PARTICIPATORY MAPPING WITH INDIGENOUS COMMUNITIES FOR CONSERVATION: CHALLENGES AND LESSONS FROM SURINAME

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ABSTRACT

The indigenous peoples of Southern Suriname depend on landscape services provided by intact, functioning ecosystems, but their use and reliance on natural landscapes is not well understood. In 2011, Conservation International Suriname (CIS) engaged in a participatory GIS (PGIS) mapping project to identify ecosystem services with the Trio and Wayana indigenous peoples living in five villages in Southern Suriname. The PGIS project involved a highly remote and inaccessible region, multiple indigenous peoples, villages with different perceptions and experiences with outsiders, and a multitude of regional development pressures. We describe the PGIS project from inception to mapping to communication of the results to the participants with a particular focus on the challenges and lessons learned from PGIS project implementation. Key challenges included decoupling the PGIS process from explicit CIS conservation objectives, engaging reluctant villages in the project, and managing participant expectations about project outcomes. Lessons learned from the challenges included the need to first build trust through effective communication, selecting initial project locations with the greatest likelihood of success, and to manage expectations by disclosing project limitations with the indigenous communities and external parties.

Keywords: Participatory GIS, PGIS, Conservation, Indigenous, Trio, Wayana

1. INTRODUCTION

Indigenous peoples have long depended on natural environments with the understanding that biological diversity is essential to the ecological services on which they depend. If ecosystems are to be managed sustainably, the value of the knowledge-practice-belief complex of indigenous peoples must be “fully recognized” (Gadgil et al., 1993, p. 151). But “full recognition” of the value of indigenous knowledge to inform conservation planning and the protection of biodiversity remains a work in progress. In several of the more widely cited and influential scientific publications on conservation planning (Margules and Pressey, 2000; Pressey et al., 2007), the potential value of indigenous knowledge to conservation is conspicuously absent, despite the view of some scholars that scientific knowledge and indigenous knowledge can be complementary (Agrawal, 1995; Houde, 2007). Regardless of the importance of indigenous knowledge, a pragmatic argument can be made that conservationists cannot rely on state bureaucracies to defend isolated, protected areas of high biodiversity (Colchester, 1998) and that biodiversity protection must occur with larger managed landscapes occupied by human beings that care about the environment and the well-being of future generations (Colchester, 2000).

Participatory mapping is a label that refers to an array of community-based research and development approaches that use local people to map places, transforming cognitive spatial knowledge into cartographic and descriptive information (Herlihy and Knapp, 2003). The participatory mapping of indigenous lands is one approach that has emerged to better understand and integrate the knowledge, practices, and beliefs of indigenous peoples into conservation planning. As noted by Chapin et al. (2005, p. 619), the mapping of indigenous lands to secure tenure, manage natural resources, and strengthen cultures began in Canada and Alaska in the 1960s and in other regions during the last decade and a half. In their review of approaches to integrating socio-spatial data into environmental planning, McLain et al. (2013) identify three broad purposes for human-ecological mapping: to secure land tenure and manage natural resources; to identify local ecological knowledge; and to identify peoples' connection to place. The majority of indigenous participatory mapping applications in Latin America, the geographic focus of this paper, have been motivated by the need to secure land tenure and continuing access to natural resources. For example, in South America, indigenous mapping has occurred in Venezuela, Guyana, Brazil, Ecuador Colombia, Bolivia, and Peru (Chapin et al., 2005, p. 635).

The number of indigenous, participatory mapping studies focused on identifying values for conservation, rather than securing tenure, property rights, or access to natural resources, is relatively few. Weber et al. (2000) provide an edited collection of case studies describing World Wildlife Fund collaborations with indigenous people in South America, Papua New Guinea, and Africa, but these collaborative efforts did not specifically involve participatory mapping for conservation values. Corbett (2009) describes examples from Peru, Thailand, Philippines, and Ghana that were focused on mapping cultural resources, natural resources, ancestral areas, and conflict over logging, respectively. McLain et al. (2013) cite a number of studies that involved the collection of local ecological knowledge (LEK), but none of these studies involved the systematic participatory mapping of conservation values. One recent example of facilitated mapping of indigenous knowledge for conservation is the work of Fagerholm et al. (2012) with rural villagers in Zanzibar, Tanzania, where participants were interviewed to identify landscape values and services, with some related to conservation. In that study, a typology of 19 different material and non-material, cultural landscape service indicators were mapped from semi-structured interviews on an aerial image using beads.

Research on participatory mapping for conservation with indigenous people remains an underdeveloped research area. There are numerous case studies of collaboration between indigenous peoples and outsiders such as NGOs and academics, but relatively few examples of participatory mapping efforts that have effectively coupled indigenous knowledge and with actions resulting in larger-scale conservation outcomes. Optimistically, participatory mapping by indigenous peoples can provide an operational bridge between indigenous and Western conceptions of conservation. As will be described, participatory mapping for the purpose of biodiversity conservation must first attend to the needs and concerns of the indigenous people through descriptive mapping of the services provided by the landscapes they use.

In this paper, we reflect on the challenges and lessons from a participatory GIS (PGIS) mapping project in Suriname, South America, sponsored and facilitated by Conservation International Suriname (CIS). In simple terms, this case study involves participatory mapping with indigenous peoples for the purpose of advancing conservation in a region with significant biological diversity. But the simplicity is deceptive. The PGIS project involved a highly remote and inaccessible region of South America, multiple indigenous peoples (Trio and Wayana), diverse villages with different perceptions and experiences with outsiders, and a multitude of regional development pressures. Despite the availability of resources on good practices in participatory mapping (Corbett, 2009), the ethics of participatory mapping (Rambaldi et al., 2006), and caveats associated with participatory mapping (Chambers, 2006), implementation of the Suriname PGIS project with indigenous peoples was never going to be easy.

There was no single source to consult to find answers to basic questions. What attributes should be mapped? How should the attributes be mapped? Who should do the mapping? How should the spatial data be analyzed? And importantly, how could the mapped information be used to leverage biodiversity conservation? This case study is characterized as participatory research mapping (PRM) that applies a participatory methodology to harness the cognitive geographic knowledge of indigenous people to make maps and with descriptive information. As noted by Herlihy and Knapp (2003), "education, empowerment, and social action can be objectives of PRM, but intercultural communication and Western-style accuracy, validity, and standardization of the results are essential" (p. 307). This latter point appears crucial—if researchers, social activists, and NGOs want to leverage indigenous knowledge and connection to place to conserve biodiversity, participatory mapping methods need to be systematic and rigorous to meet Western scientific standards of research while being implemented in the vernacular of indigenous language and culture. This is a *catch-22.* If participatory mapping appears too simplified or localized to indigenous people, it will not be accepted within the Western scientific tradition of research. Conversely, if the participatory mapping approach embraces the Western scientific methods that emphasize accuracy and validity, it will alienate indigenous peoples. A key question is whether participatory mapping by indigenous peoples can achieve sufficient credibility to influence biodiversity conservation outcomes.

