Strengthening Geospatial Data Ecosystems in the Caribbean: A Role for Academic Institutions

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Abstract: *Developing and implementing strategies to achieve, monitor, and measure progress toward the Sustainable Development Goals (SDGs) requires robust and functional national geospatial data ecosystems (NGDE). However, most countries in the Caribbean region are yet to achieve a high level of geospatial data ecosystem readiness. Several factors account for this situation including a lack of resources, infrastructure, policies, and standards, and an absence of clear and consistent leadership. In this study, we examined the state of readiness of geospatial data ecosystems in the region, identify the major challenges in achieving functional systems, and propose intervention strategies that can be developed and successfully implemented with indigenous support from academic institutions such as The University of the West Indies.*

Keywords: *Geospatial Data Ecosystems, Caribbean Data Ecosystem Readiness*

1. Introduction

Successful development, implementation, monitoring, and measurement of the 232 indicators for the Sustainable Development Goals (SDGs) are contingent on the availability of current and reliable data through a functional data ecosystem. The United Nations (UN), through the Partnership in Statistics for Development in the 21st Century, initiated the "Informing a Data Revolution" (IDR) project in 2014 to ensure that countries are able to develop such data ecosystems (PARIS21, 2018). An ecosystem is a system or group of interconnect elements formed by the interaction of a community of organisms with their environment (Dictionary.com, 2018). A data ecosystem is focused on the data and related support systems and stakeholders that foster interaction among the various elements of the environment (Heimstadt, Saunderson, and Heath, 2014).

As part of an effort to improve the use of national geospatial data ecosystems (NGDEs) in the Caribbean as a means of developing and implementing strategies in achieving and monitoring the Sustainable Development Goals, the Government of Mexico (GOM), through the United Nations Global Geographic Information Management Americas (UN-GGIM Americas), partnered with the Association of Caribbean States (ACS) and The University of the West Indies (UWI) to improve the NGDEs in the region. The project leaders successfully secured funding by arguing that more than ninety percent of all data needed to achieve the SDGs is geospatial in nature. This allows the project to focus on NGDEs, stay within the scope of the UNGGIM Americas, and significantly benefit the region. The first step of the project was to conduct an assessment of NGDE readiness to identify challenges and opportunities. The results would be used to identify specific needs in terms of human capacity development, infrastructural improvements, and data collection support, as well as to develop strategies for sustainability of NDGEs (UNGGIM Americas, 2016). Sometimes, sustainability failures can occur when there are design-actuality gaps (Heeks, 2002) caused by a lack of contextual understanding. Therefore, it was decided that the UWI, as an indigenous regional institution, would be involved in the design and execution of the project (Iaaly et al., 2016). In 2016, an agreement was formalised among the partners for the UWI to provide technical support to the regional NDGEs on a long-term basis.

This paper reports on research completed on the adaptation and the application of the Data Ecosystem Readiness Assessment Framework (DERAF) developed by the Independent Expert Advisory Group to the United Nations General Secretary (IEAG, 2014) to undertake an assessment of NGDE readiness for Caribbean countries. Based on the results of the NGDE readiness assessment, we propose strategies that can be developed and implemented with support from academic institutions and other international and regional stakeholders toward addressing current geospatial data ecosystem challenges facing the Caribbean.

2. Geospatial Data Ecosystem Readiness Assessment Frameworks

Several frameworks exist for assessing different aspects of data ecosystems readiness. These include, but are not limited to: the Open Data Barometer (ODB, 2016); the Open Data Readiness Assessment (ODRA) (World Bank 2018); various indices developed by the International Telecommunications Union to assess ICT development (ITU, 2017); the Global Open Data Index (Open Knowledge International 2018); the UN E-Government Survey (UN, 2014); the Open Data Monitor (EU, 2018); the Open Data Certificate (ODI, 2018); the Open Government Data Framework developed by the OECD (2018); the Open Data 500 for assessing the value of open data in the private sector (Govlab, 2018); and the Networked Readiness Index (WEF, 2015). However, these assessment frameworks are by design, focused on a few specific aspects of open data ecosystems rather than providing comprehensive assessment rubrics (Welle Donker and Loenen, 2017).

