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Championing a Regional Spatial Data Infrastructure: Southern African Customs Union Case

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ABSTRACT

Context and background

Infusion of technologies such as Geographical Information Systems into organizations has in most cases been associated with the concept of championing. Geographical Information Systems when developed across countries and/or regions, are integrable to create Spatial Data Infrastructure (SDI). In the Southern African Customs Union (SACU) region, the concept of SDI at national level have been acknowledged and/or kick-started by each member country. The efforts by these countries in development of National SDIs are evaluated with the aim of advancing a Southern African Customs Union Regional Spatial Data Infrastructure. SACU was incepted in 1889 and has metamorphosed into a collaborative trade block of five Southern African countries. In the context of geospatial information, it is advanced that as a region, it has discoverable opportunities and organizational platform for developing and hosting Spatial Data Infrastructure. A consideration is made that spatial data is capable of strengthening operational, tactical and strategic endeavors of SACU by providing evidence-based support to decisions and policy making.

Goal and Objectives:

The objective being interrogated in this paper, is the discoverability of geospatial data and information systems in Southern African Customs Union that can be integrated with its trade data and championed into Regional Spatial Data Infrastructure.

Methodology:

Mixed method of both quantitative and qualitative was used. In qualitative form, documents, questionnaires, interviews and workshop attendance have been utilized to decipher the attitudes of various stakeholders within Southern African Customs Union towards a Regional Spatial Data Infrastructure Concept. In a quantitative form, discoverable data has been found then further processed in line with the goal and objectives stated above.

Results:

Results obtained have enabled an elementary geodatabase proposition and maps of the region with a number of macroeconomic indicators. Furthermore, a discussion has been done to advance a preliminary determination of sponsor and champion of Southern African Customs Union Regional Spatial Data Infrastructure.

Keywords

Geographic Information Systems, Spatial Data Infrastructures, Regional, Sponsor, Champion, Geospatial, Customs Union

1. INTRODUCTION

Literature proclaims SACU as an old union in the world made by countries with a lot of commonalities in terms of territoriality, trade and the overall social system (Landell-Mills, 1971; Mccarthy, 2003; Kirk and Stern, 2005; Bogetic and Fedderke 2006). SACU member countries are Botswana, Eswatini, Lesotho, Namibia and South Africa. Despite South Africa's dominance of SACU since its formation in 1889 and inception of the 1910 Agreement, the desire to move towards equitable sharing of customs revenue resources by SACU countries has for a long time been a central pillar associated with its existence (Kirk and Stern, 2005). The interest in this paper is not to look at the trade dynamics of the SACU per se, but to dissect the possibilities of utilizing geospatial information to enhance and drive policy and operations. The objective will be, to demonstrate that products and services that form the basis of trade in SACU are location related, therefore a consideration has to be made to use spatial information to improve and streamline responsibilities.

The paper looks into the objectives of SACU agreement of 2002 and infer a picture of geospatial data as viable resources with mission-critical systems and infrastructures capable in facilitating SACU mandate. SACU Agreement of 2002, emphasize things such as trans-border trade (highly geospatial by just doing basic data mapping and comparisons); fairness (based on scale of measure, it can be categorized and mapped for each country and associated regions and settlements); common practices in legislation, competition, investment and trade which effectively seeks to improve economic development, governance and environmental management for members (SACU, 2002). To put it in the context of this paper, it is considered innovative for SACU to proceed towards geospatial driven solutions, especially when one looks at the issue of sustainable environmental management, equity and fairness in trade and revenue sharing. In total area, SACU is a substantive geographical space, but in human demographic cycles, South Africa is way ahead of its four neighbours which on average commands populations just over a two (2) million people. The question that arises is, can SACU implement geospatial based solutions and decision support to understand the common conclusion that the SACU agreements are skewed in favour of South Africa (Landell-Mills, 1971; Mccarthy, 2003; Kirk and Stern, 2005)?

Another question is, can SACU leverage on its geospatial data on issues of risk as raised by Mlipha and Kalaba (2020)? In their argument Mlipha and Kalaba (2020) advanced a number of critical factors that can be solved better with the help of geospatial data. Key among the factors they talked about were the agricultural produce, trade routes and environmental aspects. All these can be better collated in spatial format for easy viewing, analysis and reporting. A question to answer is whether the member countries have geospatial data well configured to support SACU in such endeavours? The preliminary answer to the above question will be to evaluate spatial data within SACU countries and device ways to leveraging it. Spatial data in most countries is collected, processed and held primarily by National Mapping Agencies (NMAs) (Jakobsson, 2006; de Vries, Cromptvoets, Stoter, vandenBerghe, 2011; Duchêne, Baella, Brewer, Burghardt, Bittenfield, Gaffuri et al, 2014). However, as geospatial technologies advances, a list of organizations which handle geospatial data are increasing. The geospatial technologies include Global Positioning Systems (GPS), Remote Sensing Vehicles (RSV) and Geographical Information Systems (GIS)

which are capable of collecting and processing of vast amount of data (Baker, Battersby, Bednar, Bodzin, Kolvoord, Moore et al, 2015). GIS in particular allows for easy integration, processing, analysis and reporting of geographical and attribute data into a fully-fledged evidence-based machinery to support decision-making (Baker, Battersby, Bednar, Bodzin, Kolvoord, Moore et al, 2015).