This paper is organized around the methods chosen for the PGIS project and the associated challenges with implementation, followed by an example of the spatial results produced. The core of the paper, however, is a reflective discussion on the key issues that emerged in the project as they relate to best practice in PGIS and a critical self-evaluation of the project regarding the original purpose of enhancing the conservation of biological diversity.

1.1 Purpose and Context of the PGIS Mapping Project

The participatory GIS project was conceived by Conservation International Suriname (CIS) to gain support for the concept of a Southern Suriname Conservation Corridor whose purpose is to protect and sustainably manage 2 million hectares of pristine land. CIS recognized the need to document the value of the corridor area for Suriname government agencies. CIS decided to engage with indigenous communities using PGIS to understand their values, needs, and activities within the corridor area and to use this information to better inform the conservation corridor concept.

CIS and the people of Suriname, in general, are aware that isolation has benefited Suriname's ecosystems, natural resources, and indigenous cultures which are disappearing at an increasing rate. There appears to be a limited window of opportunity to act to protect the interdependent cultures and resources of the region. Record high commodity prices have encouraged the spread of *garimpeiros* (gold miners) from Brazil, spurred potential major hydropower and mining investments, and provided incentives to construct road and dam projects. As a first step, CIS believed it was necessary to generate information about the value of the ecosystems for the local communities that live in the region to assist the government in making informed decisions about future land use and conservation projects.

In addition to the need to assess cultural and ecosystem values in the region, the indigenous communities needed an effective means to communicate their dependence on resources in the region that sustain their livelihoods. Maps of perceived social values for ecosystem services can be an effective tool for communicating with outsiders the potential impact of development in places where the indigenous communities obtain their food or generate income. This purpose is illustrated by a meeting between CIS representatives and *Kapitein* (captain) Euka, the village chief of Sipaliwini. The chief is a strong advocate of ensuring that the natural environment remains intact so that his village can continue to exist. He said: “It is important for us to be able to show the Government what parts of land are necessary for our way of life and are important to us.” He believed that maps are vitally important to this cause, especially in the case of future infrastructure development, “It’s good that everyone knows about these maps and is aware of how important this land is to our village.” As explained below, chief Euka became a champion for the PGIS project in the region, ensuring participation by other villages.

The PGIS project consisted of three stages: (1) scoping and negotiations, (2) operationalization and implementation, and (3) community feedback with PGIS data validation. In the first stage, CIS presented the PGIS project concept and negotiated with village leaders about the scope and terms of the project. In the second stage, meetings were held to reach agreement on the PGIS attributes to be mapped followed by the actual mapping activities in the different villages. In the final stage, the PGIS results were validated in village meetings, providing the opportunity for community feedback. These stages are described in detail below.

2. Methods

2.1 Overview of PGIS process

The PGIS project was implemented in each of five indigenous villages during three working sessions. The first working session included a meeting with the village chiefs (*Kapiteins*), his helpers (*basyas*), and community members. The purpose of the session was to describe the project and its benefits, to seek consent from the chiefs, and to ask the chiefs if they would support villager participation in the project. This session generally lasted two days with meetings and active discussions. During this session, if the *kapitein*, the *basyas*, and the community members approved the project, the extent of the mapping area was discussed and approved.

During the second working session, the overall research approach was discussed with the participants prior to mapping. Local adjustments to the process were made as needed. The maps were developed following some open-ended questions about villager activities in relation to the ecosystem services using a map legend as guide. The location of the ecosystem services were mapped individually by each participant but the data would be analyzed to identify collective spatial patterns of the perceived importance for ecosystem services across the landscape of each study area.

The third session consisted of a discussion of the mapped results with the participants from each village, the *kapitein*, and the *basyas*. The discussion centered on the interpretation of the results as well as the possible uses of the maps by the community as a potential tool for advocacy and land use planning.

2.2 Study Location

The participatory GIS project was carried out in five indigenous villages located in Southern Suriname: Sipaliwini, Paleletepu, Apetina, Kawemhakan, and Palumeu (see Figure 1). The study area is located approximately 350 km from the capital Paramaribo and is remote, only accessible by plane or by boat after several days of navigation through narrow rivers, creeks and multiple rapids. The landscape is dominated by high, dryland tropical forest with patches of seasonally inundated tropical rain forest, savanna forest on rocky soil, and savannah with *Cerrado* vegetation (Banki and Aguirre 2011). The topography comprises the mountain ranges of Grensgebergte, Oranjegebergte, and Toemoek Hoemakgebergte with elevations between 100-400 meters and scattered granitic outcrops that approach up to 800 meters. These mountain ranges were highlighted as high ranked areas for biodiversity conservation in a priority setting workshop for the Guayana Shield attended by Conservation International, the IUCN, and UNDP (Huber and Foster, 2002). Within the study area there is one legally protected area, the Sipaliwini nature reserve, an area of 77,500 ha dominated by Amazon savannah vegetation. The annual average precipitation in the region is 2,324 mm.

Southern Suriname is inhabited by Trio and Wayana indigenous communities. The Trio (or Tarëno) people are a group of indigenous tribes from nomadic origin living in a large area in Northern Amazonia. They probably arrived in Suriname from Brazil in the late 17th century. Geographically they are located in three drainage basins: in Suriname they are in the upper Sipaliwini-Corantijn and the Tapanahoni-Palumeu basins, with Kwamalasamutu and Paleletepu as central settlements. In Brazil, they are located in the Paru basin with the main village Missao Tiriyó. Baptist church missionaries have been working in the Surinamese area since the 1960s, concentrating on the Trio people in Kwamalasamutu and Paleletepu to facilitate education and the delivery of health care. In the last two decades, the Trio have dispersed to other missionary enclaves including Wanapan, Alalapadu, Sipaliwini, Kuruni, Amotopo and Lucie, thus marking Suriname's Trio territory (Heemskerk and Delvoye 2007).

The Wayana occupy northern Brazil, Southern Suriname, and Western French Guiana. In Suriname, the Wayana live on the banks of the upper Tapanahony, Litani, Oelemari, and Litani rivers. They arrived from Brazil in the mid-18th century and settled in Apetina, Palumeu, and Kawemhakan, with Apetina as a central settlement. Baptist church missionaries have also been living among the Wayana in Suriname evangelizing, educating, and providing health care (Heemskerk et al 2006).

