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Participatory 3D modelling as a *socially engaging and user-useful* approach in ecosystem service assessments among marginalized communities

Sara O.I. Ramirez-Gomez [a, b, *], Pita Verweij [b], Lisa Best [a], Rudi van Kanten [a], Giacomo Rambaldi [c], Roderick Zagt [d]

[a] Tropenbos International Suriname, Prof. Dr. Ruinardlaan (CELOS Building), Paramaribo, Suriname
[b] Copernicus Institute of Sustainable Development, Faculty of Geosciences, University of Utrecht, 3584 CS Utrecht, The Netherlands
[c] Technical Centre for Agricultural and Rural Cooperation, 6708 PW Wageningen, The Netherlands
[d] Tropenbos International, 6700 AE Wageningen, The Netherlands

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ABSTRACT

Land use decision making in the Upper Suriname River area knows a history of disempowerment and marginalization of the Saamaka communities inhabiting the area. Non-recognition of land rights is at the origin of this problem. This is aggravated by the increasing over-exploitation of timber resources by powerful stakeholders and the unfair distribution of timber benefits. This has left Saamakans marginalized, causing distrust and opposition among themselves and towards outsiders. Furthermore, as a result of deforestation, Saamakans face detrimental changes in the ecosystem services (ES) that support their traditional livelihoods, with important effects for their wellbeing. This environment of distrust, opposition and marginalization makes it difficult to assess these concerns. Hence, an ES assessment approach that would generate salient ES knowledge while generating trust, communication among stakeholders and local capacity building was needed. In this paper we evaluate whether Participatory 3D modelling (P3DM) is an effective approach for ecosystem services assessments in such disenabling environments. We evaluate this by using empirical data from an ES assessment in the Saamaka region using a P3DM approach. Results show the efficient identification and evaluation of 36 ES representing provisioning, cultural and regulating service categories with crops, fish, wild meat, timber and forest medicines identified as most important. We found a decrease in the demand and supply of crops, fish and wild meat associated with ecosystem degradation, out-migration and changes in lifestyles. Further, our findings show an increasing demand and decreasing supply for timber related to over-exploitation. We provide evidence of the utility of P3DM to foster multi-functional landscape development among wary communities. Further, we discuss the usefulness of the approach and the necessary conditions needed for P3DM process to tackle the needs of the local communities as well as the need for a broader P3DM implementation strategy beyond the engagement, screening, and diagnostic phases of ES assessments when the aim is to enhance ES outcomes for marginalized communities.

1. Introduction

More than 50 million people live in remote regions and depend entirely on functioning forest landscapes for the provision of food, medicines and shelter (Newton, Miller, Byenkya, & Agrawal, 2016; Sunderlin et al., 2008). Infrastructure investments such as roads and dams, as well as extractive industries like gold mining and logging, are changing forest landscapes in profound and uncertain ways (Lambin & Meyfroidt, 2010). These activities have differential impacts on localities and communities across regions in the form of changing consumption patterns, transformation of traditional land use practices, among others (Nelson et al., 2006). In some cases, they trigger forced migration and consequently marginalization

* Corresponding author. Copernicus Institute of Sustainable Development, Faculty of Geosciences, University of Utrecht, 3584 CS Utrecht, The Netherlands.
E-mail addresses: s.o.i.ramirez-gomez@uu.nl, soi.sararamirez@gmail.com (S.O.I. Ramirez-Gomez).

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and disempowerment (Terminski, 2014). Indigenous communities living in remote and poorly governed regions tend to bear the brunt of the negative effects of these developments while benefiting little of the prosperity they generate (O'Faircheallaigh, 2013). They are vulnerable because their livelihood means rely on the ecosystem services that are susceptible to the impacts of these economic activities (Willemen, Drakou, Dunbar, Mayaux, & Egoh, 2013).

In some cases, top-down, expert driven land use decision making has left rural communities feeling marginalized and disempowered, leading to distrust and opposition towards outsiders (Ban et al., 2013; Kumar & Kumar, 2008). Distrust has been recognized as an important obstacle to effective natural resource management (Hahn, Olsson, Folke, & Johansson, 2006). Hence researchers and practitioners identify trust as essential to effective natural resource management and implementation (Fazey et al., 2013; Reed, 2008; Stern & Baird, 2015). Despite the increasing research efforts, information on how to generate salient, credible and legitimate knowledge (for a definition see Cash et al., 2003) for the integrated management of natural resources among wary communities in remote regions, promoting empowerment and enabling local ownership and trust, remain key challenging issues (Chaffin, Gosnell, & Cosens, 2014; McCall, 2003; Olsson et al., 2006).

