Participatory Mapping: Caribbean Small Island Developing States

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Abstract:

Participatory mapping has emerged as a powerful tool for the collection and use of geospatially oriented traditional and local ecological knowledge (TEK, LEK) across a variety of disciplines. The growth of this initiative in small island developing states (SIDS) has been widely applied to strengthen public awareness and capacity, particularly for environmental conservation, cultural preservation, and climate change adaptation. Participatory mapping strives to build community resilience and has proven to be a valuable technique in taking positive steps towards sustainable development especially in vulnerable communities. This paper examines participatory mapping and community engagement, the value of this practise in Caribbean SIDS facing the impacts of global climate change, and the lessons learnt from a variety of case studies that have been conducted in the wider Caribbean.

Key Words:

Participatory Mapping, Participatory GIS, Participatory Three-Dimensional Modelling, Geographic Information Systems, Caribbean, Small Island Developing States, Climate Change

1 INTRODUCTION TO PARTICIPATORY MAPPING

1.1 Participatory Mapping

Participatory mapping is the solicitation of local stakeholder knowledge in geospatial data collection, and the incorporation of this data in a cartographic format appropriate for a broad audience. This process provides a wide decision-making information base that takes into consideration both collaborative collection and validation of data. In its best form, participatory mapping strives to allow stakeholders to realise the importance of their knowledge and to build ownership in the information generated (Slocum & Thomas-Slayter, 1995). Through the solicitation and incorporation of local knowledge in data collection participatory mapping can strengthen public participation in governance and social change. By leaving the control of access to the data and spatial information in the hands of the community, this practice is ideal for protecting traditional ecological knowledge (TEK) that stakeholders are hesitant to record due to a history of exploitation (Rambaldi, McCall, Kyem, & Weiner, 2006).

The term **participatory mapping**, or **community mapping**, are overarching terms used to describe a variety of techniques. Generally practiced in the southern hemisphere, **participatory geographic information system** (PGIS) is an intersection of participatory development and geospatial information technologies and systems (GIT&S). **Public participation GIS (PPGIS)** is found more prominently in the northern hemisphere as a combination of participatory planning and GIS&T (Rambaldi & Weiner, 2004). **Counter mapping** is used to influence governments to accept and promote community mapping and its results (DiGessa, 2008). **Participatory research mapping** envisions a combination of cartography and ethnography (ethno-cartography) as seen in cultural geography and anthropology (Herlihy, 2003; B. I. Sletto, 2009). Within these forms of participatory mapping lies a variety of specific mapping techniques, the breadth of which makes it a valuable development initiative. The most basic are hands-on methods; these are low-cost and not reliant on digital geospatial technologies. **Ground mapping** (ephemeral maps drawn on the ground using raw materials such as rocks, leaves, and sticks), **mental mapping** (individual maps drawn from stakeholders' memories), **sketch mapping** (paper maps recorded with markers, pens, or chalk), and **transect mapping** (paper maps depicting a cross-section of a community along an imaginary line) do not rely on exact measurements, but display relative scale. Hands-on techniques do not discriminate against non-literate community members and work well to encourage confidence in stakeholders without prior experience with maps. Drawbacks to these methods are that the final products are not scaled appropriately for geo-referencing—this lack of technical accuracy can weaken credibility with a wider audience especially government officials—and their temporary nature requires them to be photographed or scanned to a digital format (Corbett, 2009).

Additionally, there are a wide variety of more complex techniques in participatory mapping. S**cale mapping** allows for local knowledge to be recorded onto hard copy maps or aerial and remote sensing images where features are confirmed by visualising their location in reference to landmarks on the map. While this approach is fairly cheap and not particularly time-consuming, access to scale maps or imagery can be difficult for some areas, requiring intensive surveying or the purchase of expensive imagery. **Participatory three-dimensional modelling (P3DM)** combines local knowledge with three-dimensional elevation data and bathymetry to create a scaled and geo-referenced model. Participants cut sheets of cardboard or similar material representing each layer of contour lines and then use pushpins, string, and paint to represent their local knowledge. Models are very hands-on and can encourage intergenerational dialogue, however this can be labour and time intensive. Determining an appropriate location for a permanent installation of the model can also be a political issue. The use of **global positioning system (GPS)** receivers in mapping processes has risen with the decrease in price of this technology, as well as its integration into mobile phones. Data collected with community members can subsequently be included on scale maps or geo-referenced P3DMs. **Geographic information systems (GIS)** methods can be costly and expert-knowledge intensive, but allow for the creation of authoritative maps and widely applicable data. GIS has a steep learning curve, but with the rise of QGIS and Geographic Resources Analysis Support System (GRASS) GIS as free, open-source software and simplified GIS programmes (in comparison to the industry standard, ESRI's ArcGIS), the difficulties of communities needing to maintain expensive software and experts are becoming more manageable. Static **multimedia mapping** combines maps with written text or photographs, while interactive **internet-based mapping** can utilise further embeddable media (e.g. video, photographs, audio) or simply allow for exploration of the data at a variety of scales. These forms of mapping allow for more information and local knowledge to be integrated into an engaging mapping platform, however, low literacy rates and poor access to the internet can be drawbacks to these techniques (Corbett, 2009).