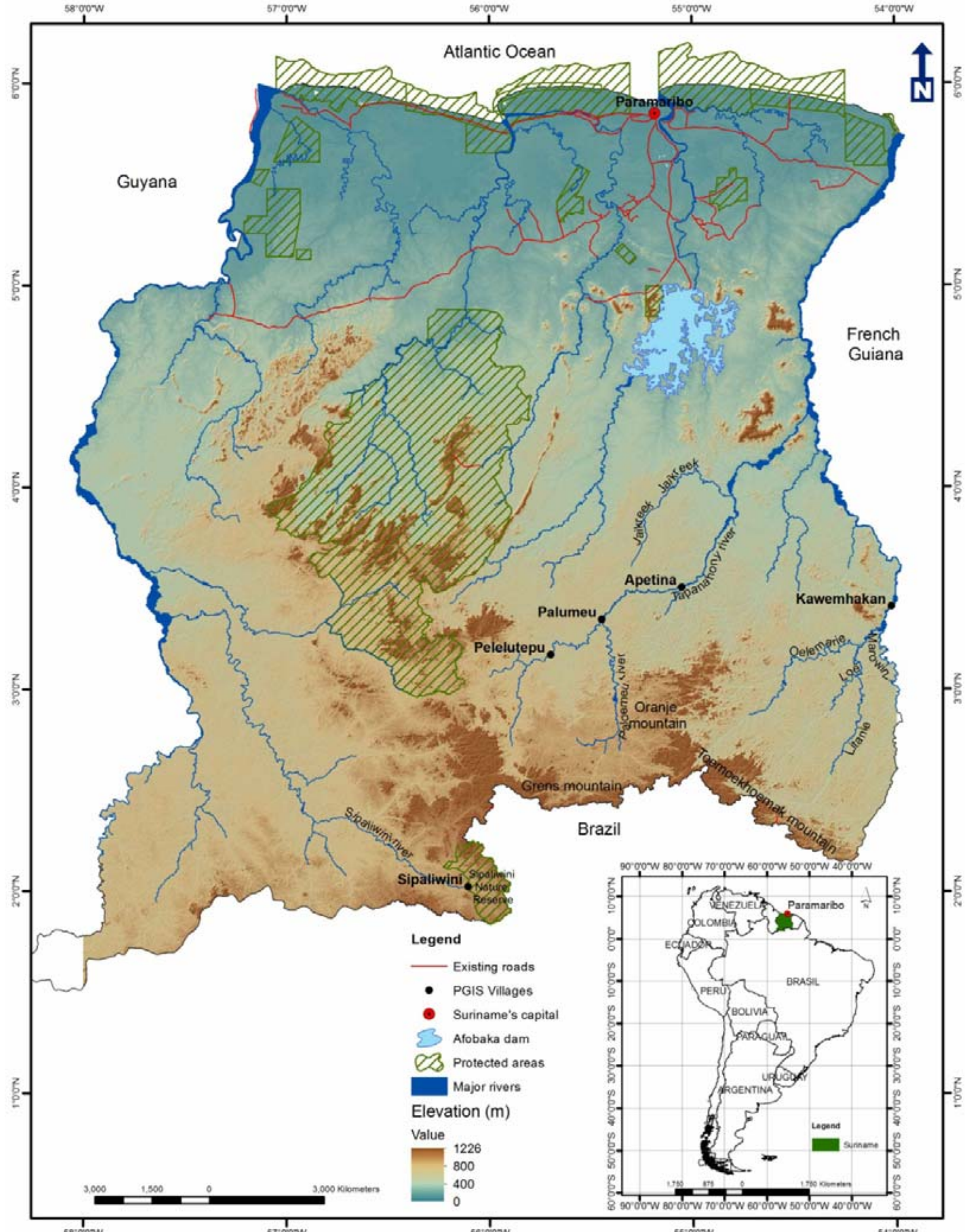
Neither the Trio nor the Wayana have formal land rights which leave them vulnerable to natural resources exploitation. Potential impacts could emerge from the development of infrastructure such as the planned North-South Road and the Tapajai Dam. The North-South Road is an extension of an existing road in the south of the country between the Eilerts de Haan and Grensgebergte to connect with roads in Brazil. The dam would impact the area within the Tapanahony-Palumeu basin.

Proximate to the Trio and the Wayana settlements, the landscape is dominated by shifting cultivation. Main agricultural products include cassava, plantain, banana, sweet potato, sugarcane, watermelon, corn, pineapple, cashew, tanya, and cayenne paper. The cultivation period lasts, on average, two years while the fallow period lasts four years.

2.3 Negotiations and Community Support

Project negotiations were initiated by the CIS Executive Director. The discussions with village leaders centered on who would own the PGIS information and how it would be used by CIS. The parties agreed that the owner of the information would be the villages/communities, but that CIS could use the information in talks with the government, provided that permission was always requested from the village authorities and that any product derived from the data would be shared with the communities. CIS indicated that it wanted to use the maps as dialogue tools with the government and outsiders to show that people in that isolated areas were entirely dependent on the ecosystems services provided and that any large-scale interventions in the area would have serious impacts on indigenous livelihoods. Some promises were made in some of the villages as a result of the negotiations. For example, in Sipaliwini, CIS was asked if it could assist the village in receiving training from the Government and University on the breeding of frogs and birds. In other villages, CIS was asked for support with gasoline to find building materials for the communal meeting place (*Tukusipan*) or monetary contributions to attend church conferences.

Figure 1: Map of Suriname showing location of villages relative to capital.



The support of the chief of Sipaliwini village (Euka) and the *Granman* (chief of the whole Wayana people in Suriname) was critical in convincing the people to engage in the mapping project. CIS worked with chief Euka and village leaders from the inception of the project. Meetings were held in the village to discuss and refine the PGIS project purpose. CIS did not introduce the concept of a conservation corridor, because it had not yet been agreed with the national government, nor the indigenous people, but CIS indicated their intent to produce spatial information to show the government and outsiders how important the area is for the well-being of the indigenous community. CIS explained that the organization wanted to make the indigenous values for ecosystem services spatially explicit for consideration in future land use planning.

Captain Euka wanted the participatory maps, not only to show the areas that are important for community well-being, but as a mechanism to talk to the government about the need to enforce protection of the existing Sipaliwini Nature Reserve, as well as extending the protected area (see Figure 1). With agreement on the mapping purpose between the Sipaliwini community and CIS, the participatory mapping process began. Concurrent with the Sipaliwini mapping process, Captain Euka was talking with people in the other villages of Southern Suriname about the benefits of the maps for the indigenous people. When CIS arrived in the other villages to discuss the project, people in the villages were aware of the PGIS project and the experiences of Sipaliwini village.

The second village to engage in the participatory mapping project was Apetina and the first meeting was with the *Granman*. He knew about the project and agreed with the purposes that CIS presented. He expressed interest in generating maps for the whole Wayana territory which was, according to him, under threat due to the constant pressure of gold miners. The *Granman* believed that the maps could help visualize whether the gold mining activities were affecting their subsistence areas now, or in the future.

The influence of these indigenous authorities from Sipaliwini and Apetina helped considerably in convincing the other villages to participate in the PGIS project. Nonetheless, additional discussions were required with the people of Palumeu and Paleletepu villages. In Palumeu, the people were cautious about CIS because a rapid biodiversity assessment would be undertaken in an area south of their village in early 2012. Explanations were needed to clarify that the purpose of the rapid assessment was to produce information about the importance of the area in terms of biodiversity while the PGIS project was needed to identify the importance of the area to people. To some villagers in Palumeu, the biological assessment became conflated with the PGIS project. The community was divided between those that believed the PGIS was linked with the establishment of a protected area and those that did not.

