PARTICIPATORY THREE DIMENSIONAL MODEL MAPPING (P3DM): EXPANDING RURAL HORIZONS AND DECISION MAKING FOR FOOD SECURITY PLANNING, CLIMATE CHANGE ADAPTATION AND FLOOD RISK REDUCTION IN GHANA

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Abstract: *Amidst the enormous agriculture and natural resource potential of Northern Ghana, food security remains a perennial issue, more recently compounded by the recurring Volta River flooding of low-lying areas threatening livelihoods, causing damages to farmlands, properties, loss of lives and socio-economic dislocation. In an attempt to strengthen rural poor communities to take control of their lives and build resilience against such threats, many community-driven initiatives employing various participatory planning and decision making tools have been pursued over the past decade in Ghana. Most of these participatory tools also explored how collaboration among external stakeholders, local institutions and beneficiary communities could be enhanced and sustained. Currently active participation and effective collaboration have not risen to an effective level. In this regards, Participatory 3-Dimensional Modelling (P3DM) is presented as a tool for active participation and effective collaboration among development agencies and beneficiary communities in Ghana. The P3DM captures the vast complex landscape resources into an incredibly concise solid contour model easily understandable to the learned and the unlearned. Using the 3D map for Northern Ghana, regional stakeholders were facilitated to identify and evaluate their areas of interest on the ground in terms of their relationship to the biophysical and socio-economic attributes of the landscape. The clarity of landscape information overlaid in the 3D enhanced discussion among stakeholders and forged collaboration for greater impact, including identification of gaps in promising areas. The use of 3D in community and regional level planning for agriculture and natural resource management presents a new and more promising opportunity for more community participation and institutional collaboration towards sustainable development of Ghana.*

INTRODUCTION

In 1992, Ghana promulgated a new constitution that enshrined the concept of decentralization as a fundamental structure for achieving democracy and equitable development throughout the country. Through the decentralization of government agencies and funding to strengthened District Assemblies and other lower level structures, it is widely believed that all citizens will be drawn more effectively into influencing programmes and policies that affect their lives.

Nowhere in Ghana has decentralization provided more hope for improvement in standards of living and reduction of extreme poverty than in the three Regions of Northern Ghana. While the Southern and Coastal Regions of Ghana have benefited from centuries of educational and natural resource development, the North has been left with a predominantly subsistence agricultural base where up to 9 out of 10 people live below the poverty line (WFP, 2011). These physical and demographic limitations have also limited the political influence of the Northern Regions in policies and resources allocated by the central government in Accra.

So, amidst significant agricultural and natural resource potential, food security remains a perennial issue in the North. In recent years, due to climate changes and creeping desertification, this situation has been compounded by the increasing droughts and Volta River flooding of low-lying areas threatening livelihoods, causing damages to farmlands, properties, loss of lives and socio-economic dislocation. In September 2010, a total of 50,874 people were affected by floods in the Northern Region, of which 5 died and 3 got injured (NADMO, 2010).

Local District Assemblies in the North struggle to spread limited funding resources to meet local needs and also address natural resource challenges that require Regional thinking and commitments. Gaining the knowledge, participation and support of local citizens is their second challenge. For rural farmers, government is often far away and not well understood. Transportation infrastructure is severely lacking and education and literacy are not widespread. For many rural residents, life centers on a few villages and the closest market for the limited crops they produce.

In such times of significant environmental challenge, solutions will require Regional-level planning and local level knowledge, acceptance and action. They will require village-based people to look beyond the closest ridge and valley and expand their horizons to meet the mounting environmental threats that will challenge their ability to survive.

Bringing Local Knowledge to the Table; Gaining Public Support for Change

Over the past decade, National and International aid programmes aimed at strengthening rural poor communities have used a variety of methods and tools to draw citizens into local planning and decision making. They have also explored how collaboration among external stakeholders, local institutions and beneficiary communities could be enhanced and sustained. But to date, as recent flooding and dislocation events have demonstrated, public participation and collaboration have not risen to an effective level.