It is prudent to study geospatial data collection, processing, use and systems within SACU countries as a pre-cursor to its integration with SACU mandate. Geospatial data relate to physical phenomena such as riverine systems, general climate, pastures, rangelands, forests, weather and geological formations. In addition, geospatial data relate to man created infrastructures such as human settlements, agricultural formations, utilities and roads within any economic platform of concern. From geospatial data, GISs of various sectors are created and these are indispensable to any consideration geared at alignment with SACU operations and policy direction. As geospatial data considerations are done, it is important to look at data sharing and exchange. In a professional sense, geospatial data sharing and exchange derivatives have largely been accepted to be better facilitated through Spatial Data Infrastructure (SDI) domains. SDI is when geospatial data is technologically built and enabled for seamless interconnection, accessibility, discoverability and retrievability within various levels of governance. GISs making an SDI need to be appropriately configured with standards and metadata for ease of integration. SDI had been regarded in the same light as infrastructures such as roads and utilities to emphasize the importance of interconnecting several GISs across local, national, regional and global entities (Rajabifard et al 1999; Rajabifard, Feeney, and Williamson, 2002; Béjar, Latre, Nogueras-Iso, Muro-Medrano, and Zarazaga-Soria, 2009). There are several GISs coupled with related SDI efforts that are traceable across these SACU countries (Sinvula et al, 2017; Makanga and Smit 2010; Mwangi et al 2016; Lance and de Vries, 2009). To come up with the concept of Regional SDI (RSDI), the approach by Rajabifard, Chan and Williamson (1999) as shown in **Figure 1** is found to be ideally helpful, with the SACU Secretariat as the central block. Hence, **Part B** of the model in **Figure 1** is found to be realistically applicable for SACU SDI consideration. In pursuit to this approach, a hierarchical model can be developed into a massive infrastructure to support several areas of decision-making scenarios and processes across SACU. According to Paixão, Nichols and Coleman (2008) when movements are made towards SDI efforts, a clear objective has to be followed to connect various users of geospatial information across governments, businesses, academia and the overall population. Furthermore, SDI addresses policies and organizational remits of all those involved by crystallizing into a geospatial solution that is not only fit for purpose, but that addresses multiuse and needs of many users and levels of governance (Rajabifard and Williamson, 2003; Rajabifard, Feeney and Williamson, 2003; Rajabifard, Feeney, and Williamson, 2002; Sinvula et al, 2017).

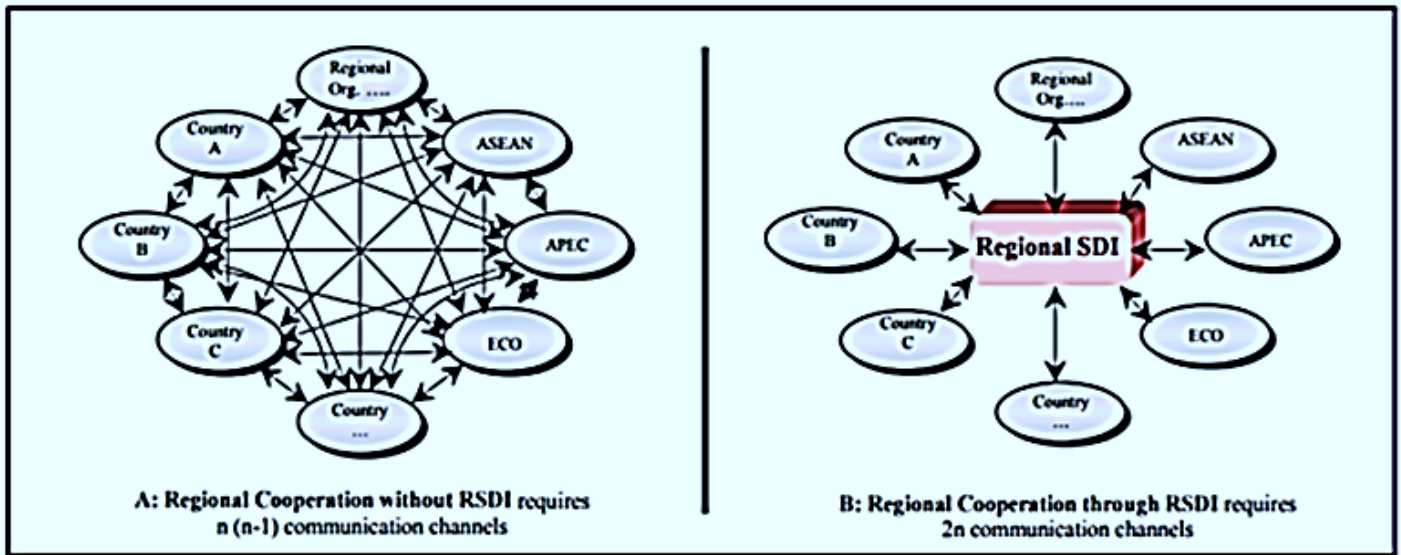


Figure 1: Regional SDI Cooperation Model. (Rajabifard, Chan and Williamson (1999))

Figure 1 has embedded levels of governance when viewed in a regional context. Among the levels of governance, SACU can be located and the concept of championing its SDI is advanced as a useful mechanism to kick start at that regional level. The idea of championing a technological intervention has been tackled by a number of scholars, and according to Beath (1991), information, material resources and political support are its main requirements. These three requirements are said to facilitate a champion much better in their facilitation and implementation of a new technology within an organization. Another interesting view point on championing, is presented by Lawless and Price (1992), who have advocated for agency as a central role of technology champions. It is considered useful to deploy the champion constructs in the context of kick-starting a RSDI that is in que with SACU developmental efforts. The championing advanced here is where those responsible for geospatial information of their member countries make it their business to innovatively kick-start the RSDI on the SACU platform.