After three months, the people of Palumeu agreed to participate but they were not convinced by CIS, but rather by a school teacher in Apetina and by the *Granman* who insisted on doing the PGIS mapping project in the Wayana territory. The school teacher worked together with CIS to translate the results of the maps from Apetina and Kawemhakan into the language of the Wayana people. The teacher knew the situation of the Wayana regarding the pressure from gold mining and he recognized the potential importance of the maps. He was impressed by the first PGIS maps and he knew the favorable disposition of the *Granman*. By coincidence, the teacher was traveling to Palumeu for different reasons. CIS gave him a copy of the mapped results from the PGIS work in Apetina, Kawemhakan and Sipaliwini and asked him to talk again with the village chief and leaders. CIS received a call via radio from the captain of Palumeu indicating that after talking with the teacher, they had decided to participate, but that CIS should prepare another basemap including areas that were missing on previous maps. CIS later learned from the teacher that the chief of Palumeu saw the PGIS maps from Southern Suriname and that his village was the only one missing and he did not want to be left out.

The PGIS project in Paleletepu was challenging in the first meeting, because villagers were aware of the divided opinion in the neighbouring village of Palumeu. The Paleletepu villagers expressed similar concerns as Palumeu; the two villages share resources in part of their territory. Paleletepu's village chief and others leaders requested time to reflect on their participation, because they had other priorities such as drinking water, unemployment, and land rights issues. The following day, after internal meetings with community members, the village leaders confirmed their participation because they believed the maps could be helpful for land rights negotiations with the national government. CIS explained that it did not intend to become involved in the land rights discussions, but that CIS would be willing to approach the indigenous association (who was aware of the PGIS maps) to see how the maps could be useful in land rights discussions.

2.4 Selection of PGIS Attributes

The broad purpose of the PGIS project in Southern Suriname was to identify the location of perceived ecosystem services that sustain indigenous livelihoods in the region that could inform the design of conservation plans and future sustainable land uses (spatial planning). The project started with a review of participatory GIS approaches in the social valuation of ecosystem services to determine which PGIS attributes would be included. Variations of a general landscape values typology developed by Brown and Reed (2000) have been used in multiple participatory mapping studies, but the majority of these studies were situated in developed countries with non-indigenous participants (see e.g., Brown, 2005; Beverly et al., 2008; Brown and Reed, 2009). Fagerholm et al. (2009) adapted the values typology to a developing country context by simplifying the values typology from 10-15 values to just four values (subsistence, traditional, aesthetic, and leisure) and used simple mapping methods that are feasible in rural settings. The research team determined that some variation of an existing value typology would likely be most effective with the indigenous communities, although the specific values that would be mapped were not predetermined. The final PGIS attributes to be mapped were developed with the assistance of the Sipaliwini village, the pilot site. The Sipaliwini villagers, through the commitment of their village chief, were receptive to the project and thus a good place to pilot the PGIS project.

During a workshop that lasted two days, the Sipaliwini villagers made a list of all the things that are important to them. They appointed a group of five community representatives to develop that list and present it to workshop participants. The list contained 90 landscape features which included several species of birds, frogs, and turtles that they trade, game species, fish, agricultural fields, drinking water sources, swimming and vacation places, places with tourism opportunities, places with aesthetic value, local names of flora that provide building material, as well as vegetation species that provide fibers and materials for ornaments.

The list of important landscape features was discussed by participants with the help of an external facilitator. The features were grouped into categories that were labeled “landscape services”. The seven services of food, building materials, culture, recreation, drinking water, tourism, and income generation were selected by villagers as containing all the features important to them. These landscape services were regrouped into two categories of provisioning and cultural services following the Millennium Ecosystem Assessment typology MEA (2003). A third category of income generation was adopted based on responses from participants. Provisioning services included food, building materials, and drinking water. Income generation included money from wildlife, fish, and tourist opportunities. Recreation value was identified as a separate cultural service. The four service groups (provisioning, cultural, income generation, recreation) were presented to the Sipaliwini villagers and accepted as the PGIS mapping attributes. These attributes were used in the other villages with some adjustments. In the other villages, recreation value was combined into cultural services and “special places” was included as a cultural value as it was suggested by the participants in Apetina village (Table 1).

Table 1: The Ecosystem Services Categories Mapped in Five Suriname Villages.

Ecosystem service category	Activity/Indicator	Questions addressed to locate the ecosystem services
Provisioning services	Fishing, hunting, planting, drinking water, finding building materials, fruits, lumber and firewood.	Where do you and your family go hunting, fishing, making agricultural fields, finding fruits, building materials, lumber and firewood?
Cultural services	Recreation (mainly swimming), opportunities for tourism, aesthetic value, sense of place.	Where do you go swimming? Where do you go on vacation? Which places do you find beautiful? Which places are special to you or unique?
Income generation services	Tourist attractions, birds, frogs and turtles with monetary value and selling wolf-fish (*Hopplias spp*. locally known as Anjoemara).	What are the activities in the landscape that provide you with monetary income? Where do you go to undertake those income generation activities?

An intentional decision was made to exclude medicines in the group of provisioning ecosystem services. When the community participants in Sipalwini, the pilot village, were asked about the location of medicinal plants, they drew a circle around the whole mapping extent. There are two possible interpretations. The participants considered the whole area to contain medicines, or they did not want to identify specific locations since the location of medicines is a sensitive issue. From this initial pilot village, the PGIS team decided to remove medicines from the legend of ecosystem services in all subsequent villages.

2.5 Maps, Materials and Mapping Process

The spatial data collection occurred in participatory mapping workshops in the five villages between January and November, 2012. The base map was a digital elevation model (DEM) of 90 meters resolution from the Shuttle Radar Topography Mission (http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp), reclassified for two elevations, above 400 meters and below 400 meters. The purpose of this reclassification was to highlight mountain ranges and inselbergs which are important spatial referents for the indigenous communities because these have strong social values attached. Base maps were printed at different scales ranging from 1:100 000 to 1:250 000 depending on the mapping extent decided by each community.

A total of 191 community members from all five villages participated in the individual mapping activity. Participation in the mapping process was voluntary but the village chief (*kapitein*) and the *baatjas* encouraged people to participate based on the suggestion from CIS that as many participants as possible were needed between the ages of 15-60. All who wanted to participate were welcomed. The village received a monetary contribution administered by the *kapitein* for the time of the villagers dedicated to the workshops.

The workshop was led by a neutral facilitator hired by CIS to explain and guide the mapping process. Additionally, there was always a local facilitator in each community assisting with translations into Trio or Wayana and guiding the mapping participants. This person was usually appointed by the village chief and received a monetary contribution for the time dedicated during the activities in all three phases of the project. (see Figure 2a). Prior to each mapping workshop, the facilitator and assistants were trained to ensure they understood the mapping region and localized landscape features, and that they understood the research approach. The mapping activity started with an overview of the process, an explanation of map legend (see Figure 2b), and a presentation of the base map. Participants were asked to think about the location of the ecosystem services indicators using prompting questions (Table 1) and then to draw polygons for the indicators using three different color markers: red for provisioning services, orange for cultural services, and blue for income generation services (see Figure 2c). The individual maps were collected and taken back to CIS' office in the capital to be digitized and analyzed. On average, the maps for each village took six weeks to digitize and process.