A spatial data infrastructure (SDI) is defined as a framework of technologies, policies, and institutional arrangements that facilitate the creation, exchange, and use of geospatial data and related information resources across an information-sharing community (OMB, 2002). Several assessment frameworks specifically focused on SDIs were developed and applied by many researchers (for example, Fernández et al. (2005), Steudler et al. (2008), Rajabifard et al. (2006), Fernández and Crompvoets (2007), and Holland, Rajabifard and Williamson (2010)). The major limitation of these frameworks is their focus on the assessment of well-established SDIs (Makanga and Smith, 2010). Most Caribbean countries do not have well-established SDIs and therefore, these frameworks are not suitable for assessing NGDEs in this context.

In 2016, a framework for assessing national data ecosystems (DERAF) was developed by the United Nations Development Programme (UNDP, 2016) to assess the readiness of national data ecosystems. The DERAF was used in eight countries including several developing countries: Trinidad and Tobago (Ramlal, 2016), Bangladesh, Moldova, Senegal, Mongolia, and Swaziland (UNDP, 2017). All aspects of the data ecosystem were assessed in a single framework providing an overall strategy to assess the readiness and functionality of national data ecosystems.

3. Adapting the Data Ecosystem Readiness Assessment Framework for NGDEs

The UNDP data ecosystem readiness assessment framework (DERAF) is guided by nine key principles (IEAG, 2014). These principles underscore the need for the provision of current, detailed and reliable data to support timely decision-making and policy formulation whilst protecting the privacy and human rights of individuals, and the national security of countries (see Table 1).

Five major components (namely, Infrastructure, Capacity, Stakeholders, Processes, and Legislation) are fundamental to the success of a data ecosystem (Figure 1). Each component is composed of several sub-components that must work in concert to allow for the provision of current and reliable data (IEAG, 2014).

Data ecosystems function through interactions amongst stakeholders. Stakeholders may be local, regional and international individuals, and organisations and are categorised into: data producers or those

Table 1. Key principles of the Data Ecosystem Readiness Assessment Framework

Key Principle	Description
Data Quality and Integrity	The quality and reliability of data significantly impact the decision-making process. The quality determines fitness for purpose and therefore the level of trust that can be placed on the data. The integrity of the data can be assessed based on the available metadata.
Disaggregated or Detailed Data	The greater the detail of the data, the more localised is the applicability of the data. While recognising the privacy of individuals and national security issues of a country, it is important to provide disaggregated data so that policy and targeted interventions are applied in addressing the challenges at hand.
Current or Timeliness of Data	Technology has made it possible to generate data quickly and more efficiently than ever before. Data needs to be made available in the shortest possible timeframe that affords timely decision-making, planning, and policy formulation.
Openness and Transparency	Data is a national asset in a country and should be shared in an open and transparent way; so that all decisions would be based on the most current and reliable data that is available to these organisations.
Usability of Data	All data that are to be shared must be presented in easy-to-understand formats and with interfaces that allow users to easily access and use the data that is made available.
Data Protection and Privacy	Policies, regulations, and legislation are needed to ensure personal privacy and national security protection while still ensuring that the public good is served
Data Governance and Independence	Data producers need to be well resourced and have the autonomy to collect, analyse, and disseminate data without political interference and influence. The data produced should meet both national and international standards and engender public confidence and satisfaction.
Resources and Capacity	The resources and capacity need to be made available to support data producing organisations to fulfil their mandates. This requires data management systems, information technology infrastructure, human capacity, and legal infrastructure to support this effort.
Data Rights	Human rights need to be at the centre of all considerations with respect to data usage. Measures are needed to minimise the misuse of data to cause harm to individuals. Protection through enacted legislation and appropriate policies and processes is required.

Source: Abstracted from IEAG (2014)
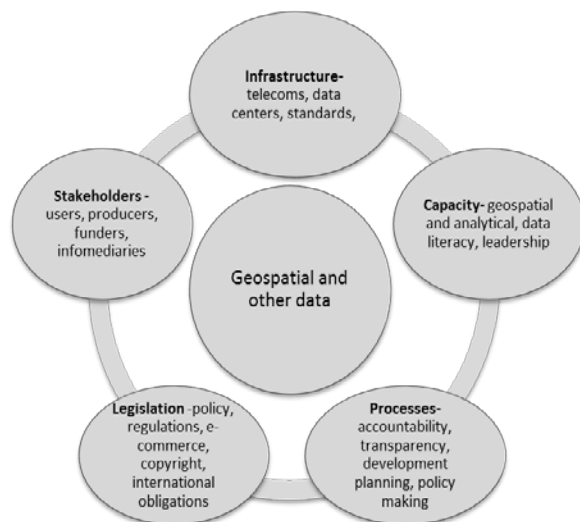
Figure 1. Components of a Geospatial Data Ecosystem
Source: Adapted from UNDP (2016)

involved in data conversion, collection, acquisition, and pre-processing; data users or those involved in data manipulation, analysis and the use of data to support decision-making processes across a number of applications; data "infomediaries," or those who use raw data to generate understandable information that may be disseminated for use by all levels of stakeholders; and data funders, or those involved in paying for, or providing support for, the collection of data (UNDP, 2016).