This introduction has set out a thought-provoking scenario for establishing a regional SACU SDI. The next section comes up with the research method geared towards answering some of the questions raised in the introduction. This involves, focus on the geospatial data and GISs of the various SACU countries and what has been done in terms of devolving them to infrastructure format. The method, also delve into SACU data and sought its geospatial relevance in terms of collating, processing, analysis and reporting. The third section reports the results for the various countries. Section four (4) then articulates a discussion leading to identification of the SACU Regional SDI Sponsor and Champion. A conclusion is drawn in section Five (5) of this paper.

2. METHODS

This research work was carried out between 2016 to 2021. It had involved visiting several organizations in the countries of study in 2017 and 2018, interviewing officers, reading documents, viewing GISs and

evaluation of internet sites by countries to gauge the status of online geospatial data that can enable SDI at national and regional levels within the SACU.

2.1 Qualitative versus Quantitative

Research usually takes two main methods being qualitative and quantitative. These methods are illustrated by Johnson and Onwuegbuzie (2004) who have made a strong argument that research tend to carry both methods either in data collection and/or in analysis. Johnson and Onwuegbuzie (2004) further advocate for the mixed-method study which allows for qualitative and quantitative intersections as appropriate. The mixed-method approach elaborated in Johnson and Onwuegbuzie (2004) is shown in **Figure 2**. The usefulness of referencing Johnson and Onwuegbuzie (2004) is that it gives simple guidance to methods' various stages of study design, data collection, analysis and methods mix. An emphasis on the mixed-method is found in Maxwell (2011) who have defined it in terms of three reasons being; "influence on research designs, research questions, conceptual frameworks, methods, and validity concerns"; "better data construction of the phenomena under study"; and "creating of dialogue between different ways of seeing, interpreting, and knowing". Relationships between variables are going to be constructed and utilized to summarize SACU SDIs and advance a sponsor and champion on the basis of comparison.

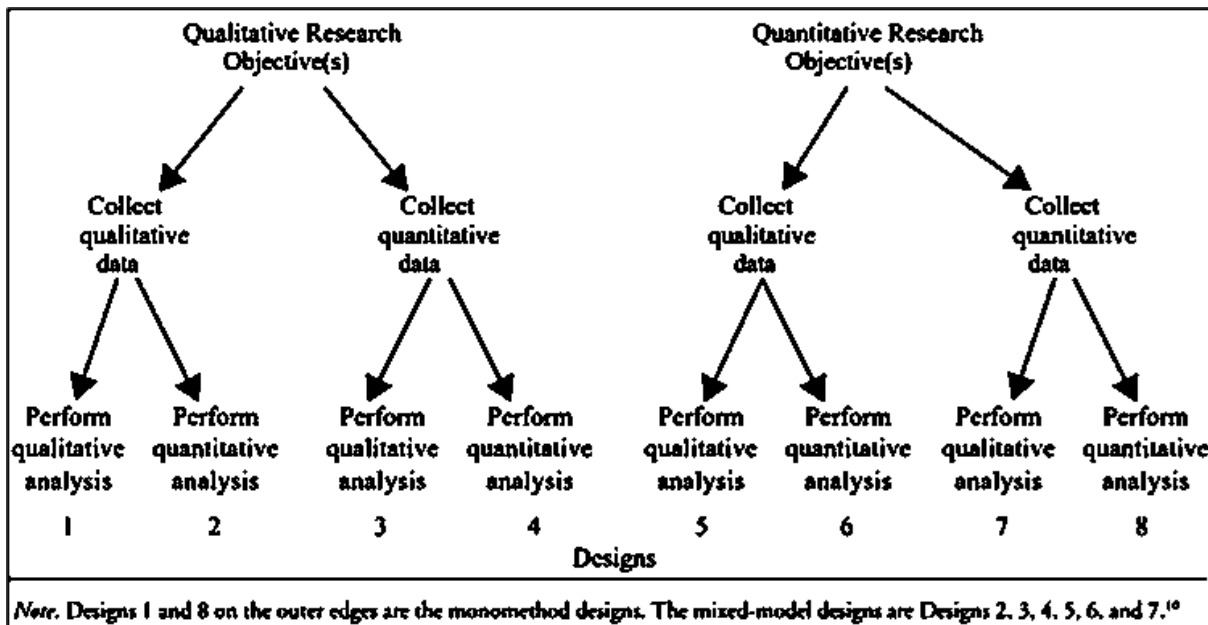


Figure 2: Monomethod versus mixed-model Research Designs (Johnson and Onwuegbuzie, 2004)

In the area of geomatics, mixed-method approach has been used by McDougall, Rajabifard and Williamson (2007). In so doing they have advocated for the dynamism of the approach in addressing complex SDI discourses. Central to the paper by McDougall, Rajabifard and Williamson (2007) is the concept of partnership which is considered pivotal in sharing of geospatial data/information. The study in this paper also took the mixed-method approach depending on the variable of study under consideration.

