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Participatory GIS for strengthening transboundary marine governance in SIDS

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Abstract

In this paper we explore the challenges involved in engaging the full range of stakeholders needed for effective marine resource management in the transboundary Grenadine Islands shared by the small island developing States (SIDS) of Saint Vincent and the Grenadines and Grenada. The study describes the ways stakeholders were engaged in the development of participatory geographic information systems (PGIS), both in terms of the research approach (process) and the final geodatabase (product); it illustrates how the approach provides a practical means to strengthen aspects of marine governance, particularly in a SIDS context. We found that PGIS can provide a foundation for ecosystem-based transboundary marine governance. The advantages of this approach are two-fold: it provides the fullest possible range of information as input for the management of marine resources and it engages the stakeholders. This engagement takes several forms: capacity to participate in research; ownership of information produced; increased stakeholder understanding; empowerment through access to information; capacity to interact with other stakeholders for information and problem-solving; and competence to participate in actual governance processes. Lastly, we discuss considerations for other practitioners contemplating using PGIS, particularly those working in similar resource-limited SIDS environments.

Keywords: Participatory GIS (PGIS); transboundary marine governance; stakeholder engagement; Grenadine Islands; small island developing States (SIDS).

1. Introduction

Challenges facing coastal and marine resource management are complex and dynamic, characterised by high levels of uncertainty and interlinked processes at multiple scales (e.g., ecological, jurisdictional, social) and levels (e.g., global, regional, national, local) (Apgar *et al*., 2009; Bavinck *et al*., 2005; Mahon *et al*., 2008). In light of this, there is a need to implement proactive and precautionary management measures based upon the best available information from all sources, even before cause and effect relationships are fully known (Mackinson and Nottestad, 1998). Conventional, top-down, single-sector management is insufficient to respond to these governance challenges (Christie and White, 2007; Mahon, 1997; Pomeroy *et al*., 2004). These challenges are even greater in Small Island Developing States (SIDS) which are highly vulnerable due to their large coastal and marine area to land area ratio, geographic dispersion, and limited resources and capacity (UNESCO, 2004). The severity of impacts on marine ecosystems can be seen in a variety of ways, including: destruction of habitats, over-exploitation of resources, and coastal pollution and erosion, all of which undermine food security as well as threaten biodiversity and coastal livelihoods (Burke and Maidens, 2004; Gardner *et al*., 2003; Paddack *et al*., 2009). If current trends continue, economic losses will be substantial for many Caribbean SIDS (Burke and Maidens, 2004; Moberg and Folke, 1999). Climate change and other global threats further aggravate already challenging situations. Taking no action for mitigation and adaptation, as may occur where governance is inadequate, is not a viable option (Bueno *et al*., 2008).

Oceans and coasts feature prominently in the Barbados Programme of Action for the Sustainable Development of SIDS (BPOA) and the Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of SIDS (MSI). The UN Conference on Sustainable Development (Rio+20) acknowledged the special case of SIDS and set out detailed

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recommendations for oceans and seas that reinforce the urgent need to implement practical measures within a framework of governance that is responsive and responsible (UN, 2012). Emerging perspectives for marine governance in SIDS embrace a comprehensive strategy, or an ecosystem approach, composed of both natural and human elements (Chakalall *et al*., 2007; Chuenpagdee and Jentoft, 2009; Garcia *et al*., 2003; Tallis *et al*., 2010; UNESCO, 2011). For example, the interactive governance approach (Bavinck *et al*., 2005) and others seek to strengthen management by addressing diversity and complexity through integrative, inclusive and diagnostic methodologies (Folke, 2004; Hughes *et al*., 2005; Ostrom *et al*., 2007; Mahon, 2008). These approaches emphasise that, in order to respond to uncertainty, management must be adaptive, cross-scale and multi-leveled, allowing for broad stakeholder involvement (Apgar *et al*., 2009; Armitage *et al*., 2008; Christie and White, 2007; Mahon *et al*., 2008). These approaches are thought to be essential for building resilient marine resource governance in order to address unprecedented marine and terrestrial, global and regional threats in SIDS (UNESCO, 2004; 2011).

While ecosystem approaches and interactive governance provide the theoretical underpinning for contending with complex socio-ecological problems, the development of practical mechanisms for their combined implementation is just starting, particularly in marine and SIDS contexts (Christie *et al*., 2007; Crowder and Norse, 2008; Tallis *et al*., 2010). The use of geographic information systems (GIS) coupled with participatory approaches is emerging as a tool for interdisciplinary community development and environmental stewardship known as participatory GIS (PGIS) (Corbett *et al*., 2006; Rambaldi *et al*., 2006). Ultimately, stakeholder empowerment through the application of principles that reflect good governance (e.g., transparency, accountability, efficiency, inclusiveness, legitimacy, respect and equity) underlies the PGIS approach (Chambers, 2006; McCall, 2003). This is both in terms of the participatory processes involved in the development of the conceptual framework and the construction of an appropriate (locally relevant) product. Technically, PGIS provides a means to collect and represent local knowledge and can empower stakeholders to effectively participate in governance. This is achieved not only by demonstrating the legitimacy of information provided by stakeholders but by allowing for a more comprehensive understanding of the socio-ecological characteristics of resource use (Aswani and Lauer, 2006; De Freitas and Tagliani, 2009; Tripathi and Bhattarya, 2004). Broad stakeholder engagement facilitates increased dialogue, understanding, and trust among stakeholders, thereby balancing power through transparency, inclusiveness and ownership in governance (Chuenpagdee *et al*., 2004). The application of PGIS not only supports the production of appropriate and accessible information but, perhaps more importantly, aids empowerment, the capacity for learning, and pluralistic problem solving, all of which ultimately aids adaption and resilience.

