

# Towards Mitigating Climate Change Threats to Small Island States Coastal Communities: Geomatics Contributions in a Holistic Governance Approach

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## **Abstract**

Coastal regions are of much importance to human socio-economic activities. As a result much of the world's population live along, or within 150 km of, coasts. Increasing coastal populations, especially in Small Island Developing States (SIDS), are on a collision course with climate change. Climate change is now considered a very real international threat. Sea level rise and other climate change phenomena such as increased frequencies of storms and hurricanes, and flooding from storm surges threaten SIDS.

A community's ability to mitigate or adapt to the effects of climate change depends on that community's vulnerability to change, resilience, and adaptive capacity. Diminishing communities' vulnerabilities while strengthening their resilience and adaptive capacities depends upon, in part, access to relevant information, including spatial information managed via geomatics technologies. Typically, however, governance in SIDS is not holistic, lacking implemented collaborative, integrative, or cooperative frameworks. This often means that needed information resides in sectoral or departmental databases without any easy sharing mechanism to facilitate informed and holistic decision making. Geomatics technologies can provide frameworks for sharing spatial information in a manner that facilitates holistic governance that in turn can be more efficient in aiding coastal communities to mitigate or adapt to climate change threats.

## Introduction

Human systems interact with natural systems, and this interaction is the basis for the survival of human communities. Changes in natural systems, caused for example by climate variability and climate change, can therefore positively or negatively affect the nature of human activities (Table 1) [Michaelowa 2001; Hardy 2003; Mendis Mills and Yantz, 2003].

Table 1  
Impacts of Climate Variability and Climate Change  
(After Michaelowa, 2001)

System	Negative Impacts	Positive Impacts
Water Resources	Decreased availability in many water-scarce regions, e.g. sub-tropics and island states	Increased availability in many water-scarce regions e.g. South-East Asia
Agriculture and Forestry	Reduced crop yields in most tropical and sub-tropical regions; and in the mid latitudes for strong warming	<ul style="list-style-type: none"> <li>• Increased crop yields in most mid-latitude regions for low to moderate warming</li> <li>• Potential increase in timber supply from appropriately managed forests</li> </ul>
Fisheries	Decreased cold fish stock in some areas	Increased warm fish stock in some areas
Human settlements, energy and industry	<ul style="list-style-type: none"> <li>• Widespread increase in flooding, landslides and avalanches</li> <li>• Permafrost melting directly destroys infrastructure</li> <li>• Increased demand for space cooling in mid- and low latitudes</li> <li>• Decreased hydro power potential and waterway transport capacity due to low water levels and decreased glacier areas</li> <li>• Loss of tourist attractiveness in mid and low latitudes and many mountain areas</li> </ul>	<ul style="list-style-type: none"> <li>• Reduced energy demands for space heating in mid and high latitudes</li> <li>• Increased hydro power and waterway transportation capacity potential in areas with increased water levels</li> <li>• Gain in tourist attractiveness in higher latitudes and some mountain areas</li> </ul>
Insurance and financial services	Increase in payments due to damages	
Human Health	Increase in number of people exposed to vector- and water-bourne diseases	Reduced winter mortality in mid and higher latitudes

Coastal regions are of much importance to human socio-economic activities, based on the fact that humans need to have close proximity to seafood sources, take advantage of fertile and productive coastal and delta lands, exploit transportation opportunities, exploit natural resources to meet socio-economic objectives, and exploit coastal areas for recreational and residential uses. Additionally, coastal regions provide natural functions such as habitat for endangered species, species' breeding and resting areas, water treatment, groundwater recharge, and flood attenuation. As a result of these perceived benefits much of the world's population live along or within 150 km of coasts.

Some Small Island Developing States (SIDS) are so small that the entire island is a coastal zone and the populations are affected by coastal phenomena no matter where on the island they live. Other SIDS certainly have populations located along their coasts, subject to the consequences of those locations [Payoyo 1994; UNEP 2007].

Six islands classified as SIDS are listed as being located in Africa. Twenty-three islands with the same classification are listed as being located in Latin America and the Caribbean, and twenty-two islands listed as being located in Asia and the Pacific. According to Small Island Developing Network (2007):

States Small Island Developing States (SIDS) are small island and low-lying coastal countries that share similar sustainable development challenges, including small population, lack of resources, remoteness, susceptibility to natural disasters, excessive dependence on international trade and vulnerability to global developments. In addition, they suffer from lack of economies of scale, high transportation and communication costs, and costly public administration and infrastructure.