2.2 Research Data

Data in this paper consists of primary and secondary data. Intensive research visits to various SDI oriented SDI organizations within SACU countries were done between April 2017 and April 2018. In case of primary data, a questionnaire, interviews and attendance of workshops were the main instruments. All the five countries of SACU National Mapping Agencies (NMAs) were written emails and called by phone but only four countries responded. Four countries which responded were **Botswana, Lesotho, Namibia** and **South Africa**. Attempts to reach Eswatini Surveyor General through email and phone calls were futile and on that note the country could not be visited to participate on this part of the study. Entry into countries was by way of purposive selection of National Mapping Agencies (NMAs) as principal informants due the fact that they are mandated by law to handle fundamental geospatial base data and undertake map productions. Where the NMA was not responsible for NSDI, the researcher was linked with the relevant organization, e.g., National Statistics Agency in Namibia. Once the logistics were done, open-ended questionnaire was administered to the leading officer of the SDI convener organization in a visited country. The questionnaire was focused on the following: SDI Time of Origin; Main Players; Recent Status; Country SDI Directions; Challenges; Benchmarking within SACU; Inputs and Outputs; Benefits; Opportunities; Coordination; Feedback; Plan; Research and Development; and Views on Regional SACU SDI.

Further collection of primary data was done through interview approach. Purposive selection of NMAs systematically led to interaction with a wider geospatial data community in the countries of study. In South Africa and Namibia, an opportunity was availed for attending country scheduled SDI workshops. In both countries, SDI workshops were scheduled for the whole year and an opportunity was extended to the researcher to freely attend these workshops. Due to time and financial constraints, only two (2) workshops were attended in South Africa and one (1) workshop in Namibia. The workshops in South Africa were one (1) day each and were attended in Durban and Cape Town. The workshop in Namibia was one (1) week long and it was attended in Windhoek. Eswatini, did not respond to the email written and as such, there was no primary data obtained from it.

To appreciate secondary data collection, it has to be noted that several countries have since 2000 attempted SDI and amongst them are the SACU members. The five countries under study appear in the literature as countries which have been involved with SDI since early 2000 (Makanga and Smit, 2010; Maphale and Phalaagae 2012; Mwange et al, 2016). More than twenty (20) years on, it is realistic to expect documented evidence and internet sites/portals of their efforts. Therefore, country SDI Documents and Geospatial Data Internet Sites/Portals are considered important in formulation of a SACU RSDI concept. Documents are critical in revealing the path taken in SDI development, the challenges met and the output achieved. Documents can further reveal portals built and ideas generated regarding the levels of SDIs by a given jurisdiction. Information Communication Technology (ICT) has become ubiquitous and solutions such as websites and/or geoportals have been built to offer information accessibility, discoverability and development of new products.

3. RESULTS

The results reported here are meant to capture the objective of this research and expose a regional SDI possibility. The results start by reporting on perceptions of the responsible authorities on SDI issues. In addition, a number of results come from discovered data, these include; country populations, SDI progressions, SACU data and a data integration framework. Data integration framework involves interfacing of geospatial data with SACU data and determination of new mappable quantities. Results for both primary and secondary data sources are collated and presented in tables in the Sub-Sections of this Section. Data derived from the questionnaire instrument is summarized with columns depicting the country responses. Data mostly derived from secondary sources are presented with countries as rows and items of SDI significant quantities and progression as columns. The tabulated data is enjoined in a robust discussion and analysis leading to a proposition for the RSDI champion in Section 4.

3.1 NSDIs Qualitative Questionnaire Responses

A qualitative questionnaire was administered across four SDI driver organizations within SACU countries of Botswana, Lesotho, Namibia and South Africa as alluded to in Section 2.2. Further, a check was carried out for a common institution that could possibly be dealing with SDI at SACU regional level and none was found to be in existence. In response, the following perceptions were captured: SDI time of origin, main players, recent activities, benchmarking, challenges, inputs, outputs, coordination and the aspects of benefits and opportunities. The responses are summarized in the **Table 1**.

Item	Botswana	Lesotho	Namibia	South Africa
Time of Origin	1994	1999	2003	1985
Main Players	Government Agencies	Government Agencies	Government Agencies	Government Agencies
Recent status	Intermittent	Dormant	Evolving	Evolving
Country SDI Interactions	SDI Committee	Committee on Environmental Data Management (CEDAMA)	Legal NSDI Secretariat	Legal Committee for Spatial Information (CSI) and six Subcommittees
Benchmarking within SACU	None	None	South Africa	None
Challenges	Funding, Understanding, Mandate (Legal) and Political Support	Understanding, Motivation, Legal and Political Will	Co-operation, Quality Data, Metadata and Funding	Funding and Structural location within Department of Rural Development and Land Re-form
Inputs	Project Team, Workshops	CEDEMA Members	Funding and Stakeholder Data	Consultation, Collaboration, Communication, Coordination
Outputs	SDI Document	SDI Document	SDI Documents, Workshops and Geoportals	SDI Documents, Website and Workshops
Benefits, opportunities and awareness	Yes	Yes	Yes	Yes
Coordination	Department of Surveys and Mapping	None	National Statistics Agency (NSA)	Department of Rural Development and Land Reform
Plan	National Development Plan (NDP11)	None	A Five-year Strategic Plan (2015 – 2020)	South African Geospatial Information Management
Research and Development	Lacking	Lacking	Done	Done
Regional SACU SDI	Willing/Interested	Willing/Interested	Willing/Interested	Willing/Interested