Fundamental to the functioning of any data ecosystem is the efficient interaction among stakeholders. For example, data producers need to ensure that they meet the needs of data users and infomediaries. Data producers must also be able to convince data funders to provide appropriate levels of resources to support their organisations. The interactions among Caribbean stakeholders are examined in a subsequent section.

A functional national data ecosystem requires capacity in terms of skilled personnel to effectively support the activities of all stakeholders including access to various data products, analytical services, and technical support. Geospatial data organisations must be adequately resourced with funding, human capacity, and ICT infrastructure for data acquisition, processing, analysis, and visualisation and empowered through legislation and policies to interact and participate in the data ecosystem. Additionally, the general public needs to be data literate to consume the geospatial data products as well as have access to the data ecosystem. Data champions are needed to ensure that financial and other support is available to data organisations. Data champions include politicians, professional organisations, heads of organisations, and other individuals who are able to lobby support for data organisations.

In the Caribbean, there is a need for additional resources to sustain existing capacity of experts in key agencies responsible for supporting the data ecosystem (UNDP, 2016, UNGGIM Americas, 2016). Competitive compensation packages, access to high quality academic programmes, local data professional bodies, service providers, and continuous professional development programmes are needed to ensure that professionals stay in the region (UNDP, 2016).

Clear and well-documented processes are needed for the creation, collection, conversion and dissemination of spatial data. In addition, mechanisms are required to receive and respond to feedback and to ensure accountability and transparency throughout the data ecosystem. Furthermore, mechanisms to allow for sharing and data and information access are limited in the Caribbean (UNGGIM Americas, 2016) and are needed to effectively support decision-making (Taylor 2011, McNaughton 2017).

Processes to clearly identify mechanisms for regional, national and public sharing and access are enabled through appropriate regulations, legislation, and policies (UNDP, 2016) and are crucial to the success of a data ecosystem. These mechanisms determine what actions are allowable, under what conditions, and by whom. In addition, the actions that are prohibited are also included in these mechanisms. Many countries have enacted legislation relevant to the implementation of geospatial data ecosystems. These include the sharing, access, and use of data in diverse ways, laws that address freedom of information, data protection, copyright, privacy, national security, and e-commerce (Taylor, 2011).

Furthermore, many Caribbean countries are signatories to international and regional agreements and resolutions such as the UN Fundamental Principles of Statistics (UNSD, 2018), the 2030 Agenda for Sustainable Development (United Nations, 2018), the UN Resolution on the Global Geodetic Reference Frame (UNGGIM, 2018), and the Treaty of Chaguaramas and subsequent agreements (CARICOM, 2018), with obligations to support the data ecosystem. Policies are often used to provide avenues for more efficient operations. For example, data sharing and pricing policies are needed to facilitate interactions amongst stakeholders (UNDP, 2016).

Robust and reliable Information and Communication Technology (ICT) infrastructure is needed to support a functional data ecosystem. For example, telecommunications networks are essential in all the activities associated with the data ecosystem, including real time collection, exchange, and consumption of digital data. Associated with the advent of these technologies is the generation of large amounts of data that must be stored and analysed for use, as well as access to data centres and supercomputing infrastructure.

Software needed to execute diverse analyses, and visualisations (such as tables, maps, charts, reports, websites) are needed to provide the results in forms that are usable by all levels of stakeholders in order to ensure proper access. The use of data requires the provision and adoption of several data standards including: interoperability standards, metadata, quality, and data definitions standards (UNDP, 2016).

4. Methodology

The readiness assessment of the NGDE among Caribbean countries is based on data obtained via an online survey administered to twenty-four heads of organisations and seventeen other members of staff of national organisations as part of the Caribbean project described above. The online survey contained questions that covered all aspects of the NGDE. For example, respondents were asked about existing legislation, regulations, and geospatial data sharing policies as part of the Legislation component of the NGDE. Respondents were required to rate the level of readiness on a scale of 1 to 5 with respect to each sub-component of the NGDE. The agencies targeted in each country are listed in Table 2.