By the same token, several scholars have pointed out the gaps towards a science-policy-practice interface in ways that enhance ecosystem services (ES) outcomes for marginalized communities: 1) Turning science and technology into action in a manner that enhances a collaboration of local stakeholders in the co-production of ES information while creating capacity among local communities so that they can better participate in decision making (Cash et al., 2003; Fischer et al., 2015; Miller et al., 2014); 2) Attaining a fair distribution of the benefits from ES (Bennett et al., 2015; Daw, Brown, Rosendo, & Pomeroy, 2011; Pascual et al., 2014) (e.g. access to provisioning services such as food, water, fertile soil, timber); 3) Identifying alternative livelihood sources for the rural poor that avoid compromising environmental sustainability (Dawson, Rounsevell, Kluvánková-Oravská, Chobotová, & Stirling, 2010; Poppy, Jepson, Pickett, & Birkett, 2014; Sayer et al., 2013) (e.g. alternatives to the involvement of poor rural communities in illegal timber and mining activities in order to make a living); and 4) Procuring appropriate communication channels between experts, local people and policy makers, in a language that is understood by all in order to deal with conflicts between actors, increase transparency, bring all perspectives into the negotiation table and establish criteria for decision making (Bennett et al., 2015; García-Nieto et al., 2015; Palomo, Felipe-Lucia, Bennett, Martín-López, & Pascual, 2016; de Groot, Alkemade, Braat, Hein, & Willemen, 2010).

It is only through the engagement of the end users of the knowledge generated by research that science on ES can pursue transformative interventions and render an important contribution towards a fair and more equitable sustainable development (Fischer et al., 2015; Reyers, Nel, O'Farrell, Sitas, & Nel, 2015; Sitas, Prozesky, Esler, & Reyers, 2014). This implies that, in marginalized regions, ES assessments should apply user friendly methods that can be understood by all (Fischer et al., 2015; Ostrom, 2009). A more friendly and inclusive ES assessment approach might enhance the quality and likelihood of durability of ES management interventions (Bohensky & Maru, 2011; McLain et al., 2013; Ostrom, 2007, 2009).

Participatory Geographic Information Systems (PGIS) comprise an array of methods based on place-based mapping by local communities, seeking to democratize spatial information and technology (Brown & Fagerholm, 2014). PGIS have been proposed as an important tool to strengthen the capacity of the end users to engage and participate effectively in decision making by legitimizing local peoples knowledge, by enabling ownership and by preparing local stakeholders to judge and respond to changing environmental conditions (Jankowski, 2009; McCall & Minang, 2005; Rambaldi, Kwaku Kyem, McCall, & Weiner, 2006; Sayer et al., 2013; Talen, 2000). Refutably, compared to conventional GIS, PGIS may lack cartographic precision (McCall, 2006), yet PGIS can be a powerful method to produce social outcomes (i.e. social learning and social capital) (Brown & Fagerholm, 2014) which "… are arguably equally important objectives in the achievement of sustainable future land use" (Brown & Kyttä, 2014, p. 13).

In this article we use a PGIS tool centered on a community-based process which integrates local knowledge on ES with data on elevation of the land to produce physical 3D models known as Participatory 3D Modelling (P3DM) (Rambaldi & Callosa-Tarr, 2001). We adopted P3DM as the means to engage with local stakeholders in a collaborative, spatially-explicit research on ecosystem services, with a view to contribute to informed and participatory decision making in the Upper Suriname River area where people, belonging to the Saamaka tribe, have lived for centuries. By using P3DM we wanted to research the social engagement and user-usefulness of the P3DM approach in collaborative ecosystem service assessment in a remote forest landscape undergoing land use pressures, in order to enhance ES outcomes for marginalized local communities that show distrust and opposition towards outsiders. We answered this question based on empirical findings that specifically: 1) identified and mapped ecosystem services that Saamaka people value most for their contribution to local livelihoods, 2) ranked ES that are more important for their income and subsistence, 3) explored local perceptions of change in the supply and demand of those prioritized services, 4) assessed the opinion of local and external stakeholders regarding the usefulness of the P3DM in the context of the study area and 5) gauged the main concerns of local community regarding the flow of important ES.

The socio-economic and cultural context of the Saamaka territory pose the need for a more user-friendly and socially engaging approach (Cowling, 2014; Cowling et al., 2008). The Saamaka people have a history of marginalization and disempowerment, both during the colonial period as well as after the independence of the country in 1975 and for this reason they have been wary towards outsiders. Some of the major causes of community disempowerment in the context of this study include:

- The building of the Brokopondo reservoir in 1960's to supply the demands of the bauxite industry and the city capital: Over 300,000 ha of Saamaka territory was flooded causing the transmigration of more than 4000 villagers which triggered the loss of burial grounds, sacred places and agricultural fields (Price, 2012a). Paradoxically, until today, 62 villages (approximately 17,000 people), including those that were transmigrated lack access to electricity.
- Absence of *de jure* land rights: Although *de facto* rights exist (Schlager & Ostrom, 1992), traditional land right are not legally recognized by the national law and therefore Saamaka communities lack both tenure security and secure access to livelihood resources.
- Lack of consultation and participation: Logging activities that have taken place in the Saamaka territory, damaging agriculture fields and other important places, without proper consultations nor implementation of free prior informed consent (Inter-American Court of Human Rights, 2007; Price, 2012b).

We used the typology for the classification of ecosystem services of Vallés-Planells, Galiana, and Van Eetvelde (2014) because in our study context it provided more flexibility to include a broader range of functions valued in economic, socio-cultural and ecological sense