Table 1: SDI Questionnaire response by Botswana, Lesotho, Namibia and South Africa

The results promulgated in **Table 1** are going to be used in discussion and analysis in Section 4.2

3.2 Data Discovery

Data discovery involved the study of country reports and technological platforms. With the advent and operational abilities of information technology, data has become ubiquitous and one way of leveraging on it is to discover it. Essentially, data is discovered across several reports and various platforms where it is stored and it is characterized as research and discourses results for which solutions and interventions are being pursued. For the purposes of this subsection, data has been discovered and collated from among others the following:

- SACU member country NSDI Reports: These are reports of countries on the efforts they have undertaken since conceptualizing SDI. The route taken, achievements and challenges associated with the country SDI development.
- United Nations Website <https://population.un.org/wpp/Download/Standard/Population/>. This is a well-maintained website for UN with suitable data to address several discourses and interests in research and governmental interventions. Populations of the countries under study is key data discovered from this source.
- SASDI home page: <http://www.sasdi.gov.za/sites/SASDI/Pages/Home.aspx>. This is the South African Spatial Data Infrastructure Website which continues to be systematically developed. Among its content are data recoverable resources such as policies, laws, regulations, reports underpinning geospatial data relating to SASDI activities and efforts. In evaluation of SASDI and the role in a SACU RSDI, documents and development status of this website were studied. Discoverable data emanating from SASDI website study is reported in this section.
- The SACU Website <http://stats.sacu.int/>. From this site, data were discovered from documents such as the New SACU Agreement, Yearly Reports and SACU Traded Commodities Portal. Data pertaining to SACU reported here include Objectives of the New SACU Agreement, SACU Institutions and Trade Commodities and Significant Trade Statistics.
- <https://nsa.org.na/page/gis-services>: Namibia national Statics Agency, through this site further portals on Namibia SDI were visited.

From these websites and other country related reports, discoveries are made which focus on the SDI Significant Quantities, NSDI Progression, The SACU New Agreement Objectives, SACU Institutions, SACU Traded Data Sets and Macroeconomic factors Statistics. All these data sets are reported and explained below and further employed to inform a discussion about a RSDI Section 4.

3.2.1 Significant Spatial Data for Country

SDI is about a country's extents, positions, population and the interactions in pursuit of environmental management and economic good. Driving SDI requires carefully authored documents such as policies, laws, regulations, technical specifications and organizational remits. In order to make a quick evaluation of nation's SDI, data such as its area, population, regional areas (provinces/districts/municipalities) are important. On the basis of the foregoing, data was discoverable for each SACU member country to help

characterize what is called SDI Significant Quantities. In the case of country area, reported numbers are official estimates for the country while the populations were discoverable from the United Nations report.

Country	Area (Km2)	2020 Population Estimate (Million)	Number of Districts or Provinces
Botswana	586,000	2.352	10
Eswatini	17,353	1.160	4
Lesotho	30,355	2.142	10
Namibia	834,295	2.541	13
South Africa	1,219,912	59.309	9

Table 2: Basic Geospatial Data of SACU Countries

Data captured in **Table 2** is just threshold to what will develop into a complex geospatial information if disaggregation is done. The data is considered to be suitable at this conceptualization stage of the SACU RSDI. Data in **Table 2** is later integrated with other data about SACU into **Erreur ! Source du renvoi introuvable.**

3.2.2 NSDI Progression

This subsection report data that is focusing on the progression and timeline activities of SACU member countries’ NSDIs. The report is edged primarily on the organizations evidently championing SDI in the member country, the year that NSDI was launched, policy and law accented to and the most recent meetings, training or capacity building activities. Results reported here are from interviews, discoveries from country reports and existing internet sites listed in 3.2 above. The results are summarized into **Table 3**.

Country	Organization (De Facto Champion)	Year launched	Year of Policy	Year of Act	Stakeholders	Documents	Internet Site/ Portal	Workshops / Meetings since 2016
Botswana	1. DIT ¹ (2001 -2007)	2001	none	none	18	4	3	1
	2. DSM ² (2007 to date)							
Eswatini	Surveyor General	none	none	none	n/a	1	1	none
Lesotho	LLAA ³	2000	none	none	6	4	1	none
Namibia	CBS ⁴ later NSA ⁵	2008	2015	2011	20 → Several	9 → Several	4	Several annually
South Africa	DLRR ⁶	2004	None	2003	10 → Several	37 → Several	6	Several annually

Table 3: SDI facilitator organizations in Botswana, Lesotho, Namibia and South Africa. ¹Department of Information Technology; ²Department of Surveys and Mapping; ³Lesotho Land Administration Authority; ⁴Central Bureau of Statistics; ⁵National Statistics Agency; ⁶Department of Land and Rural Reform.