1.2 History of Participatory Processes

The history of mapping reaches back many centuries. However, over time, cartography has often served as a way for occupying powers to 'officially' claim land. The history of participatory mapping goes back only twenty-five years, but its intent subverts the legacy of mapping for the powerful, aiming to help communities assert their knowledge. Emergent in its own right, participatory mapping developed out of a participatory process started by development agencies in the 1970s as they shifted their focus to community participation in decision-making. While initially formed by top-down sponsorship rather than bottom-up initiative, this began to change, along with the assumption of homogeneity among local interests (Thomas-Slayter, 1995). In the late 1980s, participatory rural appraisal methods began to include simple techniques such as sketch mapping in their development initiatives, allowing for an improved exchange of information (DiGessa, 2008). In the 1990s–2000s, as the cost of computer hardware began to decrease and advanced mapping technologies became more user-friendly and accessible, a diffusion of these technologies became possible, allowing for the production of higher quality and politically competitive maps. This has been further assisted by the movement to enhance public access to spatial data, such as satellite imagery (Rambaldi, McCall, et al., 2006). Over the past twenty-five years, there has been a shift in environmental management as scientists have acknowledged the importance of incorporating social and economic information with conventional scientific approaches, particularly for resource management (Berkes, 2003). This shift has brought participatory mapping into a wider range of applications and begun to recognise the intrinsic value of local knowledge.

2 COMMUNITY ENGAGEMENT

2.1 Benefits and Conflicts

Maps convey a certain sense of power, however "there is no doubt that maps of any form are subjective, imperfect cultural artefacts that often have undeserved authority … Participatory mapping only [strives] to make them less so" (Herlihy, 2003). The geographic authenticity of local knowledge is a great challenge to inaccurate maps and a way to display local justifications to claims. For example, British Admiralty and United States Defense Mapping Agency charts of the Miskito Coast, in Nicaragua, displayed cays that did not exist, incorrectly situated reefs, and labeled shoals and channels with English and poorly-spelled Spanish and Miskito names. When local stakeholders saw the maps, they said, "This is not a map of our reefs. This map is like a birth certificate with the wrong names on it." Communities then proceeded to join together to map their coastal area using GPS technologies via sailing-canoes, scuba-diving, and aerial 'video-maps'. This was a successful initiative of bottom-up participatory mapping, where the data was utilized for protection of the communities' sea territories (Nietschmann, 1994). Unfortunately, participatory mapping can also have negative political implications, such as destabilising community power relations or running the risk of a misuse of local knowledge for example government sell-out of local fishermen's valuable fishing hotspots. An important consideration when pursuing a participatory mapping project with sensitive information is to determine the best way to ensure privacy and intellectual ownership of TEK or LEK. Furthermore, there should be both local control and access to the recorded data and information. Important initial questions that should be addressed are: who should participate, what information should be visualised, what information should be made public, who decides what is important and what is included, and who owns and manages the data (Rambaldi & Weiner, 2004).

It is important to keep in mind that no community is a uniform entity, despite how ethnically or socially similar it may be. One portion of a participatory mapping initiative could engage a stakeholder, while, at the same time, disenfranchising another—a concern that requires further research into effective incorporation of diversity such as ethnicity, age, gender, profession, socio-economic status, into participatory mapping techniques (Rambaldi & Weiner, 2004). For example, during participatory mapping work in the trans-boundary Grenadines (Saint Vincent and the Grenadines and Grenada), facilitators found that some community members felt uncomfortable attending meetings in 'elite' settings such as community halls and schools, preferring less formal locales. Stakeholders can also feel marginalised by community leaders themselves, preferring not to speak up in front of these persons. In this case, it makes sense to offer multiple meetings or workshops to various types of community members (DeGraff & Baldwin, 2013). It is essential to have proper facilitation and respectful interaction with stakeholders, as well as respect for the value of local or traditional knowledge, in a participatory mapping project, regardless of what organisation, institution, or government facilitates or funds the process. All information about the process, as well as the data collected, should be shared regularly, transparently, and fairly with stakeholders; and stakeholders should be consulted and given frequent opportunities to validate and provide feedback. Participatory mapping processes depend on a level of trust and mutual understanding by communities (Patton, 2002; Quan, Oudwater, Pender, & Martin, 2001; Rambaldi, Chambers, McCall, & Fox, 2006).

There are many levels of participation, from simply informing a community of initiatives to assuring that the final decision-making remains in their control. The term participation can take on three forms under the umbrella of participatory mapping: 'participation for legitimation', mostly top-down consultation projects seeking to justify claims; 'participation for publication', short-term projects initiated for research initiatives; and 'popular participation', genuine projects providing local stakeholders with a say in decision-making (Rambaldi & Weiner, 2004). Figure 1 summarises levels of public participation that can be readily applied to participatory mapping processes.

Co-option	Compliance	Consultation	Cooperation	Co-learning	Collective Action
Token community participation; no real community power or input.	Research agenda decided by outsiders, communities are assigned tasks.	Local opinion is sought, but outsiders analyse situation and decide actions.	Local people work with researchers to determine priorities, but the process is directed by outsiders.	Local people and outsiders share knowledge and work together to form action plans.	Local people set their own agenda and carry it out in an absence of external initiators.

(Cornwall, 2008; Dana, 2010; McAllister, 1999)

Figure 1 Levels of Public Participation

The more collaborate a process is, the more valuable the outcome will be for both the community and the project itself. Facilitators must tread carefully so as not to accidently co-opt local agendas and always strive for 'bottom-up' approaches and decisions that are instigated by stakeholders themselves (Cornwall, 2008).

2.2 Geospatial Technologies

In order to appropriately utilise mapping initiatives, facilitators must have a working knowledge of GIS and cartography, community facilitation, and participatory development. Effective applications place as much value on the participatory process as the development of mapping or GIS as a tool (Quan et al., 2001; Rambaldi & Weiner, 2004). However, it is important to choose appropriate mapping tools. Geographic information system software varies drastically in pricing and capabilities. The software and hardware for the project should be chosen based on the analytical needs of the project, the costs for the technology, the costs of training facilitators and/or stakeholders, and the institutional capacity. It is impractical to choose expensive software that is overly complicated, when less complex software would suffice, especially given the technical capacity of involved stakeholders (Quan et al., 2001). ESRI's ArcGIS suite is at the high end of the spectrum, in terms of cost of software, maintenance, upgrades, and level of expertise required for fully utilizing the programme. While ArcGIS controls the majority of GIS usage, free and open source software for geospatial (FOSS4G)—such as QGIS and GRASS—has gained popularity and can provide many of the analyses required in a participatory mapping process. These technologies are not only free, but also simpler to learn, use, and maintain (Morais, 2012).