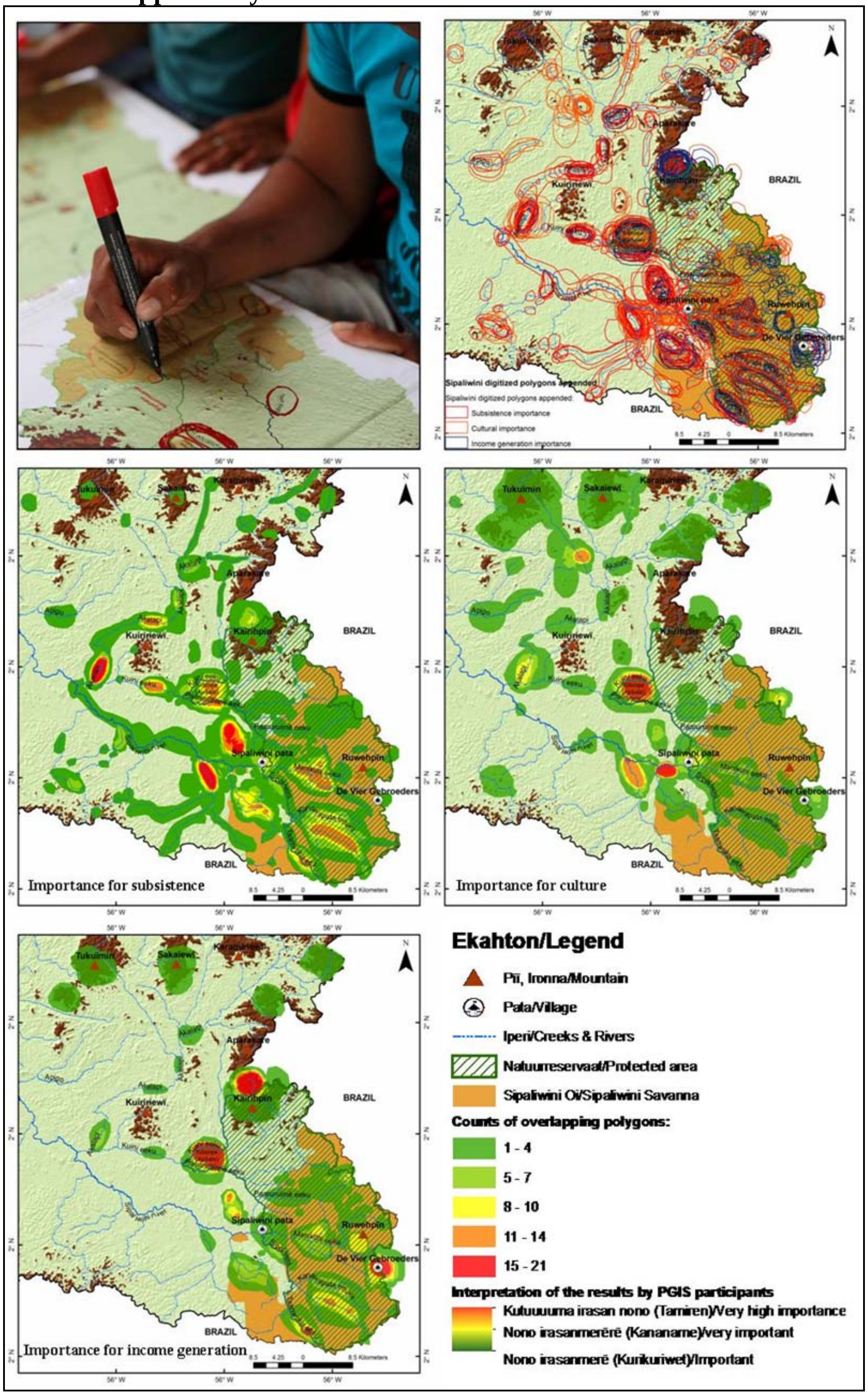
Figure 2a-c: Photos showing facilitator, legend process, and mapping activity

2.a. Left picture: Local facilitator in Sipaliwini village discussing the map and the map legend with PGIS participants. Right picture: Both external and local facilitator (in white) discussing the map in Apetina village.

2.b. Map legend elaborated together with Sipaliwini PGIS participants, our pilot activity. First a list of all the important feature in their landscape (pictures on the left) and then grouping into seven important landscape services (picture on the right): "money making, tourism, food, building materials and lumber, culture, recrea-

2.c. PGIS mapping with different color markers in Trio (left) and Wayana (right) communities.

Figure 3a-e: Mapping process: (a) drawing polygons using different colours. (b) Digitizing polygons and preparing data for analysis. (c-e) Results showing importance for each mapped ecosystem service



2.6 Spatial Data Preparation, Analysis, Presentation

Each ecosystem service polygon from each participant's map was digitized and stored as vector data in a GIS (ESRI ArcGIS® v.10) using a geographic grid as a reference. The gender of the mapping participant was also recorded with each polygon. Once all polygons were digitized into individual vector layers, the layers were appended and grouped into distinct shapefiles, one per mapped ecosystem service. The polygon features in each shapefile were separated into single part features resulting in thousands of polygons per village dataset.

The collective importance of each ecosystem services was determined by the concentration of polygons. Within ArcGIS, a customized tool was developed (Martinez, 2012) to count overlapping polygons and to create a new shapefile with polygons whose attributes were the number of overlapping polygons (see Figure 3). The tool that supports this application had six steps: (1) defining a minimum spatial area to be created with the intersection of mapped polygons; (2) the assignment of a geo-identifier for the centroid of each minimum spatial region; (3) counting the number of polygons with the same geo-identifier; 4) assigning the number of counted polygons to the spatial regions; 5) removing polygon overlap by dissolving polygons with the same geo-identifier; and, 6) editing the attribute table to have one column with the number of polygons counted in each minimum spatial region.

Maps were developed for each service (provisioning, cultural, income-generation) for each of five villages. A poster was prepared for each village that contained the maps showing the areas of importance, as well as selected photographs of participants. (See Figure 4). These posters with maps became the focal point for community discussion of the results. Approximately three months following the PGIS mapping workshops, CIS returned to the villages to present the villagers with the posters. The villagers did not have specific plans for the posters with maps, but indicated they could be used as an educational tool in local schools and to inform outsiders that visit the villages. The village chiefs wanted a personal copy for use when outsiders and mining companies visited.

3. Results

3.1 Mapping Effort and Spatial Data

The mapping effort and spatial data generated from the PGIS project completed in the five villages appears in Table 2. The number of participants ranged from 19 in Kawemhakan to 69 in Apetina. There was variability in the number, type, and size of polygons mapped by the villages. The mean number of polygons mapped per participant ranged from a low 35 polygons in Kawemhakan to a high of 63 polygons in Paleletepu. The mean number of *provisioning* polygons mapped by participants was highest in Palumeu while Paleletepu villagers mapped the greatest mean number of *cultural* and *income-generating* polygons. Paleletepu villagers drew polygons with the largest mean area for *provisioning* and *cultural* services, while Kawemhakan drew polygons with the largest mean area for *income-generating* services.

Figure 4: Poster of the PGIS process in Apetina village. A poster like this was created and delivered to each community.