Global sea level rise, one potential impact of global climate change, is now considered a very real international threat. Increases in average global ambient temperatures, thermal expansion of ocean waters, subsidence of coastal lands, and increased melting of sea ice are just some of the possible deleterious impacts of climate change that, in various combinations, can contribute to sea level rise and coastal flooding. Even minimal sea level rise could mean disaster for many coastal communities, especially in SIDS, seriously affecting the social, economic, cultural, and ecological foundations of these communities. According to the United Nations Development Programme (UNDP) [2003] and Darwin, Richards and Tol [2001] the inundation of outlying islands and loss of land above the high-tide mark may result in:

- Loss of dry land without protection;
- Loss of wetlands without protection;
- Loss of exclusive economic rights over extensive areas;
- Destruction of existing economic infrastructure as well as of existing human settlements;
- Damage to subsistence and commercial fisheries production;
- Saline intrusion that adversely affect freshwater resources;
- Negatively affected economies.

Other climate change related threats to SIDS include increased frequencies of storms and hurricanes, and flooding from storm surges. Coastal populations, especially in SIDS are on a collision course with climate change.

Information of varying types are among the requirements necessary to mitigate or adapt to climate change threats. Geomatics is the science and technology of the management of spatial information. Spatial information is one important type needed in the pursuit of climate change related mitigation and adaptation strategies. Implicit from this perspective are spatial information technologies. However, information and information technologies have reduced efficacy within ineffective or less than efficient governance frameworks. Some experts have determined that collaborative, cooperative, or integrative governance – a more holistic approach to governance – is a better way for communities to achieve their objectives [Sutherland 2005]. This paper explores some appropriate geomatics technologies within the framework of a holistic governance

approach. Community mitigation and adaptation capabilities, and as well governance concepts are first discussed.

### **Coastal Community Mitigation and Adaptation Capabilities**

A community's ability to mitigate or adapt to the effects of climate change depends on that community's vulnerability to change, its resilience, and its adaptive capacity. A community's resilience is a measure of the amount of change its systems can undergo without changing state. It is the capacity to withstand and recover from hardship. Resilience is a measure of how much a system can maintain controls, functions, structure, self-organization, capacity for learning etc. in the face of threats [Mendis, Mills and Yantz 2003].

A community's adaptive capacity is its ability to anticipate and deal with events and impacts. It is the ability to respond to internal and external stresses, create and take advantage of opportunities, and meet the diverse needs of the community in the face of beneficial or deleterious changes. Adaptive capacity focuses on [Mendis, Mills and Yantz 2003]:

- Ecological capital (environmental stock and services);
- Economic/Physical capital (financial, infrastructure etc.);
- Human capital (skills, education, experience etc.);
- Social capital (relationships among families, the demography, community and the power structure etc.).

Building adaptive capacity in a coastal community includes (among other things) [UNFCCC Secretariat 2003]:

- Strengthening disaster warning systems;
- Strengthening coastal zone management;
- Identifying, assess, and evaluate coastal technologies;
- Providing specialized capacity building packages on adaptation;
- Strengthening socio-economic analysis of adaptation options.

Vulnerability to change is described as exposure to threats that can negatively modify the *status quo*. Threats can be environmental, i.e. spatial proximity to potentially destructive environmental phenomena such as the impacts of climate change. Environmental threats in turn threaten the socioeconomic basis of communities [Mendis, Mills and Yantz 2003]. The vulnerability of community socioeconomic systems varies widely from region to region due to "regional differences in local environmental conditions, preexisting stresses to ecosystems, current resource-use patterns, and the framework of factors affecting decision-making—including government policies, prices, preferences, and values" [IPCC 2001]. A community's vulnerability may be [UNFCCC Secretariat 2003]:

- Legal (Regulation function);
- Economic (habitat function; production function);
- Socio-Cultural (Regulation function; habitat function; production function);
- Technical (information function).