Mapping tools, that is, sketch mapping, P3DM, GPS, GIS, should be decided upon at the start of a participatory mapping project. In some circumstances, using geo-technologies will not be the best avenue for the audience. Laptop computers for logging, processing, and displaying data in the field could be problematic if electricity is inconsistent; and internet-based web mapping would not be the ideal course if the stakeholders do not have regular access to the Internet. In these cases, among many others, placing costly technology into an unprepared local organisation can result in unattainable datasets once the facilitators and geospatial specialists have left the community. Procedures should be put in place regarding "ownership, expectations, iterative validation, communication, feedback, and sustainability" of all mapped data, regardless of the type of output (Quan et al., 2001). It is important to note that "the primary purpose of participatory maps is to elicit social information and organize it spatially; while [participatory] GIS does the reverse, and arranges spatial information to shed light on social phenomena" (Vajjhala, 2005). Maps utilising GIS require strong spatial precision, as this type of data tends to be regarded as fact, regardless of how incomplete or inaccurate the information contained might be. Although every type of participatory mapping seeks to collect accurate local knowledge, even a seasoned cartographer would be unable to draw a GIS-accurate mental map of their hometown. This does not, however, downplay the importance of non-GIS participatory mapping projects, which place their main focus on community engagement and discussion rather than geospatial accuracy (Quan et al., 2001). Questions that should be discussed between communities and facilitators include: what will the data be used for, does the data need to be in GIS form, who will own and update the data, who will use the data and for what purpose will the data be used? (Abbot et al., 1998).

Depending on the map audience, cartographic outputs can be in the form of GIS data, photographs, static maps, and/or interactive maps. Additionally, web mapping allows for the interactive display of a variety of different vector and raster data. Regardless of methodology or technology, community members should be encouraged to follow a common cartographic construct that will allow for any non-ephemeral maps to be both easily understood and utilised in the future, additionally all outputs and vocabulary should be understood and agreed upon by stakeholders. The audience/s of final map product/s should be determined at the onset of the project as well so that they can be appropriately designed for communities, in contrast to governments or international audiences (DiGessa, 2008; Rambaldi, Chambers, et al., 2006).

Upon deciding to use GIS technologies in participatory mapping, there comes an added responsibility to ensure that a local organisation, or a variety of local stakeholders, are sufficiently trained in that geospatial technology in order assist in analyses and in order to access and work with the data after any external facilitators or GIS specialists have left the location. Alternatively, if the use of GIS is necessary and local capacity insufficient, data should be provided in as many easy and freely available to use forms as possible. Genuine custodianship of the final products should be ensured through community nominations of representatives to maintain the data. Information can also be stored on a website or online database for community download, if it is not sensitive traditional data that should remain privately accessible (Rambaldi, Chambers, et al., 2006).

3 CARIBBEAN SMALL ISLAND DEVELOPING STATES AND THE CLIMATE

3.1 Caribbean SIDS

There are twenty-eight small island and low-lying states and territories in the wider Caribbean listed by United Nations Educational, Scientific, and Cultural Organisation (UNESCO) and the UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries, and Small Island Developing States (UN-OHRLLS) as small island developing states (SIDS). Figure 2 shows the

SIDS member states as well as the associate and non-United Nation (UN) member territories in the wider Caribbean basin.

(© A. DeGraff)

Figure 2 Reference Map of Caribbean SIDS

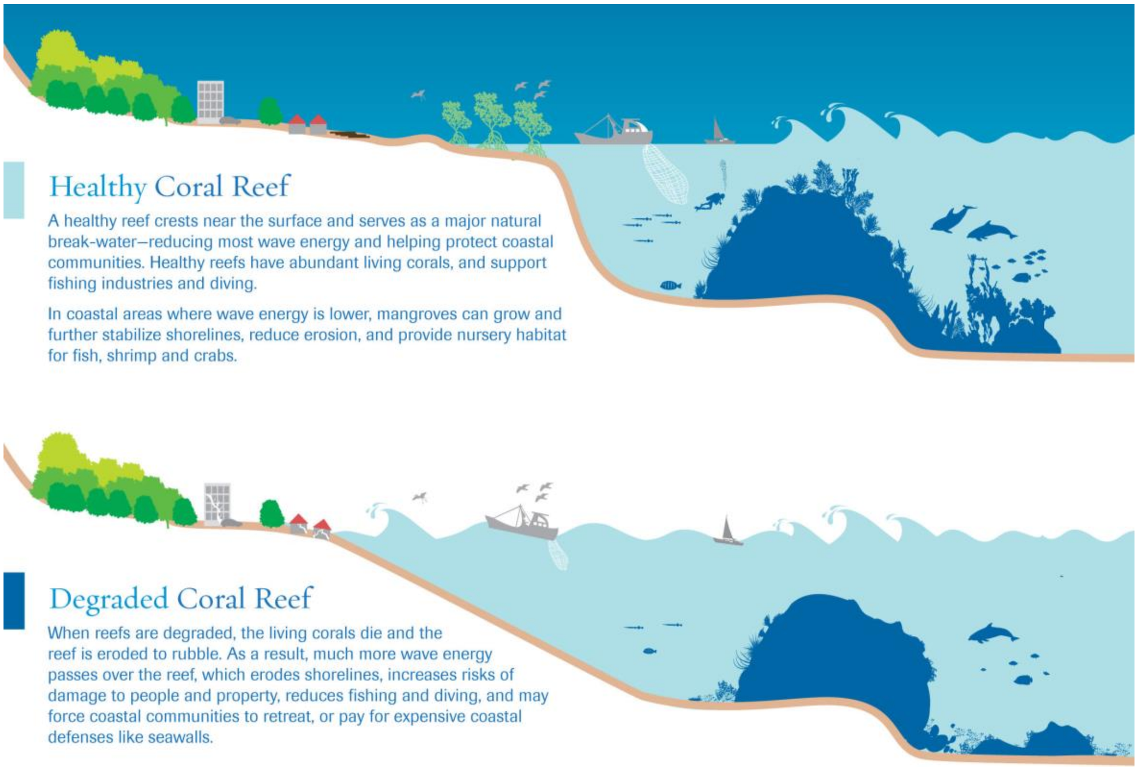
These islands share many major challenges such as their vulnerability to natural hazards and climatic events, scarce terrestrial resources, development pressures in the coastal zone, limited economic diversity, and a high dependence on imports and limited natural resources (e.g. tourism, fishing, agriculture, and forestry) (UNEP, 2008). Due to its extraordinary numbers of globally important endemic species, the Caribbean is one of the top five hotspots for biodiversity. However, these ecosystems are disappearing due to increased coastal development (Agostini, Margles, Schill, Knowles, & Blyther, 2010). Furthermore, the Eastern Caribbean has been noted as one of the top five regions in the world with the largest negative anthropologic impact on its marine ecosystems (Halpern et al., 2008). Small island developing states can be characterised by a high level of stress on the environment, both from pressures of economic activities within a limited terrain and from a restricted capacity to handle and recover from natural hazards. They are unique in their finite supply of land and yet they support important, fragile ecosystems and vulnerable communities and economies, leaving little margin for error (Mycoo, 2006; Wade & Webber, 2002).