It is evident from **Table 3** that the number of organizations involved as anchor stake-holders are important. Evidence pointing towards internet sites/portal developed to advance SDI is also reported. Further to that, the other columns reflect evidence of SDI activity in a SACU member country. The values reported are not necessarily the true total quantities of the items, but the figures are considered to be significant as evidence pointing to NSDI.

3.2.3 SACU Member States Shapefiles Discovery

To check for results that can be associated with the NSDI progression in the SACU countries, a random internet search for country portals was done. The search returned Regional Centre for Mapping of

Resources for Development (RCRMD) geoportal which contained the principal international boundaries and the province/district level administration boundaries geospatial data set shapefiles for all the five countries. RCRMD has allowed for these data sets to be discoverable, so they were downloaded to be used to demonstrate the currency of a developable RSDI in case of SACU. Downloadable links of the shapefiles are shown in **Table 4**. These shape files or spatial data sets as used in the RCMRD geoportal are produced by the National Mapping Agencies of each SACU country.

Country	Geoportal Url	Discovered Shapefiles
Botswana	http://geoportal.rcmrd.org/layers/servir%3A3Abotswana district boundary	Botswana_district_boundary.shp; Botswana_district_boundary.prj; Botswana_district_boundary.dbf; Botswana_district_boundary.cst; Botswana_district_boundary.shx
Eswatini	http://geoportal.rcmrd.org/layers/servir%3A3Aswaziland adm1	Swaziland_admin1.shp; Swaziland_admin1.prj; Swaziland_admin1.dbf; Swaziland_admin1.cst; Swaziland_admin1.shx
Lesotho	http://geoportal.rcmrd.org/layers/servir%3A3Alesotho district	Lesotho_district.shp; Lesotho_district.prj; Lesotho_district.dbf; Lesotho_district.cst; Lesotho_district.shx
Namibia	http://geoportal.rcmrd.org/layers/servir%3A3Anamibia adm1	Namibia_admin1.shp; Namibia_admin1.prj; Namibia_admin1.dbf; Namibia_admin1.cst; Namibia_admin1.shx
South Africa	http://geoportal.rcmrd.org/layers/servir%3A3Asouth africa adm1	South_africa-admin1.shp; South_africa-admin1.prj; South_africa-admin1.dbf; South_africa-admin1.cst; South_africa-admin1.shx

Table 4: RCRMD Data Discovery Portals for SACU Countries. (Source, <http://geoportal.rcmrd.org/layers/>)

In analysis, the shapefile results presented in **Table 4** are going to be integrated with other data associated with SACU to create a simple geodatabase capable of demonstrating how SACU data can be leveraged in creating visual impressions that could support improved decision-making and policy development. This is done in **Erreur ! Source du renvoi introuvable.** and in turn leading to production of **Figure 3**.

3.2.4 The New SACU Agreement, Objectives and Spatial Data

The new SACU Agreement of 2002 was evaluated and data focusing on its objectives were drawn. For each objective, postulate statements in the context of geospatial products were made. These results are consistent with making a predictive framework and a claim to justify why a geospatial solution is considered viable for SACU. The results are like a hypothesis, they are listed in **Table 5**.

SACU AGREEMENT AND OBJECTIVES	GEOSPATIAL POSTULATIONS AND POSSIBLE PRODUCTS
The Agreement	Covers five countries and can be mapped as a GIS layer
Objective 1 - Improved trans-border trade	GIS layers for each country based on traded commodities origins, routes, borders and destinations
Objective 2 - Equity in economic trade	A geostatistical map on economic trade equity parameters
Objective 3 - Fair competition practices	Geostatistical GIS maps on economic trade equity parameters
Objective 4 - Increment in investment chances	GIS prediction maps on investment
Objective 5 - Competitive advantage	Geostatistical GIS maps on competitive equity parameters
Objective 6 - Global economic integration	Geospatial map on global economic integration
Objective 7 - Fair revenue distributions	Geostatistical GIS maps on fair revenue distributions parameters
Objective 8 - Common legislative approaches	SDI is one legislative approach with commonality traits

Table 5: The objectives of the SACU Agreement of 2002 with Geospatial Solutions Propositions. (Adapted from <http://stats.sacu.int/>)

3.2.5 SACU Institutions

Institutions or Organizations are essential components in any SDI. Therefore, this sub-section is eminent in reporting evidence on institutions involved with SACU. In analysis, the organizations geospatial data involvement is viewed as a cornerstone to a presupposition for SACU RSDI. A report on the presiding SACU organizations is drawn from the New SACU Agreement and presented as data focusing on the organizational component of the envisaged RSDI as presented in **Table 6**.