Individual consultations were conducted to address gaps in the data received from the survey. Data obtained through interviews conducted as part of another study with heads of organisations from countries of the Organisation of Eastern Caribbean States (OECS), were also used to supplement the survey (Mohammed, 2016). A document analysis based on existing legislation, regulations, government reports, completed studies, and assessments from regional and international organisations, published material, and Internet resources was completed and used to triangulate the information obtained from the online survey and interviews. Gaps and challenges were also identified. Where possible, findings were verified through further interactions with stakeholders.

5. Results

The NGDEs of fourteen Caribbean countries were assessed. While several of these countries have introduced and used GIS to some extent over the last three decades, and many have initiated the development and implementation of SDIs, only The Bahamas and Jamaica were successful in achieving functional systems. SDI initiatives in Belize, Antigua and Barbuda, Dominica, Grenada, Guyana, Haiti, Suriname, and Trinidad and Tobago have had limited success, with only some components being achieved (UNGGIM Americas, 2014, 2015; Ramlal et al., 2013).

Over the last three decades years, many organisations have contributed to the development of the NGDEs in Caribbean countries; however, these have had limited success. Consequently, efforts to improve NGDEs throughout the region are on-going. At the international level, the United Nations Committee of Experts on Global Geographic Information Management (UNGGIM) was set up in 2011 to provide a forum for dialogue and coordination among member states, and to promote global frameworks, principles, policies, and standards for geospatial data and services.

The UNGGIM established several regional groups including the UNGGIM Americas, with Caribbean countries being part of this group. However, delegates

Table 2. Stakeholders consulted in each country

Country	Organisation	No of Responses
Antigua and Barbuda	Surveys and Mapping Division Department of Environment	3
The Bahamas	Bahamas National GIS Centre	2
Barbados	Lands and Surveys Department	2
Belize	Lands and Surveys Department	2
Dominica	Lands and Surveys Division Planning Division	4
Grenada	Lands and Surveys Department Planning Division	2
Guyana	Lands and Surveys Commission Ministry of Natural Resources and Environment	3
Haiti	Centre National de l'Information Geo-Spatiale	2
Jamaica	National Spatial Data Management Division National Land Agency	4
St. Kitts & Nevis	Lands and Surveys Division Department of Environment	2
St. Lucia	Ministry of Physical Development Surveying and Mapping	4
St. Vincent and Grenadines	Lands and Surveys Department Ministry of Housing	3
Suriname	Management Institute for Land Information and Registration System	3
Trinidad and Tobago	Surveying and Mapping Division Town and Country Planning Division Land Management Division	5

from Caribbean countries were not able to participate because of a lack of funding and support from governments. Financial support from the governments of Mexico and Chile has now made it possible for Caribbean delegates to attend meetings and workshops (UNGGIM Americas, 2018). In addition, the funding also provides for the development of a platform for strengthening spatial data infrastructures in Association of Caribbean States (ACS) countries, the establishment of the Caribbean Platform for Territorial Information for Disaster Prevention (PITCA) in collaboration with CDEMA (2018), and technical capacity building in collaboration with the UWI (UNGGIM Americas, 2016).

Several other recent initiatives by international organisations include: capacity building and establishing geospatial data portals using Geonode supported by the World Bank Group (The World Bank, 2018a), the CHARIM project funded by the ACP-EU Disaster Risk Reduction Programme (CHARIM, 2018), the Climate Change GIS project funded by the United Nations Population Fund (GORTT, 2018), and land registration systems development projects (USAID, 2018).

Previous initiatives by regional organisations include efforts by CARICOM to establish a regional spatial data infrastructure (Wall, 2009), establishing GIS in member countries by the OECS (Yaw Ching, 2016), and the launch of the GeoSUR project in 2007 to provide a geospatial clearinghouse for data for Latin American and Caribbean countries by the Development Bank of Latin American in conjunction with the Pan American Institute for Geography and History (PAIGH) (GeoSUR, 2018). Other efforts in the region include numerous projects completed by agencies established by the CARICOM (https://www.caricom.org), several units of the UWI including Mona Geoinformatics (http://www2.monagis.com/), the Caribbean Open Data Institute (http://caribbeanopeninstitute.org), the Centre for Resources Management and Environmental Studies (http://www.cavehill.uwi.edu/cermes/home.aspx), the Centre for Geospatial Studies (https://sta.uwi.edu/eng/ei/Services.asp) and the Geospatial Information Research and Innovation (GIRI) Group (http://uwi.maps.arcgis.com/home/index.html). Several national and regional non-governmental organisations exist in the region. One such organisation that has done significant GIS work is the Caribbean Natural Resource Institute (CANARI) (https://www.canari.org). The only professional organisation at the regional level is the URISA Caribbean Chapter. It has been involved in hosting conferences and workshops since 2001 (http://www.urisa.org/chapters/caribbean-chapter/).