Beginning in 2011, through the support of international volunteers and the Ministry of Food and Agriculture (MoFA) offices in the 3 Northern Regions, a new tool has been developed that holds promise of drawing rural people to the table and into the environmental planning process. Through construction and use of detailed, 3-Dimensional (3-D) model maps, development practitioners think they may have found the right medium for communication at every level, from the local village farmer, to the local and Regional planner and connecting to the National Agencies that will be essential in finding solutions. It is a powerful tool when integrated with Global Positioning System (GPS) and Geographic Information System (GIS).

The 3-D Map translates sophisticated topographic data into a large table-top map that turns the vast, complex landscape and its resources into an accurate, concise, solid contour model easily understandable by everyone. The use of 3-D Map around the world has clearly demonstrated that people find this visible, tactile model more understandable and engaging than 2-Dimensional maps and technical documents. The 3-D Map enables people to locate their own spatial memories and historic knowledge on a physical landscape model.

A 3-D Map becomes a powerful communication, research and planning tool that gives all stakeholders - literate and illiterate, rich and poor, professional and non-professional - a common platform to think creatively about how best to manage their environment and resources sustainable. It generates information and concepts through dialogue and collaboration by local people, development agencies and scientists using a physical model of the landscape of the community as a reference for discussion. This facilitates communication between all stakeholders and implementing agencies and has great potential to support sound policy and decision making processes (RAMBALDI AND CALLOSA-TARR, 2002).

This paper seeks to introduce Participatory 3-Dimensional model mapping as a tool for food security planning, climate change adaptation, flood risk management, environmental

degradation and sustainable development planning in Ghana. It also presents the lessons learnt from the construction and application of 3-dimensional model maps in the Northern Regions of Ghana. A map of Ghana showing the three Northern regions is shown in Figure 1. The mapping process:

1. Raised awareness and improved understanding of important ecosystem processes and critical ecosystem linkages in landscape setting.

2. Sensitized development agencies on the use of 3-Dimentional model to identify and support communities in building resilience against the perennial flooding and drought in the northern region of Ghana, and the unprecedented degradation of the natural ecosystem.

METHODOLOGY

Beginning January 2011, three P3DM mapping processes have been undertaken. These are 1:250,000 scale model of Northern Ghana, 1:50,000 scale models of Central Gonja District and Upper East Region. These maps were constructed using the methodology described by RAMBALDI (2010).
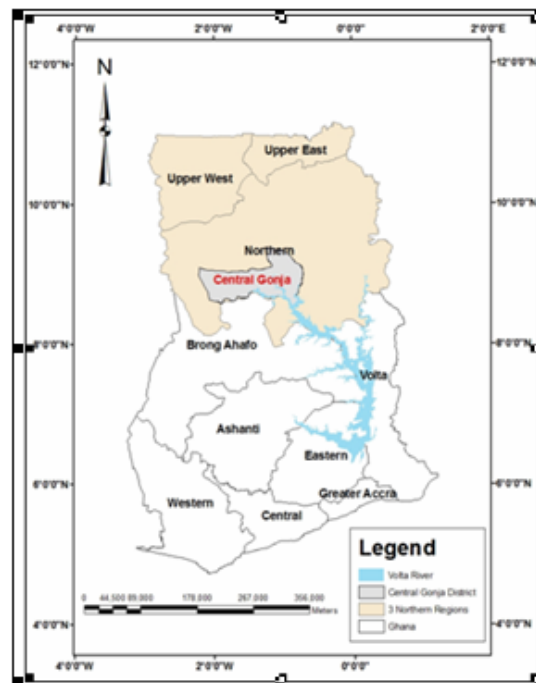