Country	Council of Ministers	Commission	Secretariat	Technical Committees
Botswana	1. Finance and Economic Development (MFED) 2. Investment, Trade and Industry	Permanent Secretary	Covers all Member Countries 1. Executive Secretary 2. Trade Facilitation and revenue	Each Member Country Represented 1. Agriculture Liaison
Eswatini	Finance and Commerce, Trade and Industry	Permanent Secretary	3. Policy Development and Research 4. Corporate Services Directorate	2. Customs Technical Liaison 3. Trade and Industry Liaison
Lesotho	Finance and Trade and Industry	Permanent Secretary		4. Transport Liaison 5. Finance Technical
Namibia	Finance Industrialization, Trade and SME Development	Executive Director		
South Africa	Finance and Trade and Industry	Permanent Secretary/ Directors-General		

Table 6: SACU Organizations. (Source, adapted from <http://stats.sacu.int/>)

3.2.6 SACU Traded Commodities

SACU deals with several traded commodities with specific codes and for illustration purposes, data from its website was downloaded for 8 of them for a period 2017. Eight (8) SACU traded commodities focusing on export were downloaded to demonstrate the massive amount of data associated with SACU (Adopted from <https://stats.sacu.int/MerchandiseTrade/TradebyProduct>).

Product_CODE	Partner Name	Currency	Product_Description	Flow	Botswana 2017	eSwatini 2017	Lesotho 2017	Namibia 2017	South Africa 2017
01	EU	USD	Live animals	Export	869			167	580920
02	EU	USD	Meat and edible meat offal	Export	45359251			25114656	8859806
03	EU	USD	Fish and crustaceans, molluscs and other aquatic invertebrates	Export		11	137902	350932760	257621025
04	EU	USD	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included	Export				3064	98567
05	EU	USD	Products of animal origin not elsewhere specified or included	Export	20		145535	167486	644717
06	EU	USD	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	Export			27307	312645	45165589
07	EU	USD	Edible vegetables and certain roots and tubers	Export			69136	2999669	23964297
08	EU	USD	Edible fruit and nuts; peel of citrus fruits or melons	Export		2566709	775422	14419414	1504849736

Table 7: SACU Traded products extracts (Source: obtained from <https://stats.sacu.int/MerchandiseTrade/TradebyProduct>)

Table 7 depicts important data items such as product description, related export values and the associated countries. The data provided above can be extensively explored and reconfigured to craft a more comprehensive story between environment and trade.

3.2.7 SACU Macroeconomic Factors

Data of macroeconomic factors are discoverable through the SACU reports e.g., SACU Report 2020. Data was discovered and extracted from this report relating to a number of macroeconomic factors. These

numbers are collated and reported in **Table 8** with the objective of integrating them with geospatial data of the SACU countries as presented in **Table 4** to create a geospatial database as presented on **Erreur ! Source du renvoi introuvable.**

Country	Revenue Share 2018/2019 (Billion Rand)	Inflation 2018 Rates (%)	Intra-SACU Imports 2017/2018 (Billion Rand)
Botswana	19.46	3.2	57.985
Eswatini	5.84	4.8	17.962
Lesotho	5.54	4.7	20.494
Namibia	17.37	4.3	55.052
South Africa	43.07	4.6	40.885

Table 8: Macroeconomic Factor Summaries. (Source: Compiled from SACU, 2020)

4. DISCUSSION AND ANALYSIS

To facilitate discussion, a reflection on the results is made, first in the context of SDI efforts within the countries. Secondly, by tracing and determining links between SDI organizations to SACU. Thirdly, by demonstrating in a subtle way the possibilities of developing a geodatabase for SACU traded commodities and macroeconomic factors for visual support of major decisions in regional policy development in the context of economic and environmental issues. Lastly, to kick-start such an effort, a RSDI Sponsor and Champion based on the strength of the results is proposed.

4.1 Summaries of SACU Member Countries NSDI Efforts

Five sub-sections are crafted below to succinctly capture a country-by-country situation relating to SDI. **Table 1, Table 2, Table 3** and **Table 4** are central to this section of discussion. It was considered fundamental to gauge the willingness of these countries' propensity to be involved with SDI at a Regional Level. In **Table 1**, results show the countries' attitudes towards development of SDI. All the four countries which responded to the questionnaire have expressed willingness to be involved with RSDI concept. Furthermore, **Table 4** to some extent confirms this willingness through an RCRMD regional effort. All the five SACU countries have contributed geospatial data to the RCRMD effort.

4.1.1 Republic of Botswana

Botswana has made several attempts in kick-starting and implementing the SDI concept. These attempts have not yielded any useful SDI to talk about owing to various challenges such as: SDI focused legal framework; strategic influence from government; dedicated funding; dedicated organizational set up and office; poor coordination and partnerships creation. Despite its failures, Botswana has massive discrete data sets within various departments such as: Department of Surveys and Mapping; Department of Town and Regional Planning; twelve (12) Regional Land Boards; Department of Water Affairs; Statistics Botswana; Water utilities Corporation; Botswana Power Corporation just to name a few. A huge opportunity for SDI exists in Botswana if a more systematic approach were to be followed to ensure sustained implementation. Botswana has shown propensity to participate in a Regional SDI effort by participating in the effort of RCRMD as **Table 4** confirms.

4.1.2 Kingdom of Eswatini

Eswatini was not physically visited but traces of SDI concept implementation were found through some documents. In another instance, as **Table 4** reveals Eswatini has participated in the regional effort of RCRMD which implies that with better organization the country can take part in a well framed SDI implementation.