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hosting conferences and workshops since 2001. Reports focused on geospatial issues for specific countries include Jaggernauth et al. (2000), Ramlal et al. (2013, 2014), Blake, (2009), and Raghoebar (2009).

The results of the NGDE readiness assessment are summarised in Table 3. A simple readiness scoring system, similar to one used by Delgado Fernández and Crompvoets (2008) was used for the online survey and includes: (1) little to no development work done, (2) very limited development achieved to date, (3) limited development achieved, (4) good development achieved, and (5) very good development achieved. A total of twenty variables were used in the assessment.

The geospatial data ecosystems of the Bahamas (66) and Jamaica (66) are the most ready, while those of Dominica, St. Lucia, and St Vincent and the Grenadines (34) are least ready. However, it is noted that overall, with an average score of 45, the data ecosystems in most countries in the Caribbean are not well developed and are unable to adequately support the countries in achieving their objectives, which include, but are not limited to, the SDGs. Countries are better prepared in terms of data production, data funding, and meeting international obligations, but are least prepared in terms of availablitity of informediaries, analytics, and capacity for policy making. Similar conclusions were made in several other studies (UNGGIM Americas, 2014, Ramlal, 2016, The World Bank, 2013, 2014, McNaughton, 2017, Delgado Fernandez and Crompvoets, 2008). Detailed discussions on each assessment component are presented below.

5.1 Data Stakeholder

While some countries such as Jamaica, Haiti, and Trinidad and Tobago show good progress in the production of geospatial data, all of the other countries made limited or very little progress (average score of 2.9 out of 5) in the production of such data sets. Several factors impacted data production including: the lack of a modern regional geodetic referencing framework; a general lack of resources to convert, collect, and acquire data, including financial, human, and technological resources; limited funding available to collect data sets at regular intervals coupled with the high cost of data acquisition; the lack of demand for, and capacity to use, available data; and a general perception that geospatial data is not important.

Overall, except for Jamaica, and to a lesser extent Antigua and Barbuda, there has been very limited development of data used and data users in the region. Several factors account for this include: a lack of knowledge of what geospatial data are available from data producers; a lack of metadata for data discovery; difficulties in accessing data because of long delays from data producers in responding to requests; the absence of online data clearing houses for data access; the absence of open access to data; and a lack of literacy and skills in

Table 3. Results of Geospatial Data Ecosystem Assessment for Caribbean Countries

Country	Total(100)	Stakeholders				Capacities				Processes				Policies				Infrastructure			
		Data Producers	Data Users	Data Funders	Infomediaries	Geospatial	Analytical	Data Literacy	Leadership	Monitoring	Development Plan	Policy Making	Knowledge Sharing	Legislation	Data Sharing Policy	E-Commerce	Int'l Obligations	Telecom	Analytics	Data Standards	Interoperability std.
Antigua & Barbuda	44	3	3	3	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2
Bahamas	**66**	3	2	4	2	2	2	3	4	3	3	4	4	4	4	4	4	4	2	4	4
Barbados	38	2	2	2	3	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2
Belize	41	3	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	1	2	2
Dominica	28	2	1	2	1	2	1	1	1	1	1	1	1	2	1	1	3	2	1	1	2
Grenada	40	3	2	3	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2
Guyana	52	3	2	3	2	2	2	3	3	2	2	3	3	3	3	3	3	4	2	2	2
Haiti	46	4	2	3	2	2	2	2	3	2	2	3	2	2	2	2	3	2	2	2	2
Jamaica	**66**	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	4	3
St. Kitts & Nevis	46	3	2	4	2	2	2	3	3	2	2	2	1	2	2	2	3	3	2	2	2
St. Lucia	34	2	2	2	1	2	1	2	2	1	1	2	1	2	2	2	2	2	1	2	2
St. Vincent & Grenadines	34	3	2	2	1	2	1	2	2	2	1	1	1	2	2	2	2	2	1	1	2
Suriname	48	2	2	2	2	2	2	3	2	2	2	3	3	3	3	3	2	3	2	3	2
Trinidad & Tobago	44	4	2	3	2	2	1	2	2	2	2	2	2	2	2	3	2	3	2	2	2
Average	45	2.9	2.1	2.8	1.9	2.1	1.8	2.4	2.4	2	1.9	2.3	2	2.3	2.1	2.4	2.6	2.6	1.7	2.2	2.2
Key	*5–Very Good, 4–Good, –Limited, 2–Very Limited, 1–Little to no work done*																				

using data.