Island states in the Caribbean are increasingly reliant on a growing tourism industry that—alongside increasing local populations and limited environmental controls—has led to problems such as pollution, deforestation, and overfishing. In 2013, the total contribution of tourism and travel in the Caribbean was 14 percent of the region's gross domestic product (GDP). However, countries such as the British Virgin Islands and Antigua and Barbuda owe more than 75 percent of their economies to tourism, and another ten countries fell between 50–75 percent (World Travel & Tourism Council, 2004, 2014). Caribbean SIDS need to determine the best processes for sustainable development that allow for them to meet basic human needs and a quality of life, while at the same time not compromising resources essential for future generations. The success of Caribbean tourism and other economic staples such as fishing, depend heavily on the existence of a beautiful and healthy environment. Efforts must be made to reduce vulnerabilities of island communities and their infrastructure to natural hazards and to maintain and protect ecosystems and biodiversity that defend the coastal zone (Wade & Webber, 2002; World Travel & Tourism Council, 2004).

3.2 Climate Change in the Caribbean

Climate change has been, and continues to be, caused by long-term indirect and direct anthropogenic activities that have altered the structure of the atmosphere (Baede, 2007). Significant risks of climate change are global warming, drying trends, heavy precipitation, increased intensity and frequency of sea-level events, sea level rise, and increased sea surface temperatures (Nurse et al., 2014). Small island developing states are disproportionately vulnerable to climatic events affecting their populations and GDP in comparison to other places in the world. Roughly 70 percent of the population of the Caribbean resides on the coast. This coastal concentration of the population, transportation and trade networks, political centres, and emergency services leaves communities extremely susceptible to natural disasters intensified by climate change (UNEP, 2008). Additionally, SIDS are reliant on their coral reefs for fishing, tourism, and coastal protection, and are therefore particularly vulnerable to coral reef bleaching and degradation due to ocean acidification. Not only will destruction of coral reefs affect livelihoods, but—without the coastal protection provided by the reefs—storm surges, and hurricanes will cause even further damage, eroding the coast and amenities along it. Further concerns include the degradation of fresh ground water supplies by seawater, changing rainfall patterns, and more extreme dry seasons on islands where communities are dependent on rainfall for potable water (Parry, Canziani, Palutikof, Linden, & Hanson, 2007). Figure 3 demonstrates the significant differences that a healthy and degraded coral reef can have on coastal communities.

It is important to note that the capacity of stakeholders in SIDS to adapt is uneven in the face of climate change. People living closest to the coast, nearest to the rivers, and on the steepest slopes bear a greater cost of climate change damages, and these are only expected to rise and affect a larger population. Much of the adaptation methods today focus on present-day risks through 'risk transfer' (e.g. insurance), 'risk spreading' (e.g. access to communal resources), or 'risk avoidance' (e.g. structural engineering). However, adaptation and mitigation methods must take into consideration the long-term effects of climate change and assure that stakeholders understand and are engaged in order to increase resilience. Adaptation methods can be more beneficial in SIDS when they include community-based approaches in disaster risk management and integrated coastal zone planning and management. Climate change adaptation in the Caribbean has primarily been discussed at a national planning and policy level, with little work to address on-the-ground priorities. Raising awareness by openly discussing the threats of climate change within communities and including stakeholders in decision-making processes has the potential to increase their long-term resilience. Collecting local geospatial knowledge through participatory mapping can assist in creating location-specific data that can be used to advise climate change mitigations and adaptations (Bobb-Prescott, 2014; Nurse et al., 2014). Disaster risk management and climate change adaptation, through the combined decision-making of the government and local communities to promote sustainable adaptation practices that stakeholders support is a positive way forward.