Figure 1: Map of Ghana showing 3 Northern regions

In building the small scale map (1:250,000), contour lines of encampments and mountains appeared clustered. Therefore individual lines were isolated using GIS. This was done for each line before printing, tracing and cutting (Figure 2). The building of the model employed the use of chip boards, white paper glue, poster and oil paint, brush, topographic map, pins, yarns, carbon paper, masking/packaging tapes, plywood, nails, wood, scissors, markers, cutters and pencils.
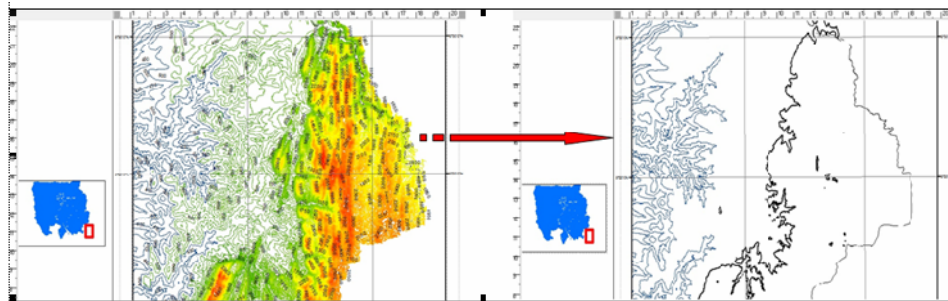
Figure 2: Isolation of contour lines

The models were built by National Service Personnel, staff of MoFA and Voluntary Services Overseas volunteers. Overlay of map features were done by all the above participants in the map construction including active peoples in communities, Assembly men and women, representatives of NGO's and other governmental institutions.

The 1:250,000 Northern Ghana model has a dimension of 1.9 x 1.5 m covering an area of approximately 11,244,000ha. The vertical exaggeration is x5. The lowest elevation is 250 m above sea level (a.s.l) and the highest is 3000 m a.s.l. Figure 3 shows the images of the uncompleted and completed model map.
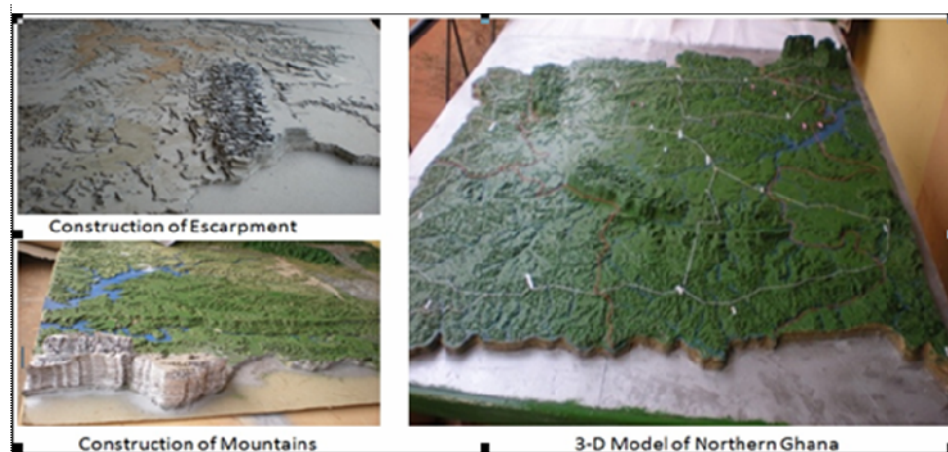

Figure 3: Three Dimensional model map of Northern Ghana (Scale 1: 250,000)

Figure 4 is the Central Gonja District 1:50,000 scale model with dimension of 2.14 m x 3.29 m covering approximately 16,464 km^2 on the ground. It has contour interval of 25m and vertical exaggeration of x2. Figure 5 is Upper East Region model at a scale of 1:50,000. The dimension of the model is 2m x 3m which represent 15,399km^2 on the ground. The contour interval is 25m with a vertical exaggeration of x2.

Workshops were conducted for all the three mapping process where Participatory Rural Appraisal (PRA) tools such as timeline, virtual maps and diagrams, transect diagrams, bioresource flow diagrams, seasonal calendars, group discussions were employed to address issues of food security, climate change, disaster management and emergency preparedness.