Weak marine governance arrangements (those appreciably deficient in the good governance principles identified above) have been recognised as a root cause of problems facing socio-ecological systems in Caribbean SIDS (CLME, 2011; Mahon *et al*., 2011). The Caribbean Large Marine Ecosystem (CLME) Project recognises the need to utilise and strengthen existing governance arrangements in this region dominated numerically by SIDS (Fanning *et al*., 2007). Yet, a regional ecosystem approach must also resonate with local frames of reference (e.g., governance, socio-economic and cultural idioms) to be successful (Aswani *et al*., 2011; Christie *et al*., 2009). Scaling down from the regional to local level, emphasis is on the establishment of vertical and horizontal connections among the diverse marine policy cycles, each with stakeholder networks, to foster cross-scale linkages for adaptation and resilience (Berkes and Folke, 1998; Berkes, 2011; Mahon *et al*., forthcoming). Since the majority of Caribbean SIDS lack capacity at national and local levels for an ecosystem approach to marine governance, interventions are needed to enhance stakeholder networks and policy linkages in order to develop the adaptive capacity of stakeholders and strengthen marine governance (Aswani *et al*., 2011; Christie *et al*., 2009; Fanning *et al*., 2011; UNESCO, 2004).

2. Study area

Located in the Eastern Caribbean, the Grenadine Islands are shared by the SIDS of Saint Vincent and the Grenadines and Grenada and comprise more than 50 islands, islets and cays atop the transboundary Grenada Bank (Figure 1). Three quarters of the Grenada Bank is shallower than 60m (Figure 1) and supports the most extensive coral reef and related habitats in the south-eastern Caribbean (CCA, 1991a; 1991b). Marine resources and their use (including marine-based tourism, fishing and transportation) are of vital importance as they provide food security, livelihoods and social identity for the small coastal communities (Baldwin *et al*., 2007).

The national boundary between the two countries runs east to west between Petite Martinique and Petit Saint Vincent (Figure 1). However, social, cultural and economic ties among all of the Grenadine Islands are historically strong and continue to be active in the areas of fishing, informal trading, tourism and social life, with little attention to the jurisdictional boundary (Baldwin, 2012). Transboundary conflicts are rare, and the Grenadines Islands are often seen as more connected to each other, for livelihoods and many other practical matters, than to their respective main islands of Saint Vincent and Grenada. Imposed upon this setting is the international regime of ocean governance based upon the rights and obligations

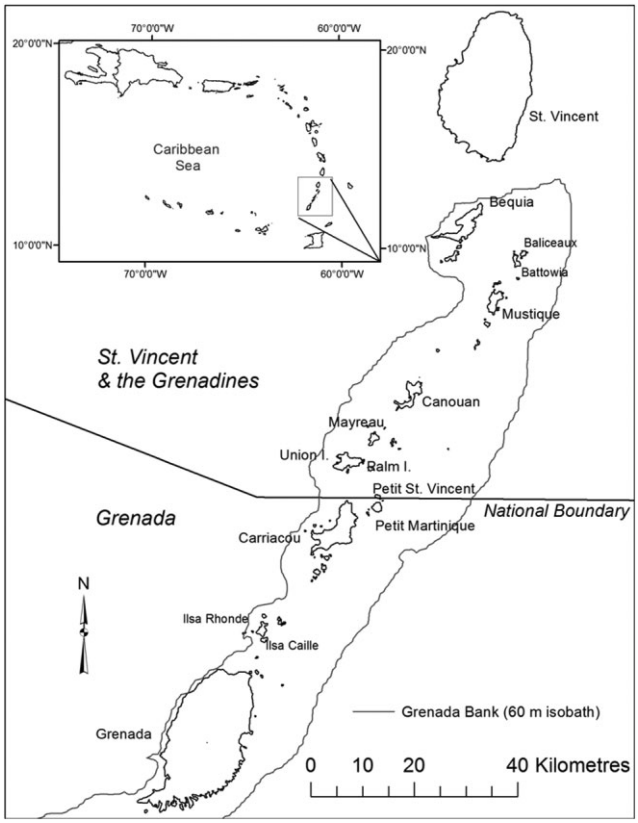

Figure 1. Geographic location of the countries of St. Vincent and the Grenadines and the tri-island State of Grenada and detail of the Grenadine Islands of the transboundary Grenada Bank study area (extending to the 60 m isobath).
Source: Authors' elaboration.

of States to manage and conserve coastal and marine resources.

Management has primarily taken a conventional top-down approach guided by somewhat generic sub-regional (i.e., Organisation of Eastern Caribbean States) and national management plans based on limited biophysical information (Culzac-Wilson, 2003; Mattai and Mahon, 2007). Furthermore, marine resource governance has not been integrated among disciplines, between nations or knowledge systems. This fragmented approach has failed to prevent environmental degradation of the Grenada Bank resources (Culzac-Wilson, 2003; ECLAC, 2004; SusGren, 2005) and demonstrates a clear need for an ecosystem approach and the strengthening of marine governance. With a heavy reliance on marine resources and an increasing number of resource users, the Grenadine Island chain provides a good locality to examine the benefits of PGIS in a complex SIDS transboundary marine governance situation, described above and illustrated in Figure 2.