Therefore, diminishing coastal communities' vulnerabilities (especially in SIDS) while strengthening their resilience and adaptive capacities depends upon, in part, access to

relevant information that forms the basis for the development of appropriate mitigation and adaptation strategies. Spatial information is one important type of information that plays vital roles in facilitating the development of mitigation and adaptation strategies to deal with climate change.

Spatial information is held by many SIDS government agencies, and is used to help in the attainment of diverse government objectives [Mercera et al 2007]. Typically, however, governments are structured into hierarchical sectors, each responsible for some aspect of a jurisdiction's daily life (e.g. defense, justice, agriculture, environment etc.) and further divided into levels that are responsible for the setting of goals and policies, strategic planning, or operational implementation. Sectors may also be divided into functional departments.

In many SIDS, obtaining all the information necessary to facilitate informed decision-making with regard to coastal spaces requires tedious visits to many agencies that do not explicitly collaborate in the sharing of information. Even with the desire to share information, barriers such as governance arrangements, access to appropriate technologies, data formats, privacy issues, varying information standards, policies etc. have to be overcome [Dawes 1996].

In coastal zones, threats (even without climate change) come from multiple natural and anthropogenic sources landward and seaward. Integrated Coastal Zone Management (ICZM) strategies are as a result of the recognition of this fact. ICZM seeks to solve coastal zone issues through the integration of multiple government- and other sectors via the integration of the mandated functions of various agencies. A lack of implemented collaborative, integrative, or cooperative governance models (such as ICZM) often mean that information needed to develop coastal communities' mitigation and adaptation strategies resides in dispersed sectoral or departmental databases without any easy data sharing mechanism to support informed and holistic decision making. This is a governance problem [Sutherland 2005].

### **What is Governance?**

Governance itself is not new, but the science of governance is a fairly new discipline [Paquet 2000a]. According to Paquet [1999] there currently exists no agreement on a lexicon or vocabulary for formulating questions in relation to governance studies. This currently remains true. Consequently, many persons and organizations have tendered various, if sometimes overlapping, definitions. These definitions may be general in perspective, specific to government, society or objective, or made from a national or international perspective. Some of these definitions of governance are as follows:

- “The science of effective coordination in the steering of an organization, where knowledge and power are distributed” [Paquet 2000a and 2000b].
- The process whereby a society, polity, economy, or organization (private, public or civic) steers itself as it pursues its objectives [Rosell 1999].
- The process of decision-making with a view to managing change in order to “promote people's wellbeing” [Kyriakou and Di Pietro 2000].
- “The set of processes and traditions which determine how a society steers itself thereby according citizens a voice on issues of public concern, and how decisions are made on these issues” [Meltzer 2000].

- “The exercise of economic, political and administrative authority to manage a country’s affairs at all levels. It comprises the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences” [Manning (quoting the UNDP) 1998].
- “The guidance of national systems shared by ensembles of organizations rooted in the three sectors (economy, polity, civil society and community)” [deBlis and Paquet 1998].
- The means by which local, regional, national and international communities organize themselves and subsequently respond to issues of interest to members of those communities. It involves leadership on the part of government and the use of policy and programs to control and influence activities within communities [Manning 1998].
- Governance is the management of stakeholder relationships as they relate to their current and possible future social, economic, political and physical environments through the dictates of value systems [Sutherland 2005].

Apart from the various perspectives, a number of other things essential to governance are alluded to in the governance literature referenced above. Firstly, governance is all encompassing, touching virtually every area of human existence. Secondly, governance can take many forms, and takes place on many levels [Masson and Farlinger, 2000]. Each form of governance makes use of facilitative processes, mechanisms and systems to pursue goals. Thirdly, governance is about the provision of *direction* towards the achievement of objectives. The direction taken must take cognizance of the interests, rights, responsibilities, and differences among the stakeholders in governance communities [Manning 1998; deBlis and Paquet 1998; Sutherland 2005]. Finally, governance requires information continually feeding into knowledge of the jurisdictional *status quo*<sup>1</sup> and *future possible*<sup>2</sup>, since both the *status quo* and the *future possible* are subject to changes in terms of time, nature, society, the economy, the polity, and science and technology developments [Kyriakou and Di Pietro 2000].

## Forms of Governance

Traditional governance models have been based on a management science approach where the premise is that leadership of organizations (public, private or civic) is strong, and have good understanding of their environment (future trends, rules of the game, and the organization's goals) [Paquet 1999]. As such, the leaders provide direction for the groups they represent.