(PRA) is a methodology to enhance the development agent's understanding of the rural reality for the planning and development of projects; and the feeling of a greater degree of ownership and responsibility in the rural poor for better results and social acceptance of the programme (JAIN AND POLMAN, 2007).

Figure 4: Three Dimensional model map of Central Gonja District (Scale 1: 50,000)

Figure 5: Three Dimensional model map of Upper East Region (Scale 1:50,000)

All the stakeholders were asked to overlay their spatial memories of vulnerable communities, community resources, activities of NGO's and governmental institutions on the maps using post-its and push pins.

Thematic maps on community resources, vulnerable infrastructures and houses, activities of organisations and institutions and their hazards were produced. By overlaying these thematic maps and other thematic maps such as soil texture, soil geology, land use and average monthly rainfall, analyses were made on the various ways P3DM can support participatory planning and decision making in Ghana.

All participating NGO and governmental institutions were also asked the following questions in an attempt to build collaboration and partnership among them:
1. What are your goals?
2. How do your activities interrelate with the landscape?
3. How are you related with activities of other institutions?
4. How can you use the 3-D model to support development in Ghana?

RESULTS AND DISCUSSIONS

All the stakeholders got a general understanding of the landscape and how it interrelates with their programmes. The whole activity helped to identify the interrelationships between projects and contributed to building collaboration between stakeholders whose activities are interrelated. It also helped to identify where most development programmes are concentrated and created an avenue to identify other areas that need interventions. It also informed all stakeholders on the appropriate interventions to take on land areas where there is high depletion of natural resources as a result of the current land use pattern. For example it was noted that there is high deforestation rate in West Gonja District as a result of their farming practices. Therefore recommendations were made on the possible development initiatives that can help recover the degraded land and forest, and also provide alternative for the current practice. Another revelation was that, most of the organizations were supporting the same farmers groups. Organizations operating within the same geographical location therefore agreed to pull resources together to strengthen existing farmer groups in order to synergize output.

Other stakeholders also used the map to identify and estimate lowlands they can put into rice cultivation as part of their ongoing programmes. The MoFA staff present at the meeting has planned to use the 3-Dimensional model to estimate the extent and damage of future flood to cropping areas using geo-referenced locations of these crops within polygon following the 3-D contour lines. Other economic initiatives were identified especially at locations where there were less resource allocation and development initiatives. Some other stakeholders also saw it as a tool to assess the environmental impacts of projects and activities across the landscape.

Stakeholders that were asked the four questions responded that most development organizations enter into communities without a detailed idea about what other organizations are doing in the community and the overall development plan or agenda of the community. This normally ends up in the duplication and cancellation of efforts. Where other development initiatives are known, it always happens that the different organizations operating on the ground have different project implementation plans that may contradict. This always confuses poorly resourced farmers which consequently hinders them to fully adopt technology or models that are introduced to them. They also observed that there are no complete data sources on available resources development initiatives in communities where external agencies can build on in their programme planning, therefore making them start from the scratch all the time.

Stakeholders unanimously recommended that 3-D model should be used as a tool to empower regions, districts and communities so that all resources and medium to long term development plans can be featured. In this way external organizations can provide support that is within the framework of the overall agenda of the community, district or region. It is hoped that this will give them control over development, in both the ability to influence decisions and managing development directly.

In March, 2011, using the Northern Region 3-D map, Regional stakeholders were able to quickly identify their problem areas on the ground and expand them to see their relationship to the biophysical and socio-economic attributes of the larger landscape. The clarity of landscape information in the 3-D Map generated active discussion among them and forged ideas for collaboration for greater impact. They could see how 3-D, in community and regional level planning for agriculture and natural resource management, presents a promising opportunity to attract village-level citizen participation and stimulate institutional collaboration towards solving the external environmental threats that have plagued Northern Ghana. Also agricultural scientists in the region are able to estimate the size of lowland valleys suitable for

rice cultivation. The map has also helped them identify potential flooding sites that will require intensive planning and crop management systems.