The Sustainable Grenadines Project (better known as SusGren) determined that in the Grenadine Islands, due to limited capacity and organisation, civil society stakeholders had little opportunity to contribute to effecting equitable and lasting change (CCACaMMP, 2002). Now developed into a transboundary NGO, SusGren has the overarching objective of promoting integrated sustainable development and biodiversity conservation in the Grenadine Islands by developing the capacity of stakeholders (including Governments, the private sector and civil society) to participate in marine governance (Mahon *et al*., 2004). Early on, the need for an integrated transboundary marine information system was broadly identified (CCACaMMP, 2002). Thus, the Grenadines Marine Resource and Space-use Information System (MarSIS) was developed as part of doctoral research undertaken by the lead author to test the practical application of PGIS and examine its potential benefits for marine governance in this Caribbean sub-regional SIDS context (Baldwin, 2012). Here we describe the ways stakeholders were engaged in the development of the MarSIS, both in terms of the research approach (process) and the final geodatabase (product). We also illustrate how PGIS provides a practical means to strengthen marine governance and argue for its applicability in a wider SIDS context.

3. Methods

In this study, stakeholder participation was used to: (1) review and refine research objectives; (2) guide methodologies; (3) acquire information and document local knowledge; (4) share and validate information produced; (5) develop locally relevant and accessible information; and (6) appraise the application of PGIS (Figure 3). Methods chosen were based on the view that they should be of low cost and require limited technological expertise so that they could be widely applied in SIDS situations.

3.1. Preliminary appraisal

Consistent with a PGIS approach, the objectives and methods remained flexible to address the needs of both the community and government. At the outset, one year was taken to conduct a preliminary appraisal (Berkes *et al*., 2001; Bunce and Pomeroy, 2003; IIRR, 1998; Walters *et al*., 1998). This was done to: identify existing information; better understand the levels and types of stakeholders and institutions across the scale of the Grenada Bank (Figures 1 and 2); share research objectives; explain guiding principles (e.g., inclusive, appropriate, transparent, comprehensive, participatory, equitable, accessible); and build the working relationships necessary for a collaborative (partnership) approach.

The preliminary appraisal began with an extensive literature and data search of secondary information on the distribution, uses and management of the coastal and marine resources of the Grenada Bank (e.g., environmental and marine-related legislation, policies, management plans; GIS datasets, imagery and maps; and other collateral

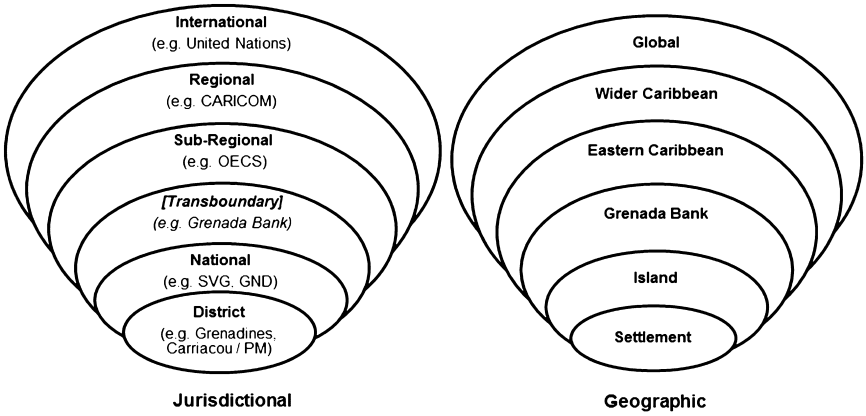

Figure 2. Schematic of the jurisdictional and geographical scales and levels to the marine resources of the Grenada Bank.
Note: CARICOM = Caribbean Community; OECS = Organisation of Eastern Caribbean States; SVG = Saint Vincent and the Grenadines; GND = Grenada; and PM = Petit Martinique.
Source: Authors' elaboration.

information) (Baldwin, 2012). Next, meetings were held with all marine-related government agency stakeholders in both countries identified by Finlay *et al*. (2003) to explain research principles, augment objectives, share information, ascertain gaps and foster transparent collaboration. Each agency was visited to conduct semi-structured key informant interviews and obtain additional secondary information (Bunce and Pomeroy, 2003). Additionally, information was acquired on each agency's mandate, institutional arrangements and management priorities, including systems of data collection and corresponding database structures.

The preliminary appraisal also included visits to each inhabited island. This was done to explain research objectives and principles, identify the types of stakeholders to be designated as marine resource users (MRUs) and determine their capacity for participatory research. A baseline study of the demographics of each community, the locations of coastal activities, key marine resources and their current uses was conducted through key informant and informal interviews (Bunce and Pomeroy, 2003). Additionally, participant observation exercises (Berkes *et al*., 2001; IIRR, 1998) were undertaken with each of type of MRU (including each kind of fishing activity) to better understand Grenadine marine livelihoods and to gain insight into stakeholder dynamics for each island.

Based on the preliminary appraisal, stakeholders were categorised as primary or secondary. Primary stakeholders included key marine-related government agencies (e.g., fisheries division, physical planning and tourism) of each country and the direct MRUs (e.g., dive operators, day-tour operators, water-taxi operators, fishers, ferry operators, yacht charter companies, cargo ship operators). Secondary stakeholders (e.g., civil society organisations, NGOs, other relevant government agencies, the general public) have an interest in marine resources but do not directly rely upon them for their livelihoods.