The Bahamas, Jamaica, and St. Kitts and Nevis are sufficiently funded to support data acquisition. However, in many countries, funding for data acquisition is negatively affected by a lack of systematic and coordinated strategies for funding data projects, a lack of oversight and priority-setting organisations, and data-producing organisations having little or no control of budgets and income.

With the exception of Barbados and Jamaica, there is very limited, or no capacity for, the provision of value-added data services in the countries surveyed. The overall number of Infomediaries available through organisations, and trained specialists with such capabilities is extremely small in the region as a whole. In addition, there seems to be a perceived lack of need for such services by data-producers and policy-makers.

5.2 Capacity

The geospatial capacity in the region continues to be very limited (UNGGIM Americas, 2014, Delgado Fernandez and Crompvoets, 2008). There is a general lack of technical and human capacities to collect, conduct analyses, and disseminate geospatial data in all the countries surveyed, with the exception of Jamaica. An important consideration is the lack of approved, public service positions for geospatial specialists. This is compounded by uncompetitive compensation packages and employment conditions that are not conducive to

attracting the best candidates to government organisations in most of these countries. Additionally, there is a general absence of analytical capacity in many government organisations in the region. There are very few trained personnel to fill regional needs. The second lowest score (1.8) was recorded in this area of assessment. Data literacy also appears to be a major challenge in most countries.

While leadership is reported as good only in the Bahamas, other countries such as Guyana, Haiti, Jamaica, St. Kitts and Nevis, reported limited leadership, and the other nine reported very limited leadership. Existing institutional arrangements of organisations within the Government bureaucratic structures seem to be a cause of frustration. The public service regulations of many countries seem to work against stable leadership in data-producing organisations. In addition, in many instances, there seem to be very few data champions at the highest levels of government.

5.3 Processes

The processes for monitoring and evaluating NGDEs are, at best, limited (average: 2). Several factors may account for this, including the absence of appropriate systems, standards, policies, regulations, and legislation to effectively monitor processes in government organisations. Additionally, there is limited use of quality management systems and inadequate systems to provide for accountability and transparency. The absence

of single, national organisations in each country, with the authority and mechanisms to coordinate data ecosystem development planning with respect to geospatial data, is also a challenge.

There is a lack of clear and well-articulated data policy formulation and adoption mechanisms that is exacerbated by a lack of capacity, resources, perceived authority, and motivation for policy-making by geospatial agencies in most countries. While some countries have had limited success with knowledge sharing, many countries do not have formal mechanisms to achieve this. In fact, there seems to be a lack of perceived need by some organisations, with limited resources allocated to support such activities. As a result, there is very little documentation and institutional memory, and therefore, greater reliance on gatekeepers.

5.4 Policies

Except for The Bahamas, no legislation exists in any of the other countries requiring government organisations to disseminate and share geospatial data at the national level in order to facilitate collaboration, coordinate efforts, and develop policies and standards. In countries where multiple data-producers exist, some duplication of efforts, resources, and authority may exist. Similarly, except for The Bahamas, most countries do not have national geospatial data-sharing policies (Taylor, 2011). Another challenge for many countries is that existing policies are inconsistent across government organisations and may be inconsistent with international obligations such as open government partnership and open data initiatives. Most countries have limited or very limited e-commerce policies. Some countries have enacted legislation to support these activities, while others have not done so to date. The level of success in meeting international obligations in the provision of geospatial data and information varies widely amongst the countries surveyed.

5.5 Infrastructure

Telecommunications services to support NDGEs are not equally available and affordable to all stakeholders across the region. While the services were considered good in The Bahamas, Guyana and Jamaica, all the other countries reported limited or very limited levels of service in this component. In addition, except for The Bahamas and Jamaica, other countries have not developed national data centres. In some instances, countries such as Trinidad and Tobago, where data centres exist, have found that national data centres are very expensive to support and are often underutilised by most government organisations (Ramlal, 2016).

Overall, the analytical capacity of the region is very limited. In fact, the lowest score was recorded for this component of assessment. However, many stakeholders suggested that there is a perception within many government organisations that there is no need for such

specialised expertise. In addition, there is a lack of documented standards in many countries. A challenge in implementing such standards is the lack of analytical infrastructure and resources. There is also limited use of data standards including metadata standards, accuracy specifications, and interoperability standards in most countries in the region.