(Mathison, 2012)

Figure 3 Infographic Comparison of Healthy and Degraded Coral Reefs

3.3 Coastal and Marine Planning

Caribbean SIDS, with their low-lying coastal land and extensive coastlines, are particularly vulnerable to the effects of climate change, due to the high concentration of amenities in the coastal zone for tourism, housing, and ports. While, at a global scale, effects on SIDS are very small, the relative impacts for small islands in the Caribbean are high, with significant changes in essential areas of the coastal zone following as little as a 0.5–1 metre rise in sea level (Mycoo, 2014). Furthermore, coral reefs in the Caribbean are significantly degraded and over 75 percent are under threat from coastal development, pollution, overfishing, and climate change (Kushner, Waite, Jungwiwattanaporn, & Burke, 2012). Integrated coastal zone planning and management (ICZPM) is a governance process that includes the political, authoritative, and institutional structures to develop management plans that integrate environmental, development, and social goals to maximise the benefits and minimise conflicts in the coastal zone (The World Bank, 1996). Marine spatial planning (MSP) is a process that seeks to balance demands of conflicting activities in a marine space and evaluate trade-offs for the environment or the services it supports (Alexander et al., 2012; Baldwin & Mahon, 2014). ICZPM and MSP are two forms of planning that have begun to realise the value of the inclusion of stakeholder engagement and consultation in planning processes. Local ecological knowledge (LEK) is a powerful decision making tool in coordination with scientific research, especially in complex systems such as marine and coastal areas in Caribbean islands (Berkes, 2003). While coastal and marine planning are not in their own right participatory mapping projects, increasing presence of these initiatives in the Caribbean and their incorporation of local knowledge and focus on engaging stakeholders in mapping processes and validation makes them worthy of mention in this work.

4 CARIBBEAN CASE STUDIES

4.1 Approaches

Participatory mapping in most developing countries around the world has been primarily externally driven. This raises concerns of ownership of the process and the resulting data, as well as what happens to the project once the foreign facilitators/funders leave (Rambaldi & Weiner, 2004). However, since the early 2000s when reporting of participatory mapping projects in the Caribbean began, foreign organisations and funders have partnered with local and regional organisations to implement these projects, combining facilitation efforts and providing a venue to maintain data and research within the local community (Agostini et al., 2010; CANARI, 2012; CartONG, 2014; Sustainable Grenadines, 2013). It should be additionally noted that it is just as important for local and regional organisations to provide prompt feedback and maintain open contact with local stakeholders as it is for foreign facilitators and organisations. This section will examine a selected variety of projects across the Caribbean that has spearheaded participatory mapping initiatives in the region. Figure 4 provides a brief timeline of when projects happened, what methods were used, and where they took place.

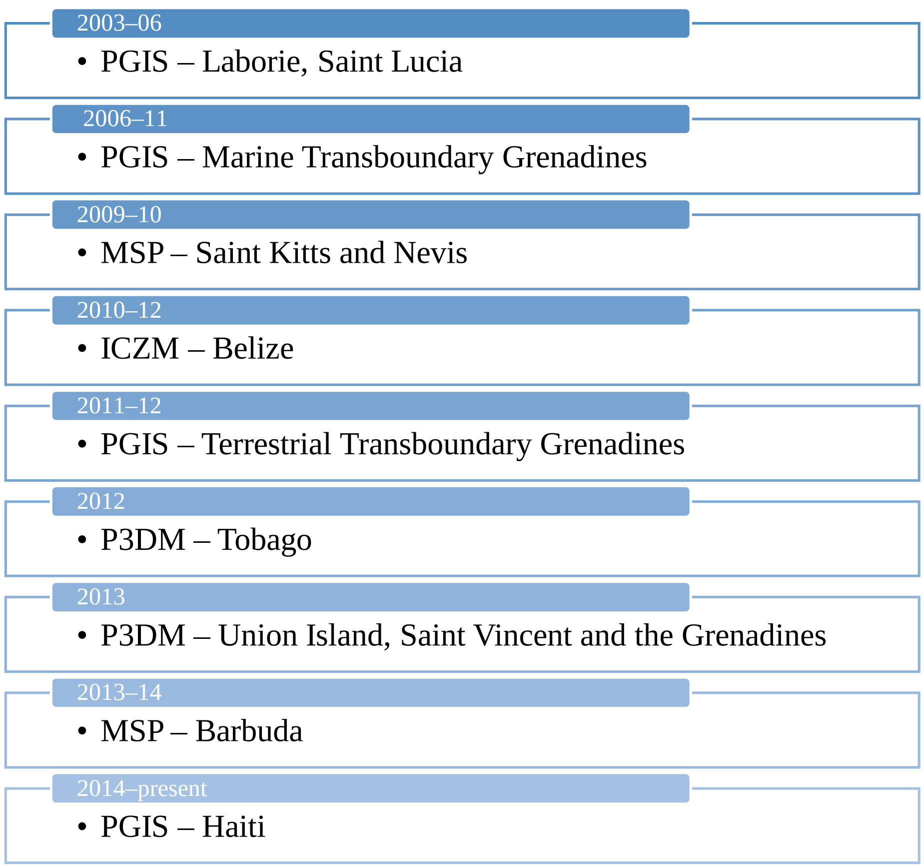


Figure 4 Participatory Mapping Case Studies in the Caribbean Timeline

4.2 Participatory 3D Modelling Case Studies

P3DM integrates local knowledge of a community or island with elevation or bathymetric data to create a scaled and geo-referenced relief model. It can be a very effective tool to assist with applications from vulnerability assessments to protected area planning. However, it requires engaged stakeholders with sufficient spare time to commit to the project and adequate funding for the facilitation and materials (Bobb-Prescott, 2014).

4.2.1 Trinidad and Tobago

The first P3DM in the Caribbean took place in Tobago as an initiative of the Caribbean Natural Resources Institute (CANARI), the Technical Centre for Agricultural and Rural Cooperation (CTA), the University of the West Indies (UWI), St. Augustine, and the Tobago House of Assembly in 2012. It was further financially supported by the United Nations Development Programme Global Environment Facility Small Grants Programme (UNDP GEF SGP) and The Nature Conservancy (TNC). Designed to utilise LEK in climate change adaptation, this P3DM project additionally served as a pilot to train facilitators and build capacity for the use of P3DM in other Caribbean countries (representatives were trained from Grenada, Saint Vincent and the Grenadines, Barbados, Saint Lucia, Jamaica, Haiti, and the Dominican Republic) (CANARI, 2012). Lessons learned included the importance of trained facilitators, the use of multiple strategies to engage stakeholders, a central location for P3DM creation, and the inclusion of sessions to improve stakeholder understanding of climate change and its impacts (Bobb-Prescott, 2014). Further P3DMs have since been completed in Roxborough, Tobago and Laventille, Trinidad.

