vehicle for indigenous spatial knowledge verification. By engaging participants in a space of hands-on discovery learning[6], P3DM further lends itself to enhanced community collaboration and participation in environmental decision-making.

Participatory 3-D Modeling for Climate Change Adaptation in India

Climate Change Adaptation: An Integrative Approach to Rural Sustainable Development

Few can deny that the natural, social, political, and economic climates of the world are changing. Environmental degradation, caused by global overconsumption, dismantles food, health, and livelihood security, and affects first and foremost the millions of people across the world that depend on locally available resources for survival. Because the long-term consequences of these changes are uncertain, there is little choice for these communities other than to minimize community vulnerability to change, while maximizing resilience.

Since 2008, The Watershed Organization Trust (WOTR) has pursued a Climate Change Adaptation (CCA) project in supplement to its former Watershed Development (WSD) work in rural Maharashtra, Madhya Pradesh, Andhra Pradesh and Rajasthan. While recognizing that direct access to water is at the core of food, health, and livelihood security in rural India, WOTR seeks further to address the cultural and behavioral complexities that contribute to resource scarcity. This initiative attempts to

Climate Change Adaptation: Project Components

- Watershed Development
- Adaptive Sustainable Agriculture
- Agro-Meteorology
- Water Budgeting
- Biodiversity & Ecosystem Services
- Disaster Risk Reduction
- Sustainable Livelihoods & Localization
- Alternate Energy

[4] Rambaldi, G. 2010. Participatory 3-Dimensional Modeling: Guiding Principles and Applications, 2010 edition. CTA, Wageningen, the Netherlands, p.6

[5] Rambaldi, G., Callosa-Tarr, J. 2000. Manual on Participatory Modeling for Natural Resource Management. *Essentials of Protected Area Management in the Philippines*, Vol. 7. NIPAP, PAWB-DENR, Philippines.

[6] Rambaldi, G. Participatory 3-Dimensional Modelling: Guiding Principles and Applications, 2010 edition. CTA, Wageningen, the Netherlands.

combine technical strategies with educational and capacity-building methods that provide communities with maximal ownership over their own development plans to alleviate poverty. The approach to CCA is systemic in nature – it comprises a variety of elemental, interconnected development processes that commonly aim at improving a community's overall ability and incentive to adapt to change – be it environmental, political, or economic. Therefore, much of the work of CCA focuses on technical *and* awareness-building endeavors that seek to 1) enhance community awareness so that lifestyle behavior sustains and benefits local ecosystem resources and 2) provide communities with the necessary tools and support to develop plans for more independent, community-based governance initiatives pertaining to overall development goals.

While the role of WOTR field staff for CCA is to provide practical guidance during project implementation and enhance community awareness surrounding the vast complexities of climate change and ecosystem dynamics, the principal body of knowledge that should inform any CCA project must come directly from the village communities themselves. Indigenous communities, as mentioned earlier, have an immense amount of knowledge stored in their collective histories that has been adjusted and refined by hundreds of years and many generations of experience. WOTR recognizes that without the active participation of stakeholder communities, and the acknowledgement and incorporation of this knowledge into development plans, any CCA initiative will undoubtedly fail. The need for capacity-building and educational tools for CCA, which address the complexities of human-environmental relationships while simultaneously placing indigenous knowledge at the forefront of project goals, is therefore paramount.

Applications of P3DM for Climate Change Adaptation

The following sections are brief descriptions of specific potential P3DM applications for WOTR's Climate Change Adaptation project.

Disaster risk reduction

Disaster Risk Reduction (DRR), as a concept, represents the overall purpose of Climate Change Adaptation, as the overall objective is to prepare communities for responding to potentially-disastrous changes. As an element of CCA, DRR focuses on providing communities with the necessary tools and resources to bolster their resilience to disasters while simultaneously minimizing their vulnerability. The primary objective of DRR is to instigate a Community-Based Disaster Management (CBDM) plan, wherein village communities first identify disasters to which the community is vulnerable and the contributing factors to vulnerability. Then, the community takes steps to address these factors while building a response-plan for use in the case of disaster.

This element of CCA possesses a large spatial component, as some vulnerability tends to be physical. For example, a DRR mapping study in Khadki Budruk, within the Akole project cluster, revealed that electrical poles around the village were frequently emitting sparks, creating major fire hazards above village homes. The identification of physical hazards is an important initial step in the CBDM process, and a large-scale P3DM can be of great aid here. On P3DM maps at 1:5,000 scale or larger, village infrastructure can be identified. On such a model, participants can demarcate physical "hazard hotspots" and "population hotspots" – any landscape feature which increases the risk of a particular disaster. Once physical hazards are identified on the model, the path has been paved for discussion of less tangible hazards, which are more conditional than physical. For example, landslides were a common hazard within Shiswad village. On a P3DM, participants can demarcate landslide-prone “zones”, where one should avoid or take precaution when nearby, especially during the rainy season. To bring a community together over the P3DM process, where old and young, men and women can collaborate together, is of great value in the CBDM initiative, because the information is clearly communicated and spread throughout the entire village in the form of a tangible, three-dimensional model. By making information tangible and localized, villagers exhibit a more thorough understanding of complex issues, and are better capacitated to make significant positive changes to increase community resilience.

A digitized P3DM poses further substantial benefits to DRR by effectively communicating regional vulnerabilities to government agencies. If presented and communicated in an “official” format, relevant government administrators will ideally be more willing to listen and respond to institutional needs pertaining to the reduction of disaster risk for remote, rural villages.

Education and Capacity Building

It is often difficult to visualize and comprehend changes that happen over generations. Human behavioral impacts on ecosystems are slow, complex and interrelated, but an understanding of these are crucial, if there is any possibility of reversing loss of biodiversity and environmental degradation. As a part of CCA, WOTR seeks to educate village communities on these issues, with the hope of building awareness to detrimental behaviors that perpetuate poverty.