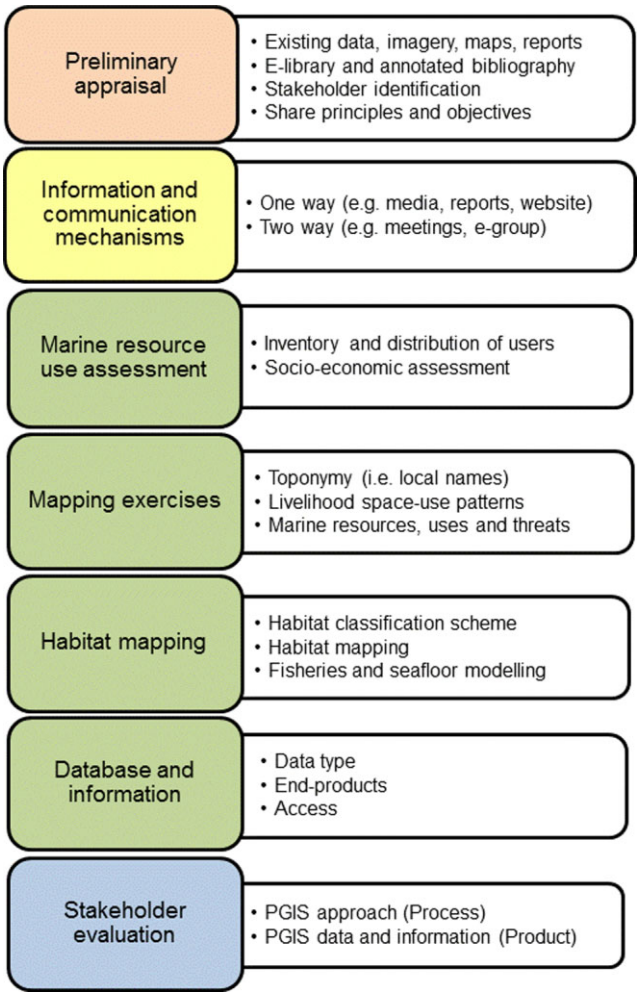

Figure 3. Schematic of the application of PGIS listed with corresponding sub-components in which stakeholder feedback was applied.
Source: Authors' elaboration.

3.2. Communication and information exchange mechanisms

To allow for transparent, inclusive and equitable cross-scale interactions, stakeholders were engaged through one- and two-way communication mechanisms at every stage. One-way channels included the regular distribution of newsletters, press releases, flyers, technical reports and a website/blog (www.grenadinesmarsis.com). Two-way channels included summary and validation meetings (McAllister and Vernooy, 1999) and email through a dedicated internet e-group (www.GrenadinesMarSIS.yahoogroups.com). The e-group and website facilitated transparent group discussion and provided easy access to information across the transboundary SIDS scale of the Grenada Bank. Information collected during the preliminary assessment was compiled into an electronic library with an annotated bibliography (Blackman *et al*., 2006) and shared via DVD and the website. Similarly, all research activities and meetings were documented using summary reports, maps, press releases and bi-monthly newsletters and distributed electronically via the e-group and website and shared in hardcopy by the researchers and SusGren.

3.3. Data collection

Participatory research methods were employed to collect the additional data considered necessary for a comprehensive data and information system (e.g., MarSIS) (Figure 3). Here we describe the steps we took in quantifying the abundance and distribution of existing resources and use patterns. Aspects of the research related to the habitat mapping and fisheries modelling are provided in Baldwin and Oxenford (forthcoming). Baldwin and Mahon (forthcoming) review the development of the geodatabase and provides a demonstration of its application for marine spatial planning and management. Lastly, we explain how participation was applied to develop appropriate and accessible information.

To start, a MRU assessment (drawing upon Berkes *et al*., 2001; Bunce and Pomeroy, 2003; Quan *et al*., 2001) was conducted to quantify the number, distribution and socio-economic conditions of each group. Questionnaires sought information on demographics, livelihood strategies, resource uses and environmental practices (Baldwin *et al*., 2007). Before being administered, survey instruments were distributed using the e-group for collaborative review and approval. A series of validation meetings were held to obtain feedback on the MRU assessment and support transparent cross-scale learning among stakeholders.

Three incremental iterative mapping exercises (drawing upon IIRR, 1998; Quan *et al*., 2001; Walters *et al*., 1998) were conducted over a three-year period to document local spatial knowledge (see Baldwin, 2012 for detailed review). In each island, mapping exercises were conducted with MRUs in the form of individual (or sometimes small group) interviews using hard-copy basemaps. The first mapping exercise was used to determine the toponymy (locally-used place names) for the beaches, bays and cays of the Grenada Bank. This was done to produce a locally-relevant basemap annotated with toponymy for each island. Next, the space-use patterns (e.g., anchorages, dive sites, ferry routes, fishing grounds, shipping lanes) of each MRU group were documented on basemaps using semi-structured interviews. The final series of mapping exercises were conducted to identify the distribution of key resources (e.g., baitfish bays, nursery grounds, oyster beds, seabird nesting sites, sea moss, whelks), areas of use (e.g., aquaculture, cultural/historical sites, recreation, shipbuilding, vending) and areas of threat (e.g., dumping, desalination outfall, dredging, erosion, mangrove cutting, sand mining).