4.1.3 Kingdom of Lesotho

Lesotho SDI efforts are associated with the early 2000 and the concept slowly waned down over the years. As **Table 3** shows, it appears that a committee headed by Ministry of Finance called CEDMA was initially set up to drive SDI interest, but its operations have since ceased. The idea of SDI is considered a good idea only in Lesotho because there are many constraints to it. Despite that, as depicted in **Table 4** Lesotho has participated in the RCRMD geospatial portal which shows their willingness to participate in SDI platforms if funding, legal and organizational imperatives are put in place.

4.1.4 Republic of Namibia

Namibia has made a number of strides towards SDI concept implementation as depicted in **Table 3**. Interestingly, Namibia developed its legal framework within the auspices of Ministry of Finance. The SDI law has been strategically inserted under the Statistics Act with the National Statistics Agency (NSA) and Surveyor General as its main players (NSA, 2015). One important factor to take note of is how the Finance Ministry which is also responsible for SACU activities is the anchor of Namibia SDI. Namibia has developed its geoportal (NSA, 2017). In addition, Namibia is prepared for collaboration regionally and internationally in geospatial information products going by its 2015 – 2020 strategic document on SDI (NSA, 2015). Through this strategic plan, political support is eminently visible from Minister of Economic Planning, National Planning Commission, Surveyor General and Statistician-General. Namibia participated in the RCRMD effort as shown in **Table 4**, which implies Namibia's quest for geospatial information products are visible locally and regionally.

4.1.5 Republic of South Africa

South Africa (SA) remains the main economic player of the SACU region and in the area of geospatial information management, SDI efforts are reported to have started as early as the late 1980s as depicted in **Table 1**. In 2003, SA enacted SDI Act and assented to it in 2004. Over the years SA has been developing a framework to implement its SDI. Where there are shortfalls, efforts continue to be made to close the gaps. SA has anchored its SDI on a robust workshopping program which is done for provinces in turn, with the objective to carry many users within national, provincial, districts and municipal organizations on board. As reported in **Table 1**, SA has an interest in RSDI efforts and like the rest of the SACU members it has participated in RCRMD effort as depicted in **Table 4**.

4.2 SDI Stakeholder Organization/SACU Institutions

Organization is one of the vital components of SDI. Therefore, studies taunting the establishment of SDI need to seriously look into organizations. One may ask, how relevant are SACU institutions to SDI? Looking back at **Table 1**, it is evident that the main players in SDI are governments through specific institutions, primarily those focusing on land and statistics sectors. All the countries which responded to the questionnaire have varying levels of literature on SDI. A comprehensive report of the documentation is done in **Table 3**. The studied documents are reflective of the various levels of the advancement of SDIs within the SACU member countries. Perusing these documents exposes various levels of successes, weaknesses, strengths and opportunities of member states NSDI efforts. **Table 1**, reports a number of milestones achieved, the most notable being legal frameworks in Namibia and South Africa and inclusion in a national Development plan in Botswana. Namibia, facilitated its National SDI (NSDI) through a five-year strategic plan which largely helped in development of its geoportal while South Africa have come up with a thirty-year geospatial management strategy. Worthy to acknowledge among these countries, is that Namibia and South Africa poses better strengths and opportunities to implementation of NSDIs. These two SACU countries have elaborative programs of workshops, consultation and plans geared towards SDI development. These strengths should be viewed as an opportunity for inter-country benchmarking with a possibility to kick-starting and growing a SACU Regional SDI.

SACU is an economic block which is largely run by Council of Ministers as constituted by Ministries of Finance and that of Trade and Industry for each country (SACU, 2020). The Chairmanship of the Council of Ministers is 1-year rotational term on a country-by-country basis. **Table 6** summarizes the various institutions of SACU. Comparing institutions in **Table 6** to those on **Table 3** the Ministry of Finance in Namibia is denoted. Within the institutions of SACU Secretariat; agriculture, customs, trade and transport are seen as highly important. These sectors are highly spatial in nature, requires mission critical interventions such as SDI in pursuit of evidence-based analysis and decision-making. To develop policies related with them, it is useful to understand their interaction with the environment. In overall, it can be deduced that institutions involved with SDI in each country and those within SACU do provide good empirical evidence for SACU to consider geospatial information as an important resource in various levels of decision-making. Regional SDI if implemented, will ensure that there is intercountry sharing of geospatial information products to support decisions and policies on trade, the environmental management; intra-boarder collaborations and improvement on integrated governance as espoused by the SACU mandate.

4.3 Geospatial Database Creations and Maps Output

Preliminary pointer regarding how SACU data presented in **Table 7** and **Table 8** are developable into a geospatial database following the propositions in **Erreur ! Source du renvoi introuvable.** The idea associated with geodatabase is to demonstrate utility of SACU data in geospatial information processing sphere. **Erreur ! Source du renvoi introuvable.** addresses itself to four main items being; Country, Disaggregated Locations, SACU Mandate and the Geospatial Attributes Dimension associated with data. **Erreur ! Source du renvoi introuvable.**, can be characterized as summary proposition to fundamental

results presented in **Table 2 - Table 8**. Therefore, **Erreur ! Source du renvoi introuvable.** is proposed as an entry point into geospatial database realm by SACU