4.2.2 Saint Vincent and the Grenadines

The Sustainable Grenadines, Inc. (SusGren) non-governmental organisation (NGO) with support from TNC, CTA, and the Grenada Fund for Conservation (GFC) facilitated a P3DM on Union Island, Saint Vincent and the Grenadines (SVG) in 2013. The project sought to gain further spatial local knowledge that could be applied to TNC's At the Water's Edge (AWE) project which has been working with communities in SVG and Grenada (GRE) to find ecosystem-based adaptations to climate change. The P3DM project, through the collection of local ecological knowledge and community participation, gathered relevant information on infrastructure, populated areas, natural habitats, and locations that have experienced changes due to climatic events. This data is being utilised in the identification of what policies and actions need to be taken to address climate change on a tiny island within in a small island developing state. The resulting model for Union Island is on display at the Revenue Office in downtown Clifton and The Nature Conservancy has data on their website in the form of a coastal resilience interactive map portal. Lessons learned included the use of other community initiatives to get stakeholders involved, ensuring local ownership of the model, the importance of allowing for critical analysis throughout the process, the value of local knowledge, and how the model can be further used as a planning tool across disaster management sectors (Sustainable Grenadines, 2013). After completion of the Union Island P3DM, another initiative spearheaded by the Grenada Fund for Conservation and partnered with TNC, CTA, and SusGren completed a P3DM from Telescope to Marquis in Grenville, Grenada (Grenada Fund for Conservation, 2013).

4.3 Participatory Mapping/PGIS Case Studies

Participatory mapping and PGIS initiatives allow for the collection and use of highly accurate data through GPS data collection, and for a greater flexibility in combined processes through diverse stakeholder interviews, field work, community meetings, community workshops (DeGraff & Baldwin, 2013).

4.3.1 Saint Lucia

The Caribbean Natural Resources Institute (CANARI), assisted by the UWI Coastal Management Research Network and funded by the United Kingdom Department for International Development, conducted a three-year study in Laborie, Saint Lucia. They looked at the relationship between marine resource user livelihoods', involvement in resource management, and coral reef health. Given the lack of recent or accurate geospatial data for this area, participatory mapping field surveys with community members were facilitated to collect data on local toponyms, locations of decreased water quality, and important marine information. Mapping this local ecological knowledge provided up-to-date, accurate geospatial information that could be used in application towards participatory management processes. Lessons learned included that stakeholders found aerial imagery easier to interpret than vector maps and that, especially in a case when disseminating data could be damaging to the community, it is important for the stakeholders to have a say in what data (and in what form) should be left in the hands of whom (Smith, 2006).

4.3.2 Trans-boundary Grenadines

Participatory mapping initiatives in the trans-boundary Grenadines (SVG and GRE) began with the doctoral research (2006–2011) of Dr Kimberly Baldwin at the University of the West Indies (UWI) – Cave Hill in Barbados entitled 'A Participatory Marine Resource and Space-use Information System (MarSIS) for the Grenadine Islands: An ecosystem approach to collaborative planning and management of trans-boundary marine resources'. Research was conducted in coordination with UWI's Sustainable Grenadines Project (which transitioned into the Sustainable Grenadines, Inc. NGO in 2010) whose objective was to engage stakeholders through the support of activities that allow for meaningful collective action. Dr. Baldwin collaboratively developed the Grenadines MarSIS with local stakeholders, both countries' governments, and local and international NGOs to include geospatial information on marine habitats, marine resource users, space-use patterns, biologically important sites, conservation areas, and areas of threat. All of the marine conservation data was collected in coordination with, ground-truth and validated by the local community and is now a publically accessible database available in the form of ArcGIS shapefiles, Google Earth (.kml) files, and static maps on the Grenadines MarSIS website (Baldwin, 2012). Lessons learned included the importance of the investment of time by facilitators in the community, the significance of a custom project that combined PGIS with conventional scientific mapping methods, and the value of transparency throughout the entire process via a regularly updated website, listserv, and social media (Baldwin & Oxenford, 2014).

As an addition to Dr Baldwin's marine PGIS research in the trans-boundary Grenadines, the Compton Foundation funded supplementary terrestrial research in the trans-boundary Grenadines from 2011–2012. Ms. Alison DeGraff worked with UWI – Cave Hill and the Sustainable Grenadines, Inc. to create a comprehensive local knowledge geospatial database of important historical, cultural, and ecological terrestrial heritage sites to fill data gaps in the Grenadines MarSIS. Through the facilitation of interviews, field visits, community meetings, and workshops with local stakeholders, the resulting database of surviving heritage sites provides an important resource for preservation. Together, this marine and terrestrial geospatial data served to strengthen Saint Vincent and the Grenadines and Grenada's current joint application as a mixed (natural and cultural) marine trans-boundary UNESCO World Heritage Site. Data is publically accessible online in the form of ArcGIS shapefiles, Google Earth (.kml) files, interactive maps, and static maps. Additionally poster-size, laminated copies are displayed in a community-recommended public building on each island and static maps were distributed across the islands following the completion of the data collection and validation. Lessons learned included the importance of flexibility in cartographic mediums as chosen by each stakeholder (i.e. aerial imagery, basic maps, field visits, and verbal descriptions) and providing meeting locations that made community members feel comfortable and heard (i.e. informal settings) (DeGraff & Baldwin, 2013).