In the Upper East Region, the MoFA is using the model in conjunction with an El Nino Southern Oscillation (ENSO) weather forecasting system, daily forecasters and regional soil properties data to develop cropping calendars, site suitability selection and cropping system management. The 3-D map has also made communication with the farmers very easy and many users believe much of the risk associated with farming will be reduced.

In a world where climate change and environmental degradation is disproportionately threatening the livelihoods of the disadvantaged and vulnerable communities, this kind of holistic approach is crucial. By understanding the place of their village and agricultural plot in a larger landscape, rural people can see the need to develop coordinated plans and initiatives. As their level of landscape knowledge grows, so does their ability and confidence in putting their needs and priorities into the local planning process. Going forward, the understanding and empowerment local people gain will translate into a stronger voice in local planning and a demand for greater accountability from all involved in the development process. 3-D Mapping can play a significant role in expanding the access to, and benefits of decentralized government in Ghana.

3-D modeling mapping will support:

1. ***Community based disaster and risk management:*** Flood hazard zoning, flood monitoring, risk prevention for flood plains and flood prone areas, and damage assessment for disaster management agencies.

Case Study: On Divinubo, a small island on the Pacific edge of the Philippines, MACEDA, et al (2009) used a 3-D model at a scale of 1:400 to help the community reduce vulnerabilities and raise capacities to withstand natural and other hazards. At the end of the process, the community identified eight assets crucial to their everyday life: the community multi-purpose hall and tourist cottages, the village houses, fishing, subsistence farming, cash crop agriculture, tourism activities, retail shops, transportation and boats. The community agreed on agricultural fields that could be protected and eventually did so with the financial support of community members. They also identified sites safe from major hazards and engendered discussions on their tenure.

A 3-D model at a scale of 1:5000 is detailed enough to support community-based vulnerability and risk assessment and flood hazard mapping. It is the right tool to support disaster and risk management for the vulnerable communities within the catchment of the Volta Rivers of Ghana. It equally supports broader land use planning at the community level. A scale of 1: 10,000 and above can be used for risk reduction planning across large geographic areas (RAMBALDI, 2010).

2. ***Collaborative Planning and Research:*** Several reports by People's Participatory GIS practitioners prove that using a 3-D model as a reference for discussion and planning improves mental handling of spatial knowledge. For example, at the regional planning level, it can support the identification of potential high and lowlands for development, assessment of environmental impacts of projects and policies and increase stakeholder dialogue on how their activities influence each other across the landscape. At the community level, the 3-D model can help community members in land use planning, resource access and utilization, identification of small water impounding sites, rainwater harvesting for irrigation, and increase information on how to effectively manage water on their farms. It can also inform development practitioners and local communities on land/site suitability for boreholes or well drilling and farming when integrated with other GIS data on hydrology, soil geology, drainage, texture, etc.

ESCOBAR et al. (2003) used a 1:3,000 scale Participatory 3-D Model of the Potrerillo sub-watershed, Microcuenca de Pescador, Cauca, Colombia in 2001 to help scientists communicate better with farmers. Until 3-D was used, scientists and farmers had different spatial perceptions of natural resources, research had not been very successful, and adoption of new technologies was very low because the information was not considered relevant by farmers.

3. ***Collaborative protected area management:*** RAMBALDI (2010) lists numerous ways in which 3-D has been used in other parts of the world to manage protected areas. RAMBALDI et al. (2005) constructed 3-D model of Ovalau Island, Lomaviti Province, Fiji Islands, for developing resource management, tangible and intangible cultural heritage preservation and development plans. Immediately after the completion, participants were able to learn names of places they don't use anymore and revived their historical memories and cultural values. Two years later Ovalau islanders were able to develop an island-wide natural and cultural resource use management plan which was followed by 3 district management plans. They have been able to establish taboo (protected) marine areas within fishing grounds of 3 districts comprising 16 villages. A nearby island partially included on the 3-D model has also set up a protected area among its 10 villages.