6. Discussion

There are major gaps and challenges in all components of the NGDEs in the Caribbean. However, these gaps are wider in some components: limited data availability, use and users, Infomediaries, and a lack of analytical capacity and infrastructure, very limited monitoring and development planning processes, limited knowledge sharing, and only a few existing data sharing policies and standards.

As part of an effort to support NGDE readiness in the Caribbean, we argue that an academic institution such as the UWI is an appropriate organisation to leverage resources for capacity development, research and other technical services (Iaaly et al., 2016). The UWI has physical presence in most of the Caribbean countries assessed here (www.uwi.edu), and has worked with many international, regional, national and governmental organisations, and many community-based and non-government organisations. It is therefore possible to build appropriate networks and support systems with diverse institutions to address many of the issues identified above. However, it is noted that there are inherent limitations with academic institutions with respect to the extent to which interventions are possible, even in conjunction with other stakeholders.

7. Geospatial Research and Innovation Centre

Given the lack of capacity in the region, many of the challenges and gaps reported in the assessment cannot be easily addressed without intervention and the provision of support to stakeholders, especially in the short term. It is therefore proposed that a regional Geospatial Research and Innovation Centre (GRIC) be established to work with stakeholders in closing gaps and mitigating existing challenges. It is envisaged that the GRIC will be composed of members from academic institutions, the geospatial industry, professional bodies, and organisations from across the region. The UWI, in collaboration with the ACS and CARICOM will provide leadership to the Centre. Initially, academics from different institutions can serve as researchers and innovators on a part-time basis. This can evolve to full-time engagement as the Centre matures.

As a formal organisation supported by major stakeholders, the GRIC would be able to coordinate efforts to secure funding from various national, regional, and international agencies to support research and development works for the Caribbean. This would allow the completion of preparatory work to establish

functional NGDEs and to sustain these systems with high-level support. The Centre could be responsible for coordinating the conduct of appropriate research and developing innovative solutions based on the specific needs of stakeholders. This would include working to develop new policies and legislation, processes, and standards and specifications. In addition, where capacity is lacking, it may be possible to deploy personnel to provide temporary high-level technical support when needed. This may be especially important in times of natural and other disasters. The Centre can work with other institutions on on-going research and development efforts from researchers across the region. These may include but are not limited to the following:

1) Development of Regional Geodetic Infrastructure to Support Geospatial Activities

As part of the Caribbean SDI project supported by the ACS and GOM, fourteen GPS CORS stations have been installed to ensure that all geospatial activities in the region are tied to an international reference framework. The data from these stations will be sent to a dedicated server housed at the UWI, St. Augustine Campus for processing and open online dissemination. Training and technical support will be provided to ensure that regional stakeholders are able to use the results. This particular initiative will ensure that all geospatial data are standardised to a single global referencing system. A regional standard needs to be developed to guide users.

2) Develop Affordable Rapid Geospatial Data Collection Methodologies

Further research needs to be conducted to develop affordable rapid geospatial data collection methodologies to support stakeholders in the region. Previous research includes the use of Unmanned Aerial Vehicles (UAV) (Hunte et al., 2016, Al-Tahir et al., 2011, Baldwin, 2017), satellite imagery (Gilbert, 2015, Helmer et al., 2008, Sonnemann et al., 2016), participatory mapping (De Graff and Ramlal, 2015, CANARI, 2018), PGIS (Baldwin, 2012; DeGraff and Baldwin, 2013; Baldwin et al., 2013, Baldwin and Oxenford, 2014), and crowd sourcing strategies (Haklay et al., 2014, GIRI, 2018). Other voluntary mapping approaches need to be evaluated to support low-cost and rapid mapping of Caribbean countries. These solutions are expected to support more-affordable and frequent data acquisition and maintenance exercises.

3) Creation of a Clearinghouse for Regional Geospatial Data

Open access to digital geospatial data sets is not common in the Caribbean. While some countries (St. Lucia, Dominica, Grenada, and St. Vincent and the Grenadines) have used Geonode and other countries (Jamaica, Trinidad and Tobago, and Suriname) have used other solutions such as ArcGIS (ESRI) online to share data,

most of these sites provide access static data. Only a few countries have set up national geospatial data clearinghouses that allow easy data access, avenues for contributing to the creation and maintenance of data sets, and therefore allow stakeholders to benefit from available data sets.