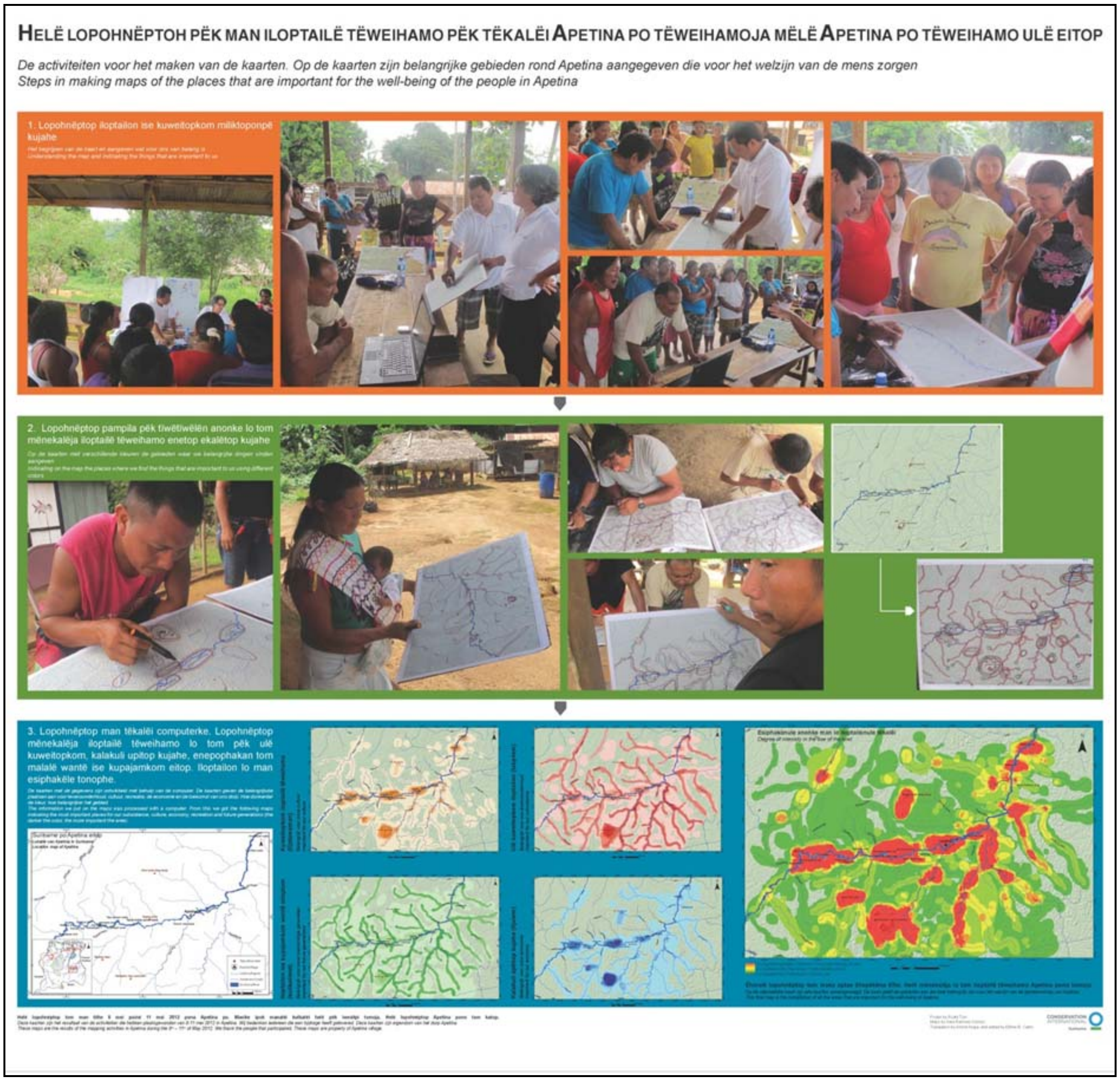


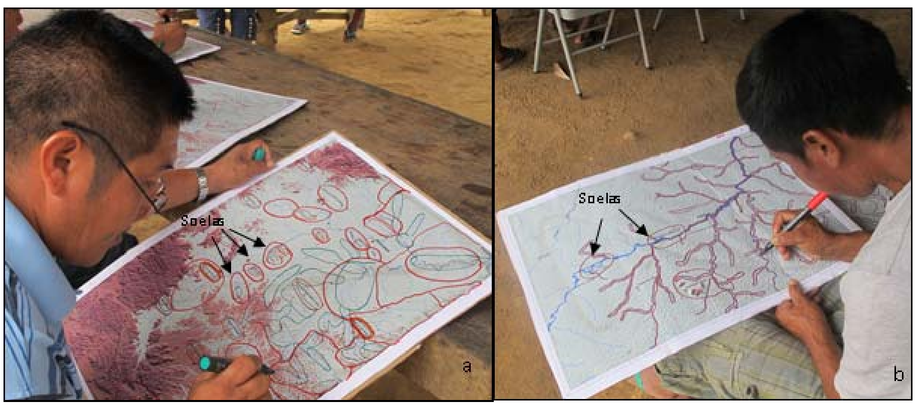
Table 2: Participatory Mapping Results for 5 Indigenous Villages in Southern Suriname.

Village	Approx. population of village	Number of individual villagers participated in mapping	Total number (mean) of **provisioning** polygons	Total area covered (hectares)	Average size of polygon (ha)	Total number (mean) of **cultural** polygons	Total area covered (hectares)	Average size of polygon	Total number (mean) of **income-generating** polygons	Total area covered (hectares)	Average size of polygon	Total number (mean) of polygons
Sipaliwini	98	22	440 (20)	120,426	936	265 (12)	115,476	1,061	259 (12)	77,619	1,108	964 (44)
Apetina	297	69	1,514 (22)	238,270	2,267	708 (10)	130,565	977	689 (10)	130,635	831	2,911 (42)
Paleletepu	260	58	1,391 (24)	807,363	7,701	1,158 (20)	727,413	3,978	1,127 (19)	656,464	2,766	3,676 (63)
Kawemhakan	82	19	399 (21)	845,535	6,110	133 (7)	264,308	3,330	135 (7)	415,882	4,806	667 (35)
Palumeu	250	30	968 (32)	732,422	3,844	264 (9)	485,582	3,676	203 (7)	481,716	4,743	1,435 (48)

3.2 Differences and Similarities in Mapping Among the Trio and the Wayana People

There were differences and similarities among the Trio and the Wayana people in the PGIS process and the mapped results. Key differences were the size and spatial distribution of mapped polygons. The Trio, having descended from nomadic people, walk extensively for days and weeks across the region. Defining the mapping extent was challenging for them because they affirmed "we go everywhere; we cannot say this is only the area of our activities". This walking habit resulted in mapped polygons that spanned the entire region. Their polygons were large, indicating general areas where they perform multiple activities (see Figure 5a). In contrast, the Wayana are known for being "river people" and most of their activities are concentrated along creeks and rivers. This was observable in the polygons they drew which were concentrated along waterways (see Figure 5b). For the Wayana, defining the mapping area was easier as they quickly identified the creeks, mountain peaks, and rapids that should be included in the mapping extent.

Figure 5: Side by side images of a Trio (a) and Wayana (b) map showing contrast in the mapping approach. The maps are annotated to show some *soelas* (rapids) in both regions.