P3DM aids in these educational strategies because it brings these difficult concepts to the local landscape. In the model construction process, participants literally watch their homelands appear before their eyes. They can visualize and articulate how the landscape has changed over generations. By bringing these complex notions into a local context is extremely valuable for communities with very little formal education or contact with other types of landscapes. P3DM is an educational tool that speaks in the universal language of space, which is accessible not only by adults, but also by children. As the capacity of village children to adapt to climate change represents the future of these villages, P3DM therefore makes a powerful educational tool in instigating behavioral change.

Watershed Development

Reliable ecosystem services are essential for maintaining village health and economic security. Therefore, practices which regenerate degraded ecosystems and aquifers are the crux of Watershed Development for CCA. However, it is absolutely vital for the sustainability of these ecosystem services that as much input and decision-making power comes from the village communities themselves. P3DM can enhance public participation in Watershed Development plans by providing a visual representation of planned infrastructural related to Watershed Development. This may involve continuous contour trenches, areas for which grazing may be banned to allow forest regeneration, or the locations of agro-met stations. WOTR’s watershed planners and agro-meteorologists can work together around a P3DM model that can be adjusted and ratified should the need arise, keeping the entire village informed of its progress.

Sustainable Agriculture[7]

Establishing practices for more sustainable agriculture will contribute largely to the securement of local soil and water resources. It lowers the overall cost of agriculture while maintaining yield, meaning that sustainable agriculture bolsters the economic security of rural villages. P3DM can be used in sustainable agriculture initiatives as a planning tool. Village communities can plan which fields should lie fallow, plan for crop rotations and companion planting. Again, the P3DM model can be amended on the basis of need, keeping the entire community up to date with current plans and objectives.

Biodiversity & Ecosystem Services

Biodiversity loss is a major contributing factor to resource scarcity. Common mono-cropping practices diminish soil nutrients, and deforestation destabilizes topsoil and destroys critical habitats. Without a common understanding of human-behavior/environment relationships, it is difficult for villages to understand the importance of bans on grazing, for example. Sustainable management of natural resources should go hand-in-hand with ecosystem stewardship. WOTR seeks to emphasize the importance of biodiversity, with the hope of encouraging villagers to recognize the inherent value of healthy ecosystems and incorporate this value into everyday behavioral choices. One mechanism, the People's Biodiversity Register (PBR), has been developed by WOTR and is currently being used as a capacity-building tool, by which village communities gather local plant specimens, record, and assess their local factors of biodiversity. The hope is that village communities can develop a conservationist mentality with regards to their local ecosystems

P3DM greatly enhances PBR of this topic because of its localized, interactive nature. Participants can demarcate "biodiversity hotspots" and fragile eco-zones. The entire PBR initiative can be mapped spatially, therefore communicating this information and creating awareness throughout the entire village.

Eco-Tourism

Eco-Tourism is a more distantly-related component of CCA than others. While may have little impact on the natural resource-base of village communities, it certainly has an impact financially. Eco-Tourism provides visitors an experience in rural Indian culture by exposing them to the realities of everyday village life. The desired outcome is that visitors are more aware of how rural people live, the challenges they may face, and the impact their urban lifestyles and daily choices may have on rural communities. In turn, Eco-Tourism provides a community income, which bolsters the local economy and provides an alternative livelihood option to agriculture.

Complete P3DM models are interactive, interesting to view. They highlight spatial information that is considered valuable to the local community, and are therefore informative and meaningful to visitors. A P3DM can portray popular vistas, and provide suggestions for tourism activities, as well as locations that are

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[7] P3DM has been used by the North Eastern Region Community Resource Management (NERCRM) project for sustainable agriculture initiatives in the village of Sasatgre, in the West Garo Hills of Northeastern India. For details see the following: http://ictupdate.cta.int/Feature-Articles/P3DM-Mapping-for-sustainable-agriculture. Project supported by the International Fund for Agricultural Development (IFAD).

culturally significant. Having been built by the community itself, a P3DM can be a source of village pride and community cohesion, which is important in successful Eco-Tourism. These models, once constructed and demarcated, clearly continue their value not only as internal planning tools for education development but also as a way to build awareness amongst external parties. P3DM models should therefore be kept and maintained in the village itself, in a commonly visited location for maximum continued awareness-raising benefits.

Method Overview

P3DM has been used and heavily documented since the late 1980's across the Global South. Today there are detailed handbooks freely available online[8], and one is can be found in the appendix to this manual. It is highly recommended that future practitioners read this supplemental manual by the , as many important details are provided there that are not present in this general overview. However, several adjustments have been made to P3DM in WOTR's implementation, and those will be outlined here. Detailed instructions and a supply list can be found in the Appendix.

Project Planning

P3DM requires significant planning by facilitators prior to engagement with local communities. The intended purposes of the P3DM model must be clearly stated and strictly followed throughout the process. This is necessary because 1) the intended purposes of the model will determine supplies purchased, and 2) Due to the time commitments to P3DM, a continually reinforced and communicated purpose reduces confusion amongst participants and guides progress. So, in order to establish and maintain the specific objectives for P3DM in any case, several decisions must be made and tasks completed before any other steps are taken.

1. **Declaring the Purpose:** P3DM is a highly adaptable tool that can be used for many purposes related to rural development. However, the specific purposes of any given P3DM project should be stated clearly and posted in a visible place throughout the entire process, to keep both participants and facilitators on task.
2. **Determining Scale:** The scale[9] of the model will determine what features will be displayed. Large scale maps (scale 1:5,000 or higher) will be able to show buildings, bridges, and other infrastructure relevant Disaster Risk Reduction, for example. By contrast, small scale maps (1:10,000 or higher) are best for dealing with large areal extent, as is necessary in Watershed Development and Biodiversity. While many benefits of P3DM do not depend on scale, the map's scale will determine the overall scope of the project, and is therefore an important part of the planning process. It should be noted that the vertical scale depends on the thickness of the corrugated cardboard that are locally available.