Next, the mapping exercise and MRU assessment data were spatially translated into GIS. Basemaps were scanned and georeferenced. Features were digitized and attribute schema was created for each feature class. Socio-economic data tables were joined to corresponding MRU spatial data. Composite maps (one each of local names, critical coastal and marine resources, livelihood and space-use patterns and areas of perceived threat) were produced for each island. Before they could be considered complete, these maps were distributed in each island at meetings and electronically (via the e-group and website) to validate information.

Two half-day meetings were held with primary stakeholders to determine the appropriate types of information to include and avenues for equitable access. Stakeholders were presented with options to determine the relevant: (1) geospatial data types (e.g., ArcGIS, Google Earth); (2) supplementary end products (e.g., atlases/maps, reports, DVDs); and (3) means of access (e.g., DVD, local computer at community centre, website). Feedback was obtained using a one-page questionnaire (Baldwin, 2012).

3.4. Stakeholder evaluation

After the compilation of the MarSIS geodatabase (Baldwin and Mahon, forthcoming), three one-day workshops were conducted with primary and secondary stakeholders to examine the application of PGIS. The practical application of the MarSIS (product) through either an ArcGIS or Google Earth interface was tested by the stakeholders themselves and reviewed in detail by Stewart and Baldwin (2012). In addition, a four-page questionnaire was administered to assess each of the participatory methods utilised (process), examine the effectiveness of the resulting Grenadines MarSIS geodatabase (product), and understand the usefulness of PGIS to support marine governance. A total of 43 participants, comprising 11 community, 23 government and nine NGO stakeholders, completed the questionnaire.

4. Results and discussion

This study tested the practical application of PGIS in a transboundary coastal and marine SIDS case. We found that PGIS resulted in the production of comprehensive and accessible information tailored to the needs of the Grenada Bank stakeholders. The PGIS process also strengthened cross-scale linkages, promoted a transparent and inclusive working environment and built capacity for adaption and resilience across a transboundary scale. Here we provide a brief assessment of each engagement mechanism, from the perspectives of both the stakeholders and researchers, and illustrate how PGIS can strengthen marine governance. Lastly, we discuss considerations for other practitioners contemplating using PGIS, particularly those working in similar resource-limited SIDS environments.

4.1. Preliminary appraisal

A large initial investment (time and effort) was made to conduct a thorough preliminary appraisal. This was considered essential to appropriately design and implement the PGIS endeavour. Existing information was scattered across the islands among government agencies, libraries, NGOs and community leaders and had never been systematically compiled. More than a year (18 months) was required to collect, appraise and catalogue information and produce an annotated bibliography and e-library for distribution. Formal government meetings (3) were useful to clearly explain the objectives, guiding principles and the role of stakeholders in the research. Key informant interviews (32) were beneficial to understand the capacity and management priorities of each agency, source additional information and build partnerships. Ultimately, the iterative collation and transparent sharing of secondary information among stakeholders continued over the course of the research. This process was truly a collaborative effort that served to empower stakeholders and build capacity (e.g., information) and was considered instrumental in strengthening working relationships and cultivating a cooperative cross-scale alliance from the outset. Where resources for acquiring information are limited, as is the case in SIDS, it is efficient to make optimal use of the existing information and to make it accessible to all stakeholders.

Field visits and interviews (57) aided the understanding of island-level demographics, coastal and marine livelihoods and the importance of marine resources to the people of the Grenadines. Participant observation was advantageous in gaining insight into the various marine livelihoods. Spending the day at sea with MRUs provided the unique opportunity to ask practical questions and allowed for a better understanding of ethnographic information such as folk taxonomies, marine space-use patterns and livelihood practices. This is information which could not have been acquired from observations or surveys on shore. For example, during activities at sea, the researcher observed the lack of use of maps or GPS units for navigation, the illiteracy of many MRUs, and the difference in local naming conventions for coastal areas and marine habitats. Moreover, going out to sea and assisting with daily activities not only earned the researcher respect but provided time for the informal discussion of resource problems and research objectives. This cultivated a deeper understanding among MRUs of the research principles and the importance of including local knowledge in the research endeavour. Ultimately, these exercises were vital to the formation of partnerships, as well as to understanding the local context and MRU capacities' across the transboundary island chain. This, in turn, was essential to determining appropriate methods and encouraging cooperation for the ensuing research activities.

4.2. Communication and information exchange mechanisms

Communication and equitable information exchange is central to both a PGIS (Rambaldi *et al*., 2006) and an ecosystem approach (De Young and Charles, 2008). Considering the geographical and socio-political complexity of the study area (Figure 2), the significance of wide-ranging, cross-scale collaboration (or connectivity) must be emphasised. The importance of communication leading to transparency and inclusiveness was reported by stakeholders as an important aspect of the research (Table 1). Participation, in terms of equitable and informed multi-level stakeholder involvement, was supported through the establishment of a number of easy-to-use and low-cost communication and information exchange channels. Of the mechanisms employed, stakeholders overwhelmingly preferred (91%) the use of meetings and emails (via the e-group) (Table 2). The MarSIS e-group, with over 500 members, easily facilitated discussion forums which continue at the time of writing. Summary reports (which 89% found useful) and maps (which 51% found useful) were pivotal to documenting research activities and served to strengthen the capacity of stakeholders. Moreover, reports were the preferred format of government stakeholders, whereas paper maps were favoured by NGO and community stakeholders, and 34% of respondents reported personal visits to be beneficial. Surprisingly, despite its importance to the researchers for obtaining secondary information and building working relationships, only half of respondents reported that the Grenadines e-library (via DVD) was a valuable tool. The majority of stakeholders (and 75% of community stakeholders) found the website useful for easily accessing information, whereas the blog was reported as one of the least desirable mechanisms for communication. It can be concluded that a spectrum of interactive communication methods (i.e., personal visits, hard copy and electronic formats) will be needed to reach and engage the full range of stakeholders in a similar project of this magnitude.