A hierarchical governance model is one such example. This form of governance, usually practiced by the state or some other governing authority, is usually enacted through policies, laws and regulations [Hoogsteden, Robertson and Benwell 1999; Paquet 1999; Savoie 1999]. This hierarchical model assumes a top-down approach is always best, whereas subsidiarity (i.e., the principle based on the assumption that individuals are better able to take care of themselves than any third party) might alternatively provide

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<sup>1</sup> The *status quo* of a jurisdiction comprises the current elements it's economic, social and political realities.

<sup>2</sup> The *future possible* of a jurisdiction is comprised of possible (and probable) realizations of achievable economic, social and political goals.

a better solution in some circumstances. Subsidiarity would support, for instance, the devolution of responsibilities to citizens by provincial/state authority (or to states/provinces by federal authority) as much as possible unless they were unable to manage [Paquet 2000a; Rosell 1999; Chiarelli, Dammeyer and Munter 1999].

The management science approach also assumes that organizations are operating in "a world of deterministic, well-behaved mechanical processes" [Paquet 1999]. However, life is full of paradoxes, contradictions, and surprises [Handy, 1996], so the management science approach has been inadequate, continually faced with situations that are ill-defined, uncertain, unstable, or unreliable [Paquet 1999]. As a result of the failure of the management science approach to governance to adequately handle all the complexities of life, other models have been proffered. These models are based on cooperation, coordination, collaboration, integration or other principles of shared responsibilities. The similarities or overlaps in the definitions of these models again underscore the absence of general principles to help guide in the design of good governance structures. Among these models are:

- Distributed governance which is embedded in a set of organizations and institutions built on market forces, the state, and civil society, and which deprives the leadership of the exercise of monopoly in the direction of the organization. [Paquet 1999; Meltzer 2000];
- Co-governance (e.g. practiced on a state-civic level) that comprises mutual organization by two or more involved groups [Charette and Graham 1999; Hoogsteden, Robertson and Benwell 1999; Paquet 2000a, 2000b; Payoyo 1994];
- Triangle-wide governance that consists of the integration of the three families of institutions (economy, society and polity) into a sort of neural network [Paquet 1999; Meltzer 2000];
- Transversal and meso-innovation systems of governance that employ "consensus and inducement-oriented systems to achieve coordination among network players" [Paquet 1999];
- Renaissance-style independency forms of governance that utilize informal terms, and the devolution and decentralization of decision-making to achieve its objectives [Paquet 2000c].

These models are by nature subversive to those organizational structures based on traditional models of governance. They challenge the view that an "omnipresent person or group has monopoly on useful knowledge and can govern top down" [Paquet 2000b].

### **Geomatics Technologies and Holistic Governance**

Geomatics technologies, e.g., Geographic Information Systems (GIS), are used by many countries, including SIDS to manage spatial information such as wind direction and force, waves, currents, storm tracks, sea levels, sea temperature, and other spatial phenomena that affect coastal communities. These spatial datasets may even be used to address climate change concerns [Mercera et al 2007]. However, the datasets are typically managed by organizations/agencies to meet their own objectives without explicit consultation or reference to other organizations/agencies that may have an interest in the same geographic areas of concern.

Holistic governance requires the sharing of information among stakeholders through collaboration, cooperation or integration [Paquet 2000a and 2000b]. For example, a Ministry of Agriculture may be concerned with property rights and agricultural production; a Ministry of Planning may be concerned with land use and community development; a Ministry of Commerce may be concerned with community economic development and sustainability; a Survey Department may be concerned with juridical cadastral information; and a Tax Department may be concerned with fiscal cadastral information. Each ministry or department might duplicate, for example, the collection and management of property rights data for its own use. Holistic governance can, through collaboration, cooperation or integration produce significant savings in terms of time and money spent on the management of common spatial information used by all.