One of the mapping similarities between the two groups was the importance that rapids or *soelas* have for ecosystem services. The *soelas* provide fish for consumption or sale, help purify the water, provide recreation places, and provide tourist attractions. The *soelas* were common landscape referents for both indigenous groups in the study region.

Another similarity across the villages that affected the mapping is the importance of religion in the lives of the people. For ethical reasons, a decision was made not to ask about sacred places related to culture, but it became clear during the mapping process that the only sacred place for the communities in the region was the church. Only in Paleletepu did participants refer to special places outside the village with sacred value where it was not acceptable to take outsiders.

There were some common landscape areas mapped by the villages. The mapping extent of Palumeu overlaps with the mapped extents for Paleletepu and Apetina. Palumeu is situated between these two villages and the inhabitants of Palumeu are both Wayana and Trio. There is a constant flow of people between Palumeu and the villages of Apetina and Paleletepu. The ecosystem service related activities near Palumeu are concentrated along the Palumeu River but they also share the resources with Paleletepu and Apetina.

3.3 Local Differences in the Importance for the Ecosystem Services Mapped

Sipaliwini village is located on the fringe of the Sipaliwini savannah, an isolated Amazonian savannah enclave with 63,000 ha of open habitat. The savannah is the only place where the poisonous blue dart frog (*Dendrobates tinctorious*) is found, a species that has a significant value for people in the village. Likewise, the seed-finch birds found in the savannah are prized for their complex songs. For Sipaliwini villagers, the frog and the birds represent important opportunities to generate income through tourism and wildlife trade. When the PGIS facilitator asked about the benefits derived from the ecosystems, the participants listed 90 species of wildlife that can only be found in the savannah (most were birds). Therefore, for the people of Sipaliwini, the importance of ecosystem services was very attached to the savannah and centered on the location of the frog and birds which appeared as important places on the maps.

Paleletepu was the only village where "special places" were indicated on the map. When the mapping extent was discussed, the village leaders included places of high value called "Natuur Ipê-Kapin", "Natuur Ipê-Kapin Nono Tun" and "Tarmin Pïï" meaning pristine nature, areas of pristine nature, and mountain Tarmin, respectively. Participants drew polygons around these places in all prompted questions. They explained that these areas provide many benefits and that outsiders are not allowed in these sites. In this village, there appeared to be a generational difference in the mapping of places. Income generating places were most important for young adults whereas older participants identified more important places in the mountain ranges in the southeastern and southwestern part of the mapping extent, areas which connect them with their Trio ancestors and relatives in Brazil.

The villagers of Palumeu are wary about working with outsiders based on past experiences and ongoing infrastructure development plans. The villagers were distrustful of CIS because they were unclear about the purpose behind a rapid biodiversity assessment carried out in the mountain area of Grensgebergte, an area highly valued by the indigenous peoples of Palumeu. During initial discussions about the PGIS project, the community expressed fear that biodiversity studies would result in the creation of a protected area that would, according to them, restrict their use of the area. After lengthy discussions, the community freely decided to engage in the PGIS project. Once they understood the purpose of the maps, some of the participants focused on drawing as many polygons as possible around the Grensgebergte area (border mountain) "to show CIS, decision makers and investors that the area is very important for them and that they should be able to continue using it no matter which projects take place".

For the villagers of Apetina, many of the perceived ecosystem services were located along the Tapanahony River, particularly around the *soelas* (rapids). According to the participants, the rapids would disappear if a planned hydroelectric power dam is built. These rapids have high value for the people living within the PGIS project area. During the mapping activity, the participants also identified ecosystem services along Jai Creek which is a stream within the scope of the dam impact.

In Kawemhakan, a village near the border with French Guiana, the participants identified important ecosystem services in areas proximate to the Oelemari, Litani and Loe rivers. People in this village travel long distances along these rivers to obtain the goods they need. However, the villagers of Kawemhakan are wealthier than indigenous people in the other villages and they increasingly buy the goods they need in downstream settlements along the Marowini River and in villages in French Guiana. The villagers of Kawemhakan obtain their income mainly from gold mining activities. In general, they were less enthusiastic in the PGIS process and we assumed it was because of their stronger economic position vis-à-vis the other poorer villages such as Apetina. In the poorer villages, the participants appeared more aware of the importance and need for the maps to sustain their future livelihoods.

4. DISCUSSION

The PGIS project in Southern Suriname faced a number of challenges from conception to implementation. In this final section, we discuss these challenges and conclude with a set of lessons for PGIS projects involving indigenous peoples.

4.1 Challenges with PGIS Project

4.1.1 Decoupling PGIS from the Conservation Corridor.

CIS initially planned to use the maps to leverage support for a conservation corridor, but because the corridor had not been negotiated with the Suriname government, and there had not been previous discussions on such a corridor with the indigenous people, CIS redefined the immediate purpose of the PGIS work. Spatial data was collected to identify ecosystem services that indigenous people ascribe to their local and regional landscapes. CIS concluded that it was unnecessary, and perhaps even a liability, to couple the PGIS project with the conservation corridor concept. The indigenous people and landscape relationships, as expressed through ecosystem services, could assist with management of natural resources and spatial planning of land uses in Suriname. CIS could make the PGIS information available to government agencies to help protect the landscape for the well–being of indigenous communities when faced with potentially deleterious land use activities or development. Alternatively, the data could potentially support future conservation management actions such as the creation of a conservation corridor.

4.1.2 Promoting Spatial Planning with PGIS Data.

Spatial planning processes do not explicitly exist in Suriname and the technical capacity of government agencies to analyze and integrate spatial data has been slow to develop. Although the PGIS data collection is concluded, it may be some time before the maps can be used and integrated into spatial planning to assist government agencies. The CIS Executive Director who championed the PGIS project has left the organization. Whether spatial planning will have the same CIS priority under new leadership is unknown, although enhancement of the national capacity for spatial planning remains part of a CIS five-year strategy. An aspiration for CIS is that Southern Suriname becomes a priority for other environmental organizations that also want to assist the government in ensuring sustainable and appropriate use of resources in the region. Optimistically, the maps produced by the indigenous communities will promote sustainable land uses and the conservation of biological and cultural resources in the region.

4.1.3 Community Benefits from the PGIS Process.

As yet, there are few tangible benefits to the villages that participated beyond the solidary and educational benefits from the PGIS mapping process. However, the PGIS maps provide a starting point for potential initiatives linked with conservation, land use, and the management of natural resources. To empower the communities through the maps, CIS will need to help link the maps to action, to projects that address local needs. For example, the mapped information could be augmented with spatial information needed to apply for land rights. In some of the villages, there was an expectation that the maps would assist with land right issues, but CIS explained that the PGIS maps needed much more information before they could support claims for land. Moreover, CIS reiterated its position that it was not taking part in land rights discussions. However, CIS did invite an individual working for the indigenous organization in Paramaribo that is leading the land rights negotiations, to view the mapping process and results so they could understand the potential use of the maps in land rights discussions. CIS referred villagers concerned about land rights to contact this organization about future use of the PGIS information for this purpose. Short of land rights support, CIS could further develop the participatory mapping project by identifying threats to indigenous use areas to help prioritize areas for management. Landscape threats were a recurrent theme during talks with villagers during the project. Villagers feel threatened by climate change (e.g., change in weather seasons, fruit seasonality, pests in their agricultural fields, food scarcity), extractive companies, and government decisions about infrastructure.