Table 1. Percentage of stakeholder agreement with statement (by group and overall mean)

Usability and appropriateness	N	Comm.	Govt.	NGO	Mean
MarSIS is what I expected it to be after hearing about it.	43	100	100	100	100
Do you feel MarSIS be useful to your agency or group?	43	100	100	100	100
The 'layers' of information within MarSIS are easy to understand.	43	100	100	100	100
Types of information in MarSIS are meaningful to me.	43	100	100	100	100
Stakeholder feedback was incorporated into the research methods.	43	82	91	78	86
MarSIS objectives have been developed according to local needs.	42	90	95	100	95
MarSIS (in terms of information) has been developed appropriately for local capacity.	43	73	87	100	86
Use of technology: MarSIS geodatabase					
MarSIS (in Google Earth) is too technical for most people to use.	43	27	4	22	14
MarSIS (in terms of technology) has been developed appropriately for local capacity.	42	80	83	100	86
Transparency, inclusiveness and ownership					
The research was carried out in a clear and open manner.	43	100	100	100	100
Communication and information exchange was an important part of this research.	42	100	100	100	100
Effort was made to include a wide range of stakeholders in the research.	43	100	91	100	95
Care was taken to properly validate information/datasets.	43	90	91	100	93
The compilation of MarSIS was a collaborative or group effort.	42	100	100	100	100
I feel a sense of ownership in the final product.	40	89	74	63	78
Increased understanding and information integration					
MarSIS is a good educational resource.	43	100	100	100	100
MarSIS can be used to better understand the marine environment.	43	100	100	100	100
MarSIS highlights the importance of the sea to the people of the Grenadines.	43	100	100	100	100
Local knowledge datasets are a useful part of MarSIS.	43	100	100	100	100
MarSIS provides information that is unique (i.e., not provided by any other source).	40	90	91	100	93
MarSIS can assist in prioritising marine management needs.	43	100	100	100	100
MarSIS can be used for informed marine decision-making.	43	100	100	100	100
MarSIS can assist in the planning of sustainable development.	43	100	100	100	100
Learning and capacity-building					
Participation in this research was a learning experience for me, in terms of:					
1. Participatory approaches used	39	100	95	100	97
2. New technology/skills	42	100	100	100	100
3. Increased my knowledge	41	100	100	100	100
The effort of participating in this research was worth my time.	41	100	95	100	97

Notes: N = sample size; Comm. = community; Govt. = government.
Source: Authors' elaboration.

Table 2. Percentage of stakeholder group reporting that the communication and information exchange mechanisms were either 'very useful' or 'useful'

Mechanism	Government	NGO	Community	Overall
Stakeholder meetings	95	86	88	91
E-group / emails	85	100	100	91
Summary reports	100	71	75	89
Website	65	43	75	63
Paper maps	25	100	75	51
E-library (DVD)	55	57	25	49
BLOG	45	43	25	40
Personal visits	35	43	25	34
Sample size	20	7	8	

Source: Authors' elaboration.

The importance of periodic validation meetings is worthy of emphasis. These not only provided quality assurance but the recurrent sharing of results showed stakeholders how the information was being used. These meetings reinforced the legitimacy and importance of locally contributed knowledge while increasing cross-scale understanding of the perspectives of the various groups and island communities. All stakeholder groups indicated that they were pleased that care was taken to inform them, validate findings and solicit feedback (Table 1). Another factor cited as contributing to the success of these meetings was the holding of different meetings targeted to stakeholder capacity and preferences (i.e., government vs. community). This was facilitated by consulting key informants to better understand stakeholder preferences for

meetings. For example, fax invitations and follow-up phone calls were important to ensuring government agency attendance; whereas for MRUs holding community meetings during the early evenings and in locations where they felt comfortable was important to attendance. We found that the use of meetings after each stage of the research (including the distribution of periodic summary reports and maps) together with the e-group and website as platforms for transparent communication and access to information was advantageous in creating a common space of understanding among such a diversity of stakeholders.

Consulting with stakeholders before each stage of the research and seeking feedback allowed for us to refine the research methods. Most stakeholders (86%) reported that feedback was adequately incorporated into the methods employed (Table 1). Likewise 22 of the 23 respondents who participated in validation meetings found them worthwhile. Albeit time-consuming, these periodic meetings fostered the legitimacy of local knowledge and a collaborative learning environment, and ultimately served to build trust in and ownership of the information produced. Most participants (93%) agreed that data from local knowledge provided unique information. Accordingly, nearly all (97%) stakeholders reported that the effort of participation in this research was worthwhile. We found the continual use of stakeholder feedback empowering for stakeholders, instrumental for the smooth conduction of the subsequent participatory research, and imperative for sustained cooperation over the course of the study.

Respondents unanimously agreed that: the research was conducted in a clear and open manner, communication and information exchange were important aspects, and the compilation of the MarSIS was a collaborative effort. We found that communication and information exchange mechanisms helped to support governance principles, thereby providing connectivity and the creation of a transboundary learning environment among stakeholders. In agreement with the findings of UNESCO (2004), we found the use of low-cost information communication technologies (e.g., e-group and website) were instrumental in removing previous barriers to information access in this transboundary SIDS case. This encouraged transparent and equitable information-sharing and provided a forum for listening and soliciting help among the diversity of stakeholders.