In order to address this challenge, technical support and access to computer resources are made available to data-producers in the region to allow the hosting of clearinghouses, data sets, and other relevant information. Strategies to facilitate the regular upload and maintenance of data sets in the clearinghouse need to be developed. In addition, further research needs to be conducted to identify the most appropriate strategies to develop and sustain national data clearinghouses in the Caribbean.

4) Programme Development for Capacity Building

Most Caribbean countries have limited numbers of well-trained geospatial personnel to support the many activities of NGDEs. A major challenge with training additional personnel is that many migrate or move into the private sector once further training is provided. At present, with the introduction of appropriate education technology solutions at most academic institutions, and the availability of appropriate ICT services to the region (CTU, 2017), it is now possible to develop and make available training modules for online delivery and access. See for example: Spatial Query Lab (2018), ESRI (2018), Geo-for-All (www.geoforall.org), UNIGIS (2018), and the Centre for Geographic Analysis (2018). Several Massive Open Online Courses (MOOC, 2018) and YouTube videos are also accessible as resources to support such efforts.

The availability of several open access software packages and digital data (GeoSur, 2018, GEO, 2018, www.data4sdg.com) for training purposes also contributes to greater affordability by stakeholders. However, online offerings of specialised and regionally-relevant modules to train technicians, specialists, analysts, and managers, need to be developed to meet the particular requirements of Caribbean countries. Agreements may be negotiated with local institutions in the respective countries to support efforts to facilitate the development and delivery of training to stakeholders. This initiative is expected to address several challenges, especially in capacity requirements, which in turn will lead to improvements amongst data stakeholders, change processes, inform policies, and support infrastructural development and maintenance.

5) Building Leadership Awareness and Capacity

The value and benefits of developing robust geospatial data ecosystems are quite significant (Oxera Consulting, 2013, Vershulst and Young, 2017, AlphaBeta, 2017) and are important for supporting efforts towards implementing and monitoring strategies for the

sustainable development of countries (UNGGIM, 2017). Specialised training modules, seminars, and high-level meetings and forums targeted to leaders of geospatial organisations and high-level government officials, need to be developed and delivered at national and regional levels, where possible. It may be argued that national political leaders are more likely to become data champions if they appreciate the benefits and value of NGDEs.

The GRIC can serve as a vehicle to secure assistance from organisations such as The World Bank (2018b), the UNGGIM Academic Network (http://unggim.academicnetwork.org), the Group for Earth Observation (GEO, 2018), the Open Source Geospatial Foundation, (OSGEO, 2018), and the Global Spatial Data Infrastructure Association (GSDI, 2018) to provide, where appropriate, financial or technical support for these initiatives.

While several of these organisations and programmes have existed for many years, there has limited effort to secure such support. This may be due to several factors, including a lack of awareness by stakeholders, a lack of adequate numbers of geospatial personnel to benefit from such support, and a perceived lack of importance by political leaders and managers. In addition, much of the funding received in the region is for short-term projects. Most interventions are therefore, not sustainable. Mechanisms to provide sustained and indigenous support through the GRIC may prove to be more successful (Heeks, 2002).

6) Geospatial Best Practices Clearinghouse

Knowledge sharing by geospatial practitioners and academics within and among Caribbean countries is very limited; therefore, the GRIC should develop a Clearinghouse to provide access to appropriate material and publications to all stakeholders. This material should include the latest developments in technology, standards, specifications, hardware, software, mobile applications, legislation, policies, and processes. Blogs, webinars, newsletters, and technical publications should be made available to Caribbean practitioners online. Support from other academic networks and professional organisations such as the UNGGIM Academic Network (http://unggim.academicnetwork.org), the Academic Network of the Americas (http://redacademica.org), URISA (http://www.urisa.org), and other organisations, would be sought in this regard.

8. Conclusions

Most Caribbean countries require assistance to improve the functional readiness of their NGDE to support the development, implementation and monitoring of strategies to achieve the SDGs and other national priorities. Several major challenges and gaps exist and require intervention from various internal and external stakeholders. The UWI, in collaboration with other

organisations, can play a significant role in influencing change by providing indigenous input to mount a coordinated effort to develop and deliver much-needed support and services to address many of these issues.

While such initiatives would reap real benefits, convincing organisations in the region to work together will require much effort. Academic institutions will benefit in diverse ways from the implementation of the initiatives discussed above. Improved functionality and awareness in the region would likely lead to cost-savings, increased employment of geospatial personnel, and greater demand for further training and professional development. It is necessary and feasible to address many of the issues plaguing NGDEs in the Caribbean using available indigenous talent and resources.

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