4.3.3 Haiti

OpenStreetMap (OSM) and the Humanitarian OpenStreetMap Team (HOT) have been widely used across the globe for disaster risk management and disaster response. They began work in Haiti following the earthquake in 2010 to assist in rescue efforts and response planning, as very little detailed geospatial data existed, particularly in rural areas. HOT continued work in Haiti to ensure that crowd-sourced OSM data was validated and improved upon by the local community through the support of the International Organization of Migration and the *Comunite OpenStreetMap de Haiti* (COSMHA) (Humanitarian OpenStreetMap Team, 2011). An additional partnership with *CartONG* has deployed volunteers to Haiti to assist in the use of unmanned aerial vehicles (UAV) to improve the imagery available for participatory mapping in the country. *CartONG* is working to train stakeholders in UAV data collection and use for participatory mapping for disaster response and risk prevention so that communities can lead their own projects. An ongoing project, lessons learned include choosing a mini-server for processing UAV images without consistent electricity and internet, and training communities in UAV flights and image processing in ArcGIS and QGIS (CartONG, 2014).

4.4 Coastal and Marine Spatial Planning with Stakeholder Engagement Case Studies

Intensive coastal development in the Caribbean has resulted in conflicting demands on the coastal zone and near-coastal waters, particularly threatening the marine habitats that provide ecosystem services such as coastal protection, tourism destinations, and food security. Governments and communities are increasingly realizing the importance of mitigating and adapting to the impacts of climate change. However, stakeholders and decision-makers alike often do not understand the costs and benefits of adapting to these changes or to increasing development, limiting their ability to prepare for future challenges. There are few cases thus far in the Caribbean, however comprehensive marine zoning could be used as a strong approach to address effects of climate change on the coastal and marine environment (Agostini et al., 2010; Natural Capital Project, 2013).

4.4.1 Belize

In 1998, the government of Belize established a Coastal Zone Management Authority and Institute (CZMAI), however it was not until 2010 that they began the work on a plan to balance sustainable development and ecosystem protection. Partnering with the World Wildlife Fund and the Natural Capital Project, CZMAI chose to use Integrated Valuation of Environmental Services and Trade-offs (InVEST) software to develop a plan for managing the coastal zone. This software assists in environmental economic valuation, which seeks to put a monetary value on ecosystems to value their anticipated benefits. This part of an integrated coastal zone management process is particularly effective with stakeholder engagement practices as community members, policymakers, and scientists come together to validate and add local knowledge data and analyse scenarios that highlight conservation versus development, as well as ‘middle-ground’ informed management scenarios. Stakeholder input was incorporated into the entire process through coastal advisory committees and public consultations. Furthermore, the Natural Capital Project experimented with their online mapping tool, InVEST Scenario Modeler (InSEAM), to allow community members to virtually collaborate and add data to a base map, however facilitators found other methods to be more effective for the stakeholders involved (Rosenthal et al. Undated).

4.4.2 Saint Kitts and Nevis

The marine spatial planning process on Saint Kitts and Nevis (SKN) was facilitated by The Nature Conservancy and USAID in coordination with the SKN government. This pilot project developed a draft marine space-use zoning plan while adhering to a guiding principle to continuously engage community members across government departments, NGOs, and individual stakeholders. Technology and accurate geospatial data are necessary to implement a MSP, however transparency and community engagement in the planning process are also important. Interactive decision support systems (DSS) enable scenario analysis in order to attempt to resolve user conflicts and reveal trade-offs in management scenarios, in this case the chosen software was the freely available Marxan with Zones. Accurate, current, and relevant spatial databases are essential for marine zoning, but are rare in SIDS without the financial resources to consistently create and update data. TNC/USAID carried out detailed ecosystem health field surveys and supplemented that with participatory mapping with local stakeholders. Community members continued to be engaged through the entirety of the MSP process, as zoning plans show a much higher rate of success when supported and appreciated by user groups. To allow for public access to the data, TNC made it available in the form of a geospatial database, georeferenced portable document formats (pdf), and on a web-based map viewer. Lessons learned included the importance of integrating ecological and socioeconomic data into conservation planning tools, assuring transparency and stakeholder understanding with DSS, and strong in-country partnerships (Agostini et al., 2010).

4.4.3 Barbuda

The Blue Halo Initiative – a collaboration with the Barbuda Council and the citizens of Barbuda, funded by the Waitt Institute, initiated a community-driven ocean zoning project in 2013 using a DSS called SeaSketch. SeaSketch allowed for the visualization of how stakeholder-generated zones could combine with scientific data and policy to maximise ecosystem protection and minimise negative economic impacts on fishermen (SeaSketch, 2014). The three primary steps for the project were to "1) establish scientific guidelines, 2) identify stakeholder priorities, and 3) balance stakeholder preferences while meeting science guidelines" (Johnson & McClintock, 2013). Through the collection of habitat and fisheries data, ocean use surveys, and documentation of stakeholder priorities, baseline information to use a DSS was established. Through the use of a local cellular service-based internet connection, facilitators held stakeholder interviews and public meetings to take community members through the web-based SeaSketch maps. The project settled on six no-take marine sanctuaries, three net-banned zones on coral reef/sensitive habitats, and four mooring areas, restricting anchorage to everywhere else. In 2014, the Barbuda government passed new ocean regulations that protect this 33 percent of the coastal zone (SeaSketch, 2014).