4.3. Data collection

Participatory research demonstrated the relevance of information provided by stakeholders. It also supported an ecosystem approach through the use of multi-discipline and multi-knowledge information sources for management, corroborating the findings of Christie and White (2007) and DeFreitas and Tagliani (2009). The MRU assessment allowed for the quantification of marine livelihoods; yet the geographic scale (11 inhabited islands), diversity and number of identified MRUs (close to 1,000) was a challenge, requiring the work of five people over a three-month period. Posting the survey instruments on the e-group allowed for questions to be rephrased with local terminology. Also noteworthy was the need for researchers to have strong interpersonal skills to obtain wide stakeholder participation, particularly among fishers. For example, attendance at community festivals (i.e., fishing tournaments, sailing regattas) as well as time spent "lingering" around town, marinas and fishing ramps to observe local activities and chat with community members were necessary in order to provide an opportunity to informally explain the purpose of the surveys and the importance of full participation.

During mapping exercises, researchers systematically collected each island community's spatial knowledge of resources and use patterns. Additionally, recurrent personal visits to distribute maps and summary reports and holding validation meetings had several benefits. First, it allowed for the production of accurate information based on local knowledge. This further demonstrated to stakeholders the legitimacy of their knowledge, and thereby promoted ownership of the information produced. Conducting mapping exercises in an incremental fashion provided the time needed to build capacity for participation as well as the trust required for MRUs to share controversial information (such as illegal activities). Combining the socio-economic information with the spatial mapping data provided comprehensive ecosystem-based transboundary information. This included several unique GIS datasets (e.g., 12 for space-use patterns, seven for marine resources, eight for issues or threats, as well as the local names of coastal features) and composite island maps (e.g., basemaps annotated with local names, marine resources, space-use patterns, areas of issues or threat) (Baldwin and Mahon, forthcoming).

We found that participation in data collection (Figure 3) fostered stakeholder cooperation and the PGIS approach. The collection of local knowledge became easier, as evidenced by the identification of key informants and their willingness to participate over the course of the study. This collaborative working environment demonstrated the usefulness of local knowledge and collaboration and substantiated the capacity and willingness of stakeholders to participate, thus ultimately legitimizing their involvement.

The development of an appropriate PGIS product requires consideration of stakeholders' technical capacity (McCall, 2003; Rambaldi *et al*., 2006). The preliminary appraisal coupled with collaborative planning meetings provided the opportunity to ascertain the preferences and capacity of the various stakeholders. For example, the Google Earth interface was identified (67%) as the most appropriate software application, although ArcGIS was preferred by government stakeholders (Baldwin, 2012). Access to the internet was identified (84%) as the most

appropriate avenue to ensure equitable public access to information. In similar cross-scale SIDS endeavours, an array of data products may be required.

The stakeholder evaluation was also used to examine the appropriateness of the geodatabase (product). Participants unanimously noted that the MarSIS (product): is what they had anticipated at the outset; provides an accessible resource; and increases understanding of the importance of the marine environment to the people of the Grenadines (Table 1). All participants reported that the MarSIS information is meaningful, easy to understand and useful for their respective groups, particularly for prioritising marine management needs, informing decision-making and planning. Overall 78% of respondents (and 89% of community stakeholders) expressed a sense of ownership in the MarSIS (product).

Beyond the benefits identified above, a participatory approach may also facilitate improved governance by building adaptive capacity and resilience. The application of PGIS resulted in a broad set of ecosystem-based information which has been actively used by stakeholders since its public release. On the international level, the United Nations Economic Commission for Latin America and the Caribbean used the MarSIS to quantify the economic value provided by reef ecosystem services in Saint Vincent and the Grenadines (O. Joslyn, pers. comm., 15 March 2012). Subsequently, on the sub-regional level, the MarSIS has been used to support: a transboundary marine multi-use zoning design for the Grenadine Islands (SusGren, 2009); a transboundary application to designate the Grenadine Islands as an UNESCO marine mixed World Heritage Site (De Graff and Baldwin, 2013); and the Nature Conservancy's "At the Water's Edge: Coastal Resilience in Grenada and Saint Vincent and the Grenadines" project (J. Knowles, pers. comm., 12 August 2012). Nationally, the planning departments of both countries regularly use the MarSIS to check the validity of environmental impact assessments submitted to the government. Locally, two NGOs have used the MarSIS to contest environmentally unsustainable coastal development projects; to show the consequence of a dredging and sand reclamation project in Canouan (Price, 2011); and to rally against a proposed free port development in Carriacou (PIA, 2011). Additionally, Grenadine school teachers have developed environmental curricula based on the use of the MarSIS in Google Earth (Baldwin, 2010). These examples substantiate the importance of PGIS in strengthening connectivity for learning systems and empowering stakeholders to participate in governance, as suggested Kooiman *et al*. (2005).

4.4. Constraints of the approach

Despite the overall success of PGIS in this study, there are constraints that should be considered. First, the cost of PGIS should be carefully evaluated. Accordingly, the timeframe, objectives and level of participation should be clearly defined (McCall, 2003; Rambaldi *et al*., 2006). In this case, stakeholder engagement was time-consuming yet instrumental in fostering a conflict-free, collaborative work environment and creating buy-in. We conclude that the initial investment spent in terms of the preliminary appraisal and connectivity resulted in a considerable amount of stakeholder in-kind support and private sector funding. For example, over 2,500 hours were contributed via participation in interviews and attendance in validation meetings. Similarly, more than US$ 50,000 in grants and private sector support was donated over the course of the study. This in turn markedly reduced the financial burden of both participation in research activities and the field surveys (Baldwin and Oxenford, forthcoming).