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[8] See www.iapad.org

[9] See the attached manual, p. 6-8 for details on determining horizontal and vertical scales.

3. **Determining Size:** The scope of a P3DM initiative will also depend on model size. Will this model be displayed for public awareness? In this case, larger maps are better. Is the map intended for planning purposes only? Then, perhaps a smaller model will suffice. This also should be decided prior to procuring necessary materials.
4. **Training and Preparing Facilitators:** The positive outcomes of P3DM depend heavily on the reliability and transparency, and commitment of P3DM facilitators. It is therefore mandatory that facilitators have a thorough understanding of P3DM and are prepared to guide participants through the process using clear communication. It is also ideal if some of the facilitators have had prior contact with the village, an understanding of the local sociopolitical situation and a familiarity with the participants.

Procuring Materials and Associated Secondary Data[10]

The next step in the P3DM process is the procurement of necessary materials. This step highlights the importance of the initial planning decisions discussed above, because these decisions determine types and amount of supplies needed. The supply list for various applications of P3DM will vary, but generally materials may be grouped into the various stages of P3DM. In other words, certain materials will be necessary for 1) construction of the base model 2) demarcating the base model 3) digitizing a complete model into GIS (if this step is included). A general supplies list can be found in the appendix to this manual.

P3DM relies on the availability of topographic data on the area of interest. For adjusting the scale to specific needs, it will be necessary that this data is digital. Having digital baseline data also facilitates accurate demarcation as well as model digitization. Digital Elevation Models (DEM's) can be purchased from the State Government. To date, WOTR has digital topographic data for the Akole, Pathar 1 and Pathar 2 clusters but not the cluster in Madhya Pradesh. Standard reference contour intervals are 20m, although 10m contours may be more ideal. This will depend on the chosen map scale. Once size, scale and contour interval are determined, 2D topographic maps must be extracted from DEM's or scanned toposheets, and printed to the exact size of the planned P3DM model for tracing and cutting the cardboard contour layers.

Organizing Participants and the Construction Venue

Prior to beginning the model construction, it is necessary that the participants are organized and informed about P3DM and the intentions for implementing the tool in their village. Participants should volunteer on their own accord, and the group would ideally consist of men and women as well as elders and young children, to enhance community cohesion and establish a truly representative body of the stakeholder village. If village leaders and WOTR-affiliated village representatives (such as SHG's and Vashundhara sevaks) are not involved in the P3DM constituency, they should be at least included in the initial introductory P3DM sessions. It is also important to make the entire process open to whoever within the village community would like to observe the process.

[10] See the attached Manual on Participatory 3-D Modeling for Natural Resource Management (Rambaldi and Callosa), p.9 for details on materials procurement.

Other P3DM projects have divided participants into several groups based on functionality. Facilitators have used local students and teachers for the initial construction of the model itself[11], and then relied more heavily on elders, who contain valuable spatial knowledge, in the demarcation process. WOTR has not practiced this method – we have included all participants in all stages of the process (though specific tasks are divided among small groups for efficiency – participants can then exchange tasks after some time). However, the precise protocol for this should best fit the purposes of the specific application of P3DM.

The venue will also have to be predetermined – this must be a spacious area in the village itself that can accommodate roughly 25 people and various simultaneous construction activities. It should also be located centrally in the village to maximize exposure to the entire community.

Constructing the Base Model

The following outlines a basic step-by step method for constructing the P3DM base model. As mentioned earlier, more detailed instructions are included in the appendix to this document and can these (photographs can be found in the attached Manual on Participatory 3D Modeling for Natural Resource Management by G. Rambaldi and J. Callosa-Tarr for the NIPAP/PAWB-DENR, Philippines (beginning on page 10).

1. A layer of carbon paper is taped to the bottom of the reference base map (topographic), with the marking side facing out.
2. Corrugated cardboard sheets are prepared, the exact same size as the reference base map, are prepared.
3. On each sheet of cardboard, a single contour is traced, using the base map with carbon paper underneath as a reference. Sheets are labeled with the contour elevation and a north-pointing arrow, for proper orientation.
4. Contours are cut from the cardboard sheets.[12]
5. Contour sheets are superimposed on one another in the correct order and the precise orientation[13], and then pasted together.
6. Once dry and secure, the model is covered with a thin paper, pasted using acrylic white or translucent gel medium. This paper smoothes out the contour layers and helps with terrain continuity.
7. Meanwhile, a table is custom built to the exact size of the model, for the purposes of public accessibility and display. The base model is then mounted on the table. WOTR has not constructed custom tables, but has instead used plywood sheets for working on and displaying the model.

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[11] See Manual on P3DM for Natural Resource Management, page 5.

[12] Note: In WOTR's full trial of P3DM for Partala, Madhya Pradesh, steps 1-4 were completed in the Pune office before engaging with village participants. Due to the lack of time, this was an ideal option in this case. However, it should be noted that ideally participants, even if only a small group of them, should be included in the entire construction process.

[13] The Manual on P3DM for Natural Resource Management contains special methods on how to secure contour layers in the exact locations, although these have not yet been employed by WOTR.

Model Demarcation

Now begins a consultative process by which participants engage in a consultative process that leads to the model's demarcation. Over the complete base model, participants orient themselves, and discuss landscape features, valuable ecosystem resources, culturally or socially significant areas, and participants may also share local historical events. This is a delicate, collaborative space that should be given plenty of time for dialogue. Facilitators should be prepared for the possibility of social inequities to arise, or ongoing social or political conflicts that may be simultaneously occurring in the village. Participants may argue over the precise location of a particular feature. These conflicts should be allowed because they allow community vulnerabilities and specific development-related concerns to emerge, and facilitators must strike a balance between allowing conflict and acting as a mediator that diffuses the situation, if this becomes necessary.

Before anyone marks on the model, the participants must determine the legend with the assistance of P3DM facilitators. It is absolutely necessary that the participants have as much control over the decision-making pertaining to feature-coding on the map as possible, with practical guidance from P3DM facilitators. General guidelines for legend-making can be found within the more detailed instructions located in the Appendix to this document, as well as the attached Manual on Participatory 3D Modeling for Natural Resource Management.