4.1.4 Managing Community Expectations.

A key challenge was managing community expectations. When the PGIS team entered the villages, people expected that many ongoing village concerns were going to be directly addressed and sometimes solved by CIS. Some of the issues were related to land rights, gold mining, infrastructure investments, drinking water supply, and the lack of income generation activities. From a CIS perspective, the purpose of the PGIS project was not to directly solve community problems but to create a communicative tool that could be used by both CIS and the villages for potentially different needs. CIS wanted to facilitate the production of local knowledge about the importance of ecosystem services for the indigenous communities in Southern Suriname. This information could potentially be used in future spatial planning for the region where several mining projects and infrastructure investments are being promoted without a clear understanding of the potential impacts to the indigenous people in the region. Some of the communities envisioned that the maps could be used to leverage land rights claims, to advocate positions in development projects, for education purposes, or to assist in the local management of natural resources.

Whether the expectations of the communities and CIS were fully reconciled remains to be seen. There is a natural tendency for humans to look at the potential of PGIS to address myriad social and environmental problems. But the path from the generation of PGIS information to effective social action using that information is one that few have travelled. CIS and other NGO’s are supporting government agencies in capacity building for spatial planning for the purposes of rational resource use and the prevention of land use conflicts in Southern Suriname. The positive social influence of capacity building will require time to manifest.

4.1.5 Finding the Local Champions.

Project success required the support of the village chief of Sipaliwini who had a clear vision of the importance of the PGIS project for the communities. The chief prompted community reflections and motivated the people to communicate with outsiders through maps. He supported the initial phase of the PGIS process not only in Sipaliwini village, but accompanied CIS to talk with the people of Palumeu while facilitating communication with other community leaders across the project area. The PGIS project team confronted a specific challenge in the village of Palumeu. During the negotiation phase of the project, the team found the community very wary of outsiders, extractive companies, the government, and NGOs including CIS, because all had visited Palumeu to talk about dams, roads, mining, or conservation projects. The people of Palumeu are in a vulnerable position because of a planned dam that will flood their area. When the PGIS project was presented, community opinion was divided among those who wanted to engage in the mapping activity and a minority of individuals that included many young adults. The latter group was distrustful, saying that the CIS project team consisted of multinational corporate spies who wanted to map the location of their natural resources. The PGIS project did not commence in Palumeu until months later when the village chief asked CIS to develop the maps collaboratively. The PGIS mapping was completed under difficult circumstances because the village was divided; some individuals opposed to participation threatened participants during the mapping process. As a result, many community members stayed outside and were afraid to participate.

4.1.6 Managing People During the Mapping Process.

There were challenges during the mapping process itself. The PGIS approach was designed for community participants to individually map the location of ecosystem services. However, some community members that claimed to have more knowledge tried to influence the work of other participants by telling them where to draw polygons. This was managed by subtly asking these individuals to work separately. A similar situation was faced with husbands telling their wives where to draw. As a result, the PGIS team asked women and men to work in different places inside the room. Although community participants walked around the room during the mapping activity to observe each other's work and to discuss the location of polygons, the maps were developed as much as possible individually.

4.1.7 Project Logistics.

Implementing the PGIS project in Southern Suriname was a costly and time consuming process. The villages where the project took place are remote, accessible only by plane, few of them have mobile telephone services, and radio contact was not as easy as expected. Additionally, many airstrips are affected by the rainy season. Therefore, project implementation often had delays. To handle communication with villages lacking communication facilities, the project team established a network of different people traveling throughout the area. The resources required for this project (e.g., finances, human resources, and transportation) were very high.

4.2 Lessons from PGIS Project

4.2.1 Locating and Cultivating the Internal "Champion".

PGIS projects with indigenous people are unlikely to be successful without a strong internal "champion" or advocate of the project that enjoys the trust and respect of the people. In this project, two strong advocates emerged to secure the commitment of the people to participate. Not only did the chief of the Sipaliwini village commit his village to participate in the PGIS project, he advocated the project to other villages. A second champion, a school teacher who enjoyed the trust of the people of Palumeu, encouraged people in this reluctant village to participate.

4.2.2 Communication Comes before Advocacy.

Language and cultural differences represent formidable barriers to effectively engage with indigenous people. Participatory mapping helps facilitate communication across cultures, a prerequisite for obtaining commitment to support particular advocacy outcomes. Although indigenous commitment to a conservation corridor in Suriname was not a direct outcome of this PGIS project, a communication foundation was established that can potentially lead to future indigenous support for the creation of a corridor. The lesson here is that PGIS projects with indigenous peoples must first establish trust through communication; all other participatory mapping objectives must be subservient to this basic requirement.

4.2.3 Perceived Threats can Overcome Participatory Inertia.

The presence of perceived external threats can help overcome indigenous reluctance to participate in mapping. The lesson here is that PGIS project timing is important. Normatively, a PGIS process should be proactive and anticipate threats to help indigenous communities plan and secure continued access to the lands that sustain them. And yet, some actual negative impacts from development can help motivate indigenous participation by showing that development threats are real. Optimal PGIS project timing should be early enough to influence major land use decisions, and not too late to create a sense of collective urgency to engage.

4.2.4 Early Success Builds Momentum.

Project participation in the village of Palumeu was difficult to obtain for reasons previously described. Promises about positive PGIS outcomes ring hollow in the absence of trust which CIS (as well as other external parties) lacked with the village of Palumeu. CIS success with the other villages provided maps that the villagers of Palumeu could observe. Seeing the mapped output helped the villagers of Palumeu to overcome their fear of the project. The lesson here is to select initial PGIS sites or groups with the highest probability of successful participation and to use these favorable outcomes to build momentum for the more challenging PGIS sites/groups.

4.2.5 "Strategic" Mapping is Inevitable, Deal with It Honestly.

Some PGIS participants will engage in "strategic" mapping to identify places and attributes that they believe will lead to desired outcomes in future land use. These participant inferences about how the maps will influence future land use will be made with, or without, specific information about how the maps will be used. Strategic mapping will take the form of mapping with more, larger, or different types of PGIS attributes. For example, the villagers of Palumeu drew as many polygons as possible in the Grensgebergte area (border mountain) as a potential deterrent to future development. Facilitators of PGIS projects must decide how to present this information. Presenting the mapped information as an objective truth without acknowledging its limitations, including strategic bias, is likely to be self-defeating as it will undermine the credibility of participatory mapping.

5. CONCLUSION

We have described a significant case study of PGIS with indigenous peoples of Southern Suriname. Given the novelty and challenges of the project, we focused more on the PGIS process than the mapped outcomes. Future research will need to evaluate the usefulness and limitations of the PGIS data generated for actual conservation and spatial planning outcomes in Suriname. For the indigenous people of Southern Suriname, and the conservation of global biodiversity, the consequences could not be more significant.

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