Ideally, PGIS should result in ownership and maintenance of information (Corbett *et al*., 2006). In this transboundary SIDS case, there is a mismatch between the existing jurisdictional scale and the geographical (social/ecological) scale of the Grenada Bank (Figure 2). We used an academic-NGO partnership to work between and within the existing institutional frameworks of the two countries, as well as to bridge the various levels of stakeholders across the scale of the transboundary island chain. Focus group discussions underscored the opinion that this academic-NGO partnership was a credible institutional basis for the PGIS endeavour (Baldwin, 2012). Nevertheless, the maintenance of the MarSIS will require additional capacity-building, particularly in terms of GIS skills. Although all stakeholders reported to have learned new skills (e.g., participation, information, technology), at present only public sector stakeholders have the capacity to use GIS software. The transboundary processes necessary to sustain the MarSIS require a partnership including the public and private sectors and civil society. While the fundamental role of the NGO SusGren as a bridging organisation from the local to transboundary level should not be underestimated, they do not have the technological capacity to maintain the MarSIS. However, this PGIS initiative has laid a foundation for continuity by developing the cross-scale linkages among stakeholders and constructing the geodatabase — two activities found to be the most time-consuming aspects of similar projects (De Freitas and Tagliani, 2009). Despite the fact that the ownership of the transboundary MarSIS after the conclusion of this study is unclear, stakeholders recognise the importance of a continued, wide-ranging collaborative effort to maintain the information (Baldwin, 2012).

5. Conclusions

This research demonstrates the many benefits of utilising a PGIS approach to strengthen SIDS coastal and marine governance. It supports the claim by McCall (2003) that PGIS promotes a range of characteristics necessary for good governance. These include comprehensiveness,

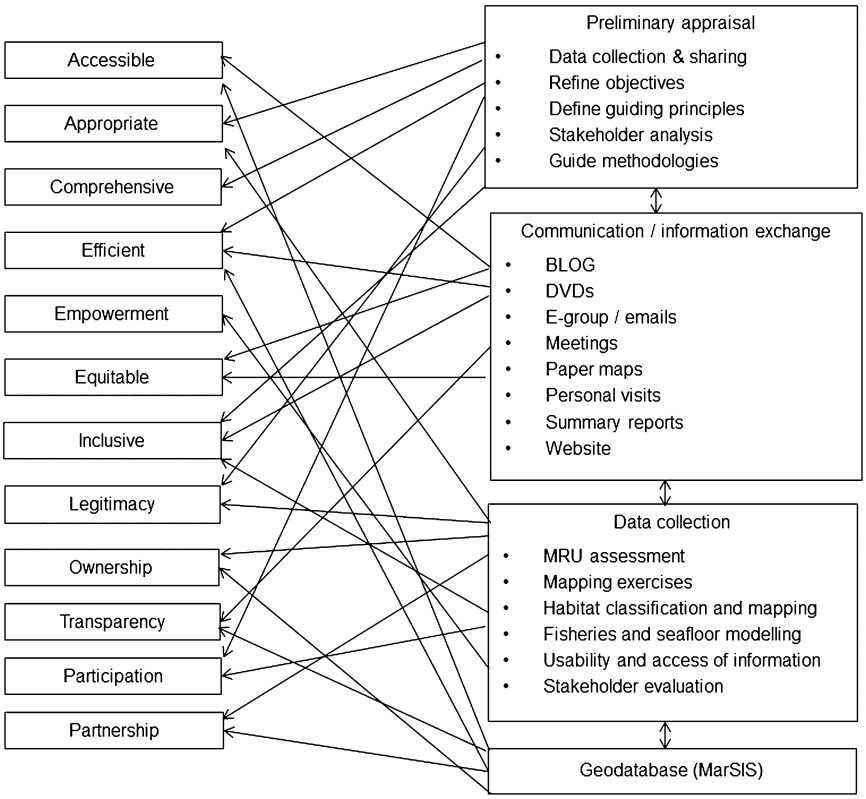

Figure 4. How PGIS methods can support the principles of governance.
Source: Authors' elaboration.

participation, inclusiveness, transparency, partnerships, appropriateness, equitable access, ownership and legitimacy (Figure 4).

In this transboundary SIDS context, we found the application of clearly defined governance principles to be of key importance to the collaborative construction of an appropriate ecosystem-based PGIS, corroborating Mahon *et al*. 2008. The advantages of the approach are two-fold: (1) it provides the fullest possible range of information as input for the national and transboundary management of coastal and marine resources; and (2) through stakeholder engagement, it strengthens the process of governance by enhancing the observance of the desirable principles listed above. These principles support self-organisation for positive adaptation and resilience in a transboundary marine SIDS context, and they can support sustainable development. If this is the future that we want for SIDS, post-2015 or otherwise, then a more concerted effort is needed to bring available science and technology to bear upon societal problem-solving and creation of opportunities; this is the role of governance. The combination of science, technology and governance as demonstrated in this PGIS initiative is synergistic, resulting in benefits that exceed the sum of their parts. If SIDS can harness such synergies, then sustainable development is possible.

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