Once the legend is created, participants can then begin demarcating boundaries and relevant point, line, and areal (polygon) features. It is recommended that participants mark with pencil or light pen, until a particular feature is precisely located and agreed-upon. This process will also take significant time, and great care should be taken by facilitators that the process is organized, features are clearly identifiable and the model maintains complete consistency with the legend.

Depending on the intended objectives of a P3DM project, several key discussions related to environmental decision-making may take place throughout this process. For example, if the model is intended for Watershed Development purposes, discussion of land-regeneration and water restoration schemes must be decided upon at this stage. As another example, if the model is intended for Sustainable Agriculture, this session may need to be supplemented with education on crop rotations and drip irrigation prospects. The entire P3DM process must be placed in the context of its ultimate objectives, which should be continually reinforced by participants and facilitators.

Transposing Participatory 3-D Models into Geographic Information Systems

A great benefit of P3DM is that the spatial information comes directly from stakeholder communities, while it is also communicable with relevant external agencies via GIS. However, WOTR has found that this process is not necessary for attaining the benefits of P3DM to participatory environmental decision-making and education at the village level. Models should be digitized if WOTR decides that the information stored in a participatory 3D model would be of aid at research and policy levels. However, the establishment of a permanent model in the village for internal planning and community use alone justifies model creation.

Digitization occurs after the model is completely demarcated and has been officially handed over to the community at large. This process should be reserved for GIS technicians who have an understanding of the extraction process and have been thoroughly informed of the model's contents and legend (if they did not take part in the construction process). In the NIPAP initiative in the Philippines, GIS practitioners used plastic sheeting and superimposed reference grids to trace all spatial features, which were then scanned and geo-referenced in a GIS. It is essential for this process that the spatial features are marked by points, lines, and polygons, as these represent all spatial data in GIS. This process should be carried out systematically, with a high-degree of accuracy to minimize errors when geo-referencing the data in GIS. Facilitators must be careful to ensure that the information to be digitized is properly categorized and documented in detail, to avoid confusion amongst GIS practitioners. There is also a possibility of using digital cameras to produce images of models that can be uploaded into a GIS and geo-located. However, great care must be taken in making the digital photographs, as any pitch or tilt in the camera angle will distort the image, and one must calculate the precise relative altitude of the camera lens in order to account for scale in GIS. While seemingly more convenient, this method poses a greater risk for spatial inaccuracies.

To date, WOTR has not made an attempt to digitize a 3-D model. However, there are great possibilities for both CCA and government-stakeholder communication should WOTR develop a standard digitization protocol that would include P3DM systematically in pre-established GIS practices within the organization.

Good Practices in Participatory Mapping: Notes for Facilitators

It is important to remember that P3DM is not a solution - it is only a tool. While P3DM poses significant potential benefits to CCA, the realization of these benefits will depend largely on how well the tool is implemented by WOTR staff and received by village communities and relevant external agencies. Therefore, sensitization to well-established guidelines for P3DM practitioners is essential.

Three T's

Successful application of P3DM for CCA will mandate conscious efforts towards providing a positive, enabling environment throughout the entire process. P3DM construction and demarcation naturally lends itself to collective knowledge sharing amongst participants, but a positive impetus for this must also come from facilitators. Participatory mappers from around the world[14] have presented three essential elements in maintaining an enabling environment for P3DM participants, which they call the "Three 'T's".

Transparency: To be transparent is to communicate clearly and honestly, without withholding any information from stakeholder communities. Potential shortcomings and future commitments associated with the P3DM work may arise in the process, and these should be communicated amongst all participants. Transparency requires that facilitators and GIS users are openly held accountable for their actions by

[14] Corbett et al., Overview: Mapping for Change: the Emergence of a New Practice. Mapping for Change: Practice, Technologies, and Communication. *Participatory Learning and Action*, No. 54, April 2006.

participants. It may not be possible for the entire village to play an active role in the P3DM process, but facilitators should do everything they can to ensure that meetings are at least open to everyone.

Time: Time constraints imposed by facilitators to fit external agendas places a detrimental pressure on the P3DM process. It should be acknowledged that to create a space in which village participants are comfortable to share traditional knowledge takes time: time to build relationships between facilitators and participants, time for participants to understand the P3DM process, and time for the intended outcomes of P3DM to emerge. Time may be one of the largest commitments required by P3DM, but it is also essential to allow the process to unfold in as much time as it may take.

Trust: Trust is the essential ingredient that allows participants to communicate freely amongst themselves and amongst P3DM facilitators. Without open communication, P3DM immediately loses its value in reflecting true indigenous perspectives. P3DM reveals potentially fragile information concerning local culture, tradition, and natural resources, which requires a large degree of trust amongst all present throughout the process. Excellent P3DM facilitators take time to build relationships with participants before, during, and after model construction.

Consistency and Accuracy

It is not always compulsory that a participatory 3D model is entirely spatially accurate. Again, the construction and demarcation processes themselves are at the heart of the tool's value because it is these processes that engage communities in participatory decision-making and enhance community cohesion. The model intends, above all others, to provide relevant information and raise awareness amongst village communities. However, great attention must be paid to accuracy if the model is to be digitized, because only this accuracy makes indigenous knowledge credible at research and policy levels. Therefore, in the case of construction and digitization facilitators must therefore take great (and possibly painstaking) care guide P3DM so that spatial accuracy is maintained.

While accuracy is not always a concern, facilitators must make a point to uphold consistency with the initial goals of P3DM throughout the process. Last-minute changes create confusion and can dissolve model relevance and participant motivation. Strict consistency with regards to the legend is also required. Changes might prove necessary for the legend, however it is advisable that these are minimized to avoid confusion and maintain the model's visual aesthetic nature.

Keeping a Larger Perspective

It may be easy to get caught up in the details of the P3DM process, but facilitators should keep in mind the larger perspective – the overall goals that P3DM and CCA seek to accomplish. The reason that participatory methods are effective for development is because they raise community awareness and motivation to invest time, physical effort, and sometimes financial resources to their own development initiatives. The hope is that better awareness and better governance will lead to better behavior – behavior that sustains livelihoods and local ecosystem health. That is why WOTR seeks to engage in participatory methods for Climate Change Adaptation.

However, it is important to note that local sociopolitical hierarchies sometimes cause participatory methods to become tools of power used by those "in charge". If better governance and awareness does in fact lead to better behavior, facilitators must pay attention to any social inequities that might arise and take measures to minimize them so that all voices are heard. It is important to learn that indigenous knowledge from a local community is not one voice, it is many, and facilitators should make a point to ensure that P3DM reflects a collaboration of village perspectives.

A Word on Ethics

It is important to note the sensitivity of indigenous spatial knowledge when conducting any participatory mapping initiative. The Information transposed on a P3DM holds great significance to the people who supplied it, and care should be taken so that such information remains in responsible hands. Throughout centuries, maps have been used as tools for exploitation of the powerless by the powerful. In certain cases, the release of spatial information concerning natural resources, for example, runs a risk of allowing others to use it for exploitative purposes. At the start of any P3DM workshop, facilitators and participants should therefore design the project together in a communicative space where all must be transparent in their intentions for the model (i.e. how the geographic information will be used, if transposed into GIS).

Future Opportunities for WOTR, and Realistic Challenges

While in theory P3DM presents bright potential for enhancing the Climate Change Adaptation project, several logistical challenges arise in practice. It is important for P3DM practitioners to understand and prepare for these challenges, in order to maximize the tool's benefits.

"Scaling Up"

P3DM is not only a significant tool for WOTR but also for India as a whole. P3DM can greatly reduce the technological, social, and political gaps between those who implement resource legislation, and those who directly use the resources. To bring village communities into resource management dialogue through high-resolution, community-based digital maps would be an unprecedented accomplishment in national development objectives. Furthermore, it would bolster Indian governmental databases of high-resolution spatial information, which is currently lacking. However, to use P3DM in this way would require tight communication and collaboration amongst all related parties. WOTR currently has the advantage of a closely maintained relationship with relevant government agencies, which would facilitate knowledge transfer. Internally for WOTR, this would require a closer relationship between the Capacity-Building and IT Teams. To date, the P3DM pioneers at WOTR have not been able to successfully digitize a P3DM, due to logistical limitations. In order to reap the digital benefits of P3DM, these two teams must collaborate to produce a standard digitization protocol by which the indigenous knowledge represented on a P3DM can be geo-referenced and accurately demarcated in the field, and transferred to the office for digitization. This, too, will require time and human resources, but in light of the profound benefits of P3DM, it becomes quite possible.

The Necessity of Time

While other PGIS methods are disadvantaged by financial limitations or lack of expertise, the biggest drawback of P3DM, rather, is its time requirements. P3DM can be employed easily on a limited budget using locally available materials. However, in order to grasp its full potential, ample time is required for organizing participants and materials, initial instruction and orienting, model construction and demarcation, thorough dialogue amongst participants, and model digitization. Given WOTR's multifarious commitments throughout CCA, time and manpower will be the largest constraints to P3DM implementation. A possible solution to this would be to propose an internship opportunity for a P3DM coordinator. Under the Capacity-Building Team, this position would involve scheduling workshops, organizing field teams and transport, procuring supplies, reporting, and training. If enough time is spent with this manual and associated P3DM documentation, a single internship would ameliorate many of these challenges, and help secure P3DM as a core tool for WOTR.

Conclusion

There is little doubt that Participatory 3-Dimemensional Modeling poses substantial enhancement potential to increasing stakeholder participation in the Watershed Organization Trust's Climate Change Adaptation Initiative. As a comprehensive, technical and educational tool for environmental decision-making at the grassroots level, P3DM surpasses other Participatory Geographic Information Systems methods for rural development because it provides local communities with a hands-on experience that produces both a tangible model that villages can use in manifold ways, but also digitized maps representing indigenous spatial knowledge that can be used at organizational, governmental, or academic levels. Specifically for WOTR, P3DM presents an important avenue of communication between government and village communities that has historically been blocked by institutional hierarchies and sociopolitical inequities. It brings village voices to the policymaking table. However, perhaps more importantly, village communities feel more connected to development interventions in the creation of a P3DM, and the process is conducive to increased community cohesion and confidence by way of indigenous knowledge exchange.

P3DM can be used as a supplement to the various initiatives of CCA, applied independently or collectively. The only drawback is the significant human resource and time commitments required by the method. Any P3DM initiative should be allowed ample time in all stages, as time constrains severely limit the flexibility of the model's use and the information that can be drawn from participants. If WOTR can devise the means for satisfying time and human-resource needs, then P3DM can greatly enhance the CCA project in almost every aspect.

This document is meant to serve future P3DM practitioners within WOTR's CCA project, as well as those looking to further develop the tool in innovative ways for the Indian development context. This document outlines WOTR's current understanding of P3DM and its vision's for future opportunities. We highly suggest that future practitioners will further develop and merge P3DM with WOTR'S development initiatives and continue to supplement and ratify the information outlined here.

References

Rambaldi, G. 2010. Participatory 3-Dimensional Modeling: Guiding Principles and Applications, 2010 edition. CTA, Wageningen, the Netherlands.

Rambaldi, G., Callosa-Tarr, J. 2000. Manual on Participatory Modeling for Natural Resource Management. *Essentials of Protected Area Management in the Philippines*, Vol. 7. NIPAP, PAWB-DENR, Philippines.

Appendix:

A Basic Step-by-Step Guide to Preparation and Facilitation

The following is a basic step-by-step guide to P3DM as it has been used by WOTR. It covers steps from model preparation through construction and demarcation. The method is adapted from the Manual on Participatory 3D Modeling for Natural Resource Management (Rambaldi, Callosa-Tarr 2000). This manual is attached and should be consulted in conjunction with the following guide, as it includes a methodology for the P3DM digitization process, which is currently beyond the scope of WOTR's experience with the tool.

I. Model Design and Preparation

Crucial details must be determined at the beginning of any P3DM initiative. These decisions drive the model's progress and determine the types and amounts of necessary materials. Planning decisions concerning the following are essential:

1. **Overall Objectives**: P3DM is an integrated, multi-purpose tool that can be used for a variety of purposes within the CCA project. However, it is unreasonable to attempt to address all of these possibilities in one P3DM session. P3DM should be used to satisfy key objectives within a community that are based on local needs. In other words, the specific objectives of any P3DM must be relevant to the community, clearly communicated, and continually referenced throughout the entire process. Once this process is complete, the model can be used again for additional purposes of CCA in the future.
2. **Size and Composition of the Participant Group**: The specific objectives for P3DM should be a driver for the participant group assembly. Facilitators must decide how many participants should be included in the process, and the specific community members that should be present. For example, if the specific purpose of P3DM is to gather indigenous knowledge on historic land use, then several key elders should be present in the participant group. If the purpose of P3DM is to provide educational outreach, then the participant group should represent the entire demographic of the community, including both elders and young children, men and women. As a rule, a participant should be a strong representation of the greater village community.
3. **Location**: P3DM demands an open space where multiple groups of people can discuss and work together at once. The location should also be in a central location in the village to maximize transparency to those not directly involved in the process. Meeting Houses or temples work well for these purposes.
4. **Size of the Model**: Chosen objectives, number of participants, and location will influence the size of the model, and vice versa. A large model can accommodate more people, but will take more time and supplies will cost more. Facilitators must weigh these decisions in the planning process and commit before any other steps are taken in the P3DM process.

5. **Horizontal and Vertical Scale**: Scale and size are related, and also depend on the specific objectives. For example, if the purpose of P3DM is land use planning, smaller scales (1:10,000+) are useful because they cover more area. However, if the purpose of P3DM is DRR, participants will need to identify individual structures, which will require a larger scale (1:5,000-). For more on determining scales, see the Manual on Participatory 3D Modeling for Natural Resource Management, p.6.
6. **Organizational Approach**: Facilitators must design the sessions to minimize confusion and maximize time use-efficiency amongst participants. The P3DM process lends itself to multiple ongoing tasks, such as cutting, tracing, and pasting contour layers, and so it helps to divide the participants into functional groups. The organizational approach to the P3DM process should be determined amongst facilitators, and this approach should be consistently followed to avoid confusion.

   WOTR has diverged from other P3DM projects by cutting and tracing the corrugated cardboard layers in the Pune office prior to a P3DM workshop. The participants then paste the layers together in the proper order only. This approach cuts time from the workshop but also complicates transportation – large square cardboard pieces are easier and less delicate than the cut pieces. Facilitators should decide, based on the overall objective, whether to trace and cut layers in the field with participants or beforehand in the office.
7. **Projected Budget and Estimated Timeline** for administrative purposes.

II. The Reference Map

The reference map will provide the topographical information necessary to construct the model. The size of the reference map will also determine the size of the 3D model. It is therefore a fundamental component of the P3DM and should be made correctly. WOTR contains Digital Elevation Models (DEMs) of its project watersheds, and topographic contour layers have been extracted from these models in 10 or 20m intervals. 10m intervals are ideal because they contain more detail. Other spatial data, such as hydrology, roads, settlements, or government boundaries can also be included on the reference map.

Reference maps should be prepared from the digital topographic data layers stored in ArcGIS and printed at the desired size and scale. If digital data is not available, you must use scanned topographic maps. In this case, you must crop the image to the desired area (as these maps tend to cover more area than desirable for a P3DM). Knowing the precise scale of the cropped image is impossible, which rules out transposing the resulting P3DM into GIS. Therefore, use digital data as much as possible so that the precise scale and size can be determined. It is advisable to print two or more copies of the reference map.

III. Supplies Procurement

Once the planning stage is complete, supply procurement can begin. P3DM supplies are readily available and can be found largely at art supply stores throughout Pune. WOTR has purchased Corrugated Cardboard (3mm) from **Cubic Cartons** in Pune. These suppliers provide corrugated cardboard in varying thicknesses and will cut cardboard sheets to the needed size. Other supplies associated with the Base Model and the Demarcation processes were purchased from **Venus Traders** in Pune.

P3DM works best with corrugated cardboard – it is durable but also easily cut. It also comes in varying widths – 1mm, 3mm, 5mm – and the width chosen for a P3DM model will depend on the chosen vertical scale, as each contour will have a corresponding height on the model. This is important not only for visual recognition, but also for spatial accuracy when a P3DM is transposed into a GIS. It is normally advised that the vertical scale should be the same as the horizontal scale, but depending on the local topography and the size of the model, it might be necessary to vertically exaggerate the model (i.e. make the vertical scale larger than the horizontal scale). Size, scale, as well as degree of vertical exaggeration of the model must be decided and calculated before purchasing the right type of corrugated cardboard.

Venus Traders
No. 31, Appa Balwant
Chowk, Budhwar Peth,
Pune, Maharashtra
411002
Phone: 020 2445 7023

Cubic Cartons
27 Sinhagad Road
Vadagaon Budruk
B/H Auram Engineers
Pune, Maharashtra,
411041
Phone: 020 2435 1430

A Supply List for Base Model Construction:

1. Corrugated Cardboard: the exact size of the intended model; one sheet for each contour layer plus several extra sheets (for use in the case of mistakes).
2. Packaging tape: one standard-width roll and one wide-width roll
3. Box Cutters
4. Ballpoint Pens, Pencils
5. Permanent Markers, for marking elevation and orientation on the corrugated cardboard layers as well as the base map
6. Carbon Paper, for tracing the contours from the reference map to corrugated cardboard layers
7. Paste, for securing the superimposed corrugated cardboard layers
8. Newspaper-thin paper sheets (for covering/priming model). Actual newspaper can be used.
9. White Acrylic Medium, for priming and sealing the base model (i.e. Camel brand)
10. Reference Map, at least 2 copies

A Supply List for Model Demarcation:

Note: The colors chosen for the model should be very distinct to one another to ensure clear boundaries between two features. In other words, light yellow and yellow should not be used together on the same P3DM, although dark green and light green may be possible. It is sometimes advisable to use colors that visually resemble natural landscape features, such as blue for water and dark green for forest. However, this is not always necessary, nor possible. As long is a legend is created and well established, any bright colors are good options for P3DM features. Colors should be chosen before going out to get supplies. All pins, yarn, and paints should be gathered in the chosen colors.

Facilitators may choose to use a reference grid on the model and the reference map for ensuring the spatial accuracy of certain features. In this case, additional supplies are needed.

1. Pencils for marking landscape features prior to permanent marking
2. String or twine for creating a reference grid on the model (optional)
3. Ruler or Tape Measure for drawing corresponding reference grid on the Reference Map (optional)
4. Pins with colored heads for mapping point features (i.e. wells, homes)
5. Yarn for marking line features (i.e. roads, forest boundaries, territorial boundaries, streams)
6. Acrylic Paint for painting features of large areal extent (i.e. lakes/reservoirs, cultivated land, protected forest). Commonly-used colors – Green, Yellow, Brown, Hot Pink/Magenta, Purple, Red, Orange, Black
7. A large poster board for posting the final legend. This should be large and posted in a place for all participants to use and reference.
8. Permanent Markers for writing the legend
9. Paint Brushes of varying widths
10. Plastic Cups for cleaning paint brushes – used Dahi containers work well.
11. Scissors

Other Supplies for Facilitators

1. Digital Camera, to document progress for future reference
2. Digital Voice Recorder, for recording indigenous voices, important knowledge, stories, etc.
3. Whiteboard and Dry-Erase Markers, to help in facilitator explanations, or general knowledge-sharing
4. GPS, for verifying the locations of some features (optional – but necessary for digitization)

All supplies and plans should be organized and prepared for transport to the construction location, where the P3DM workshop will begin.

III. Orienting and Preparing Participants (Day 1)

To initiate the P3DM workshop, facilitators should communicate the intentions of the workshop, the basic concept of P3DM, the objectives of the model (i.e. exactly what the model will be used for, whether or not it is digitized). Facilitators should make a point to establish relationships of trust amongst participants and between participants and facilitators, as these relationships facilitate the emergence of necessary indigenous knowledge to the P3DM. Participants should clearly understand their roles as well as the roles of the participants. It should be stressed by facilitators that the P3DM workshop is meant to provide a collective space of knowledge-sharing that will prepare the community to address concerns and needs related to the CCA project. It is suggested that the objectives are written on a large paper or poster board and posted for everyone to see throughout the process.

Also in this stage, facilitators will divide participants into functional groups with assigned tasks for the construction process. If facilitators decide that this would not cause confusion, functional groups should rotate tasks so that everyone has a chance to participate in all elements of the P3DM.

IV. Base Model Construction (Days 1-3)

The following is a basic step-by-step process for constructing the P3DM model. It is suggested that facilitators have familiarized themselves with this process so that they are ready to confidently lead participants.

Tracing Elevation Contours from the Reference Map

1. Ensure that the contours on the enlarged topographic map are clearly labeled with the correct elevation. This is necessary to avoid mistakes in the tracing process. Mark which direction is north, as this will continually be an orientation reference throughout model construction.
2. Tape carbon paper sheets to the bottom of the enlarged topographic map so that the bottom of the map is completely covered. The side of the carbon paper that marks should be facing outwards (marked side facing map, plain side facing out). There should be no white space showing. Carbon paper sheets may need to be trimmed so that they fit the map correctly.
3. Overlay the reference map/carbon paper over a sheet of corrugated cardboard, so that the topographic map is facing upwards. The map should be EXACTLY the same size as the cardboard layer.
4. Secure the map on the cardboard layer with pins so that it does not move while tracing. DO NOT USE TAPE or the map will rip. Keep in mind that the map/carbon paper must remain well intact. Secure all subsequent cardboard layers to the map using the same pinholes.
5. You are ready to begin tracing a single contour. It helps to begin with the lowest elevation and work towards higher elevations. Using a sharp pencil or ballpoint pen, trace along a single contour line (i.e. 720m). Make sure that all contour lines of the same elevation are traced. Don't forget about isolated mountain peaks (this will become more important with increasing elevation. While tracing, be sure to stay as close to the appropriate contour interval as possible to maintain the spatial integrity of the resulting model. This is important especially with small-scale maps (1:10,000+)
6. Lift the paper slightly to ensure that the carbon paper has properly transferred your tracing to the cardboard layer. If so, remove the bottom cardboard layer and replace it with another.
7. Using a permanent ink pen, clearly mark the cardboard layer with the contour elevation and a north-pointing arrow. Make sure that disconnected contour intervals (such as those on mountain peaks) are labeled and oriented also, as they will be cut and possibly separated from others
8. Repeat steps 4-7 until all elevation contours have been traced, each on a single cardboard Layer.

The Contour Layers

9. Now it is time to cut out and trim the cardboard contour layers. If you are working in multiple task groups, this step can begin as soon as the first contour is traced, and can be happening simultaneously with tracing, which is a more efficient use of time.
10. Keep traced and cut layers organized as they accumulate to avoid losing small pieces.
11. Once all layers are traced and cut, the model can then be assembled.

Assembling the Base Model

12. The P3DM should be assembled on a single layer of corrugated cardboard (same size as the model, uncut). This represents the lowest elevation in the covered area.
13. Apply a layer of paste to the top of the lowest layer, and then overlay the next higher elevation layer.
14. Repeat step 13 for each additional elevation contour layer (i.e. 720m, followed by 730m, 740m, 750m, etc). Ensure that the layers are superimposed in the correct order and orientation, and are placed in precisely the same corresponding locations where they were traced on the reference map.
15. It may be necessary to place paint bottles, stones, or other heavy objects on the model while it is drying to ensure the layers do not slip out of place.
16. Allow the model to dry completely.

Priming the Base Model

17. Cut or tear sheets of newspaper-thin paper into strips or small squares. This can be assigned to a single task group
18. Using paint brushes, paint a very thin layer of white acrylic primer on a small area of the model.
19. Press the paper onto the area, so that the paper is flush to the surface but minimizes the appearance of the contour layers.
20. Paint another thin layer on top of the thin paper.
21. Continue steps 17-20 until the model is completely covered in a single layer of paper/primer.
22. Let the model dry completely.

V. Preparation for Model Demarcation (Day 4)

The blank model is complete, and now facilitators must begin a process by which the participants will use their instinctive and inherent knowledge of and relationship with the landscape to demarcate the model. However, before any mark on the model is made, the following tasks must be executed by the facilitators.

1. **Revisit the Objectives**: this is a good time to revisit the original objectives of P3DM. Facilitators should engage with the participants to remind them why the blank model was built in the first place. This discussion helps to bring everyone back to the original purpose of the workshop after all of the technical construction activities.

2. **Introduce the Demarcation Process** (explained below): Facilitators should present the necessary process for demarcating the model to accomplish these objectives. A step-by-step process should be explained to the participants, and it is compulsory that the process is universally understood before beginning demarcation.
3. **Encourage Precursory Discussion amongst Participants**: Facilitators must ask participants what features should be placed on the model, based on the overall P3DM objectives. In these discussions, facilitators should gauge participant reactions, observations, and motivation levels to ensure that everyone is on a positive track with the intentions of the model and the process involved.
4. **Create the map Legend**: The most important part of this preparatory stage is the creation of the Legend. The legend is the reference code for all features placed on the model by participants. It is therefore essential that the participants have complete control over the creation and establishment of the legend, with technical assistance from facilitators. The legend should include all basic familiar landmarks and landscape features, such as bridges, important hilltops, settlements, temples, streams, rivers, and reservoirs. In addition, the participants will identify features relevant to the P3DM objective at hand. For example, if this model is being used for Biodiversity initiatives within CCA, then the legend should also include a symbol (or color, rather) for biodiversity hotspots. It is compulsory that the model legend is completed, posted, universally understood, and followed consistently amongst both facilitators and participants throughout the demarcation process.

VI. Demarcating the Model (Days 4-6)

Now begins the most important process of P3DM, by which the blank model is demarcated by the participants. This is a very delicate space, as community knowledge is shared among men and women and across generations. Facilitators should intervene only when necessary, allowing stories, conflicts, and collaboration to occur on its own. Facilitators may feel the need to ask guiding questions throughout this process that may stimulate discussion, such as “How has the landscape changed in your lifetime?”, or “How do you define the boundaries of your domain?” Guiding questions should of course be relevant to the overall objectives. Regardless, it is important to remember that this collaborative space should be nurtured and reinforced by facilitators, and not dictated.

The Demarcation process may take anywhere between 1-3 days, depending on the size of the model, the social dynamics of the participant group and the objectives of the workshop. The following is a step-by-step summary of the demarcation process.

1. Gather the participants around the model. Provide pencils for initial demarcation. Facilitators should encourage the conversations to remain open to the entire group. Allow participants to discuss and sketch, referring to the legend and the reference maps, until they feel that the model is ready to be permanently demarcated. Depending on the objectives and the size of the map and the attention

levels of the group, this process may take an entire day at most. Facilitators are discouraged from rushing the process.

2. Facilitators should heavily document conversations and interactions for future reference in further CCA initiatives, as often key social conflicts or financial/environmental concerns from the community are revealed through this process.
3. Once the features have been penciled in, the model will be ready for permanent demarcation using pins, yarn, and paint. Again, pins are used for point features, such as wells or temples. Line features are used for roads, bridges, rivers, etc., and paint will be used to show features of areal extent, such as conserved forest area or farmland. This protocol should be consistently followed throughout the demarcation process, especially if the model is to be transposed into GIS, to avoid confusion and error. It is also ESSENTIAL that the participants adhere to the legend they created in preparation.
4. Facilitators are also responsible for making sure the supplies are available and in order: paints, brushes, cups of water for washing brushes, scissors, yarn, and pins throughout the process.

VII. Formally Concluding the Process (Day 7)

When the Demarcation process in complete, the model should be formally handed over to the participant group and introduced to the community as a whole. Facilitators should revisit the original objectives with the participants, discuss any changes or adjustments, and take note of observations and feedback from participants. There should be discussion about the impact of the model and the various possible objectives that the mode could accomplish in the future. The model now officially belongs to the community as a part of CCA, and facilitators should ensure that the model will be displayed in a public place and cared for in their absence. A concluding ceremony isn't always necessary, but it helps to ensure all participants have a sense of closure with P3DM and that the model has been made available for the entire community. At this point, P3DM is complete.

WOTR has yet to digitize a P3DM model. While P3DM without digitization is highly valuable, digitization maximizes benefits in terms of wider communication to research institutions and policymakers. The next step for WOTR is to develop a digitization protocol that can supplement this handbook, to complete P3DM as an official tool for CCA.

Participants assembling corrugated cardboard layers for the first time, Partala, Madhya Pradesh.

Referring to the Reference Map, Partala, Madhya Pradhes

Priming the Model, Partala, Madhya Pradesh

Completed Blank Base Model, Partala, Madhya Pradesh

Beginning Demarcation with pins and yarn, Partala, Madhya Pradesh

Painting final features, Partala, Madhya Pradesh

The final model, Partala, Madhya Pradesh