However, there are some technological barriers to the sharing of information, including spatial information [Dawes 1996]. These barriers include incompatible or different data formats, datum and projection differences, and varying information standards in relation to database design and construction. Administrative barriers that affect spatial information sharing include database information privacy issues, and data management issues related to maintaining databases in forms conducive to pursuing organizational mandates. This is especially true where, in the pursuit of their own mandates, organizations/agencies of the same government historically invested in a variety of information systems without reference to other government organizations/agencies. These situations are common even in developed countries, but especially in SIDS and other developing countries where individual organizations pursued and attracted development funding from a variety of International Funding Institutions that do not communicate with one another when implementing projects in the same jurisdictions. These barriers can be overcome by certain geomatics technologies (described below) if other barriers, such as the political will to share information and the implementation of internet access (among others), can also be overcome.

The geomatics technologies referred to in this paper are internet-based (i.e., internet mapping technologies) and can provide a common user interface that incorporates spatial information sourced dynamically from geographically dispersed organizations that cater to various socioeconomic sectors [Sutherland, Nichols, and Wilkins 2002]. Examples of these technologies include CARIS Spatial Fusion and Arc Server (formerly known as ArcIMS) among others. These internet mapping technologies provide user interfaces that allow participating stakeholders, who agree to supply spatial information for inclusion in this type of application, to maintain their own spatial data at their own sites, and in their own data formats, allowing datum and projection transformations to be done on the fly while dynamically incorporating all the various datasets in one interface for presentation and query [Figure 1]. Additionally, stakeholders' database privacy concerns are facilitated by the ability to specify which portions of their databases may be made available for viewing in the common interface.

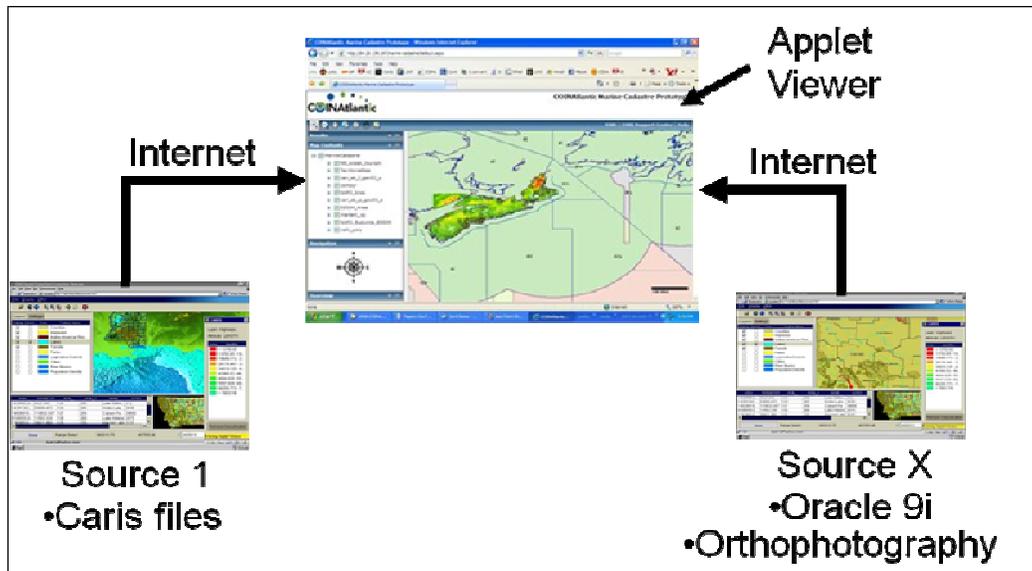


Figure 1 – Example of Data Sharing via Web Mapping Interface

## Conclusion

Geomatics technologies can provide frameworks for sharing spatial and thematic information in a manner that facilitates cooperative, collaborative, or integrative governance. In turn this type of information support for holistic governance can be more efficient in aiding coastal communities in SIDS to mitigate or adapt to climate change threats.

The technologies described in this paper, especially ArcServer, are already part of spatial information management software installed in government- and other agencies in many SIDS. They are mainly used to support narrow mandates without explicit data sharing among agency stakeholders with interests in the same spatial extents. However, the various sectoral organizations in these SIDS that may agree to share information within a holistic governance framework can use these technologies and still pursue their mandated objectives with minimal organizational changes, especially where organizational change is a barrier to the implementation of holistic governance frameworks. The collaborative, cooperative or integrative decision-making support needed for such issues as climate change mitigation and adaptation will be facilitated by the aggregated information. In this manner holistic governance may be supported by geomatics technologies.

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