5 PARTICIPATORY MAPPING IN THE CARIBBEAN

5.1 Approaches

Participatory mapping remains fairly new to the Caribbean, despite dating back to the 1980s–90s in Africa, Asia, and Central America (DiGessa, 2008). Caribbean natural resources are at a fragile state in the face of increasing development (to support growing populations and tourism economies) and climate change. These changes intimately affect the people in small island developing states and the voices of their stakeholders should play a significant role in any planning work that aims for good governance. This makes participatory mapping particularly valuable today in SIDS as a tool for raising awareness and educating stakeholders on sustainable development and conservation efforts (Baldwin & Oxenford, 2014; Bobb-Prescott, 2014). Methodologies utilised thus far in the Caribbean include participatory mapping and PGIS primarily through the use of P3DM and GIS/GPS mapping (CANARI, 2012; DeGraff & Baldwin, 2013; Smith, 2006; Sustainable Grenadines, 2013). These approaches work well in a Caribbean context as they both engage communities and attempt to provide spatially accurate data that can be used in maps and policy decisions. The most effective way to use participatory mapping to its full potential is through 'bottom-up' projects that intimately engage stakeholders throughout the entire process. It is also important to note that the participatory mapping process can be just as valuable as the end-product (i.e. map), through community discussions and reflections on their environment.

Applications of participatory mapping, that has been and continue to be especially beneficial for the region, include resource mapping, heritage mapping, and disaster risk and vulnerability mapping. However, there are many more ways that participatory processes can be integrated into projects in the Caribbean. Mapping of coastal resources and ecosystems for conservation efforts and improved spatial planning initiatives such as MSP and ICZM can be further enhanced by ensuring that community involvement does not stop after the completion of a map. For example, participatory co-management of marine parks or protected areas or committees or groups committed to maintaining up-to-date data for the area. Mapping of local toponyms and historical, cultural, and ecological heritage features could be also further added to by stakeholders applying for historic landmark status or the creation of maps and reports to alert would-be property holders to the value of structures on the land to enhance preservation efforts. Additionally, efforts to map areas that could be affected by climate change or areas of particular vulnerability to natural hazards should be on-going collaborative community processes in coordination with governments and adaptation/mitigation policies. Capacity building at the community, organisational, and governmental level will help to take positive steps towards heritage preservation, sustainable development, ecosystem-based adaptation, and climate change resilience.

5.2 Accessibility

In an age of improved access to technology, the use of digital and web-based mapping efforts is increasingly utilised in participatory processes. While there are still many places across the Caribbean without internet, accessibility improves every year, especially with the popularity of mobile 'smartphones' and tablets that can access the internet on data or via wireless internet. This increase in web-enabled technology opens doors to online participatory mapping projects that could allow for the inclusion of remotely located stakeholders as well as those unable to participate at the time of the project (Kyem & Saku, 2009). Crowd-sourced online community mapping, or volunteered geographic information (VGI), has also developed as a powerful tool, particularly in disaster situations, allowing for unaffected stakeholders and those with knowledge of the region to map infrastructure from aerial and satellite imagery for disaster relief management (Humanitarian OpenStreetMap Team, 2014). Additionally, participatory projects could include significant in-person work supplemented by web GIS capabilities for further data collection or data validation. This technology can integrate data from multiple sources as well as make it available before, during, and after participatory mapping projects. Internet-based systems can be both simpler and cheaper than GIS software and are often optimised for mobile viewing or have smart phone applications (Kyem & Saku, 2009). It is important to note that having access to internet-enabled technology does not equal participation in decision support systems, however, well-developed and well-publicised internet PGIS can assist in managing the distance, time, and costs of stakeholders attending workshops and meetings (Gerlach, 2010; Laituri, 2003).

A decrease in pricing in technologies such as GPS units and unmanned aerial vehicles has opened the door for their wider usage. The majority of smart phones and tablets are now GPS-enabled and both free and low-cost applications turn these increasingly common technologies into simple GPS devices. GPS units themselves have also dropped drastically in price, and GPS-enabled cameras allow for coordinated data collection (IFAD, 2010). UAVs or 'drones' allow for the collection of powerful, location-specific, geo-referenced aerial imagery. This is especially relevant across areas without access to affordable satellite imagery. A common problem with aerial imagery in the tropics is finding imagery without cloud cover. Deployment of low-flying UAVs by community members, engages stakeholders and can avoid the complications of cloud cover (CartONG, 2014).

Another aspect to keep in mind when planning to use GIS is accessibility to base data. Geospatial data in the Caribbean tends to not be easily accessible as it is spread between government agencies, ministries and regional/international NGOs, each with their own procedures for data sharing. Data that is available is frequently limited, outdated, inaccurate, or lacking the metadata necessary to determine the source and quality, often necessitating further base data validation and collection (Pandey & Lyon, 2013; Rambaldi & Weiner, 2004). In these cases—if PGIS is the most appropriate format—adequate time and resources should be set aside at the onset of the project for this data collection or ground-truthing, which should additionally be validated by local stakeholders (Quan et al., 2001). The World Bank has recently developed an initiative to work with countries in the Eastern Caribbean to begin to utilise an open-source geospatial data sharing and management platform called GeoNode. This type of data sharing strives to make geospatial data more accessible for disaster risk management and the wider impacts of climate change in the Caribbean (The World Bank, 2013).

6 CONCLUSIONS

Participatory mapping is a powerful tool that can be applied to visualise and represent peoples spatial stories and defend local knowledge (Rambaldi & Weiner, 2004). Through the collaborative collection of data, participatory mapping can strengthen public participation in governance and drive community engagement (Slocum & Thomas-Slayter, 1995). The emergence of this initiative in the Caribbean has led to a variety of projects across the Caribbean basin, a particularly vulnerable region to the impacts of climate change (UNEP, 2008). Small islands developing states could greatly benefit from an increase in publically accessible, accurate geospatial data, especially local knowledge that relates to conservation of ecosystems, preservation of cultural heritage, and adaptation to the effects of climate change. Conservation and planning strategies show a higher rate of success when local stakeholders support a project through informed decision-making, and the use of participatory mapping initiatives and decision support systems are powerful tools for public awareness and capacity strengthening (Agostini et al., 2010). As participatory mapping grows and evolves as a discipline, from the work of development practitioners to community-driven social processes, it steadily becomes a more relevant and engaging resource, and the small island developing states in the Caribbean could easily be at the forefront of realising the value of this initiative (Sletto, 2012).

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