Potential areas of use in Ghana may include:

• Involving communities in developing resource-use and management plans, including zoning and boundary delineation;

• Conducting collaborative research on the distribution of species;

• Monitoring changes in land use, vegetation cover, human settlement, infrastructure development and other features;

• Raising awareness about the hydraulics of watersheds (e.g. upstream-erosion/downstream sedimentation effects);

• Conducting a preliminary census of protected area occupants;

• Increasing public involvement and comprehension at public hearings and planning workshops; and

• Supporting students' learning about local geography and resource use.

4. ***People Empowerment:*** As people become accustomed to communicating around the map with planners and district officials, their understanding of the role of government will improve. The clarity of landscape resource information at the hands of the community will transform them from passive to active participants in land use policy decisions and landscape initiatives with the confidence to demand accountability from their elected officials.

5. ***Collection of new information:*** It helps discover resources which hitherto were not known to external stakeholders and some community members. It provides a birds-eye view, which helps participants understand how the landscape interrelates with their livelihoods.

6. ***Improving communication***: It is a powerful tool that enables disadvantaged and illiterate people to effectively participate in planning. It eases communication and overcomes language barriers.

7. ***Traditional knowledge and intellectual property rights:*** A detailed or small scale map allows people with specialized or arcane knowledge to accurately locate and communicate their information. For example, people with knowledge of indigenous and endangered medicinal plant species can pass this valuable information on species and location to the younger generation using the 3-D map. People can also help map out past flooding incidences to aid disaster risk management.

Case Study: A 3-D model of the Mau Complex, Nakuru and Narok Districts, Kenya, was constructed in 2006 for the Ogiek People to regain their cultural identity and lost ancestral

territories. Elders populated the model with their memories dating back to 1925 and reconstructed the landscape as it was at that time. The map raised awareness on the critical status of the entire Mau Complex in terms of depleted forest cover and affected watershed functions. The mapping process stimulated community cohesion and surfaced lost memories. At the end of the process, elders got a more holistic understanding of their social, cultural and bio-physical environments (RAMBALDI et al., 2007).

8. ***Monitoring and Evaluation:*** It is very useful when integrated with GPS and GIS in monitoring deforestation and desertification over a period of time.

CONCLUSION

Changes in global temperatures and the effects of natural and human activities everywhere are bringing an unprecedented urgency for improved, landscape-level planning and citizen-backed action to avoid a crisis in the systems that shelter and feed the people of the world. Science and technology cannot manage and alleviate these threats alone; they will require the political will to make difficult changes in human attitudes and behaviors. Such changes will require the understanding and collaboration of people in every region of the globe.

When presented with the 3-D map, multidisciplinary and inter-institutional stakeholders immediately identified their areas of interest in communities across the landscape. This geographic location readily enabled them to relate to agro-ecological and socio-economic attributes of the land that concerns them and discussed with other institutions on commonalities of their programmes, and started forging areas of collaboration. Gaps were identified for potential areas that remain largely untouched. For example: the huge irrigable lands and the potential water based on the nearest water resources were identified. Also, the flooding hazards were particularly discussed especially in relation to crop losses, damages to properties and loss of lives, community resettlement, and disaster management. Other issues like accessibility and roads networks, human settlements, mining, livestock areas, crop zoning and natural reserves were discussed as understanding of the landscape attributes are more clearly presented in the 3-D model.

The 3-D Map is not a new idea; it has been used for several decades, often to involve citizens in local planning or to attract prospective buyers and investors in new urban and recreation developments. It has proven successful because it gives the viewer a vivid and comprehensive picture of a landscape terrain. It enables people to identify themselves and their activities in the landscape while stretching their horizons to a bigger picture. Those broader horizons, whether from the village or from the Regional Minister's planning office, provide the scope that will be essential if people are to adapt to coming challenges. 3-D Maps are some of the most effective tools to bring everyone into the solution with a shared understanding and a shared and stronger voice.

In Ghana, giving that scope, vision and voice to rural communities will bring the 3 Regions of Northern Ghana more effectively to the National policy and funding table and help to realize the full benefits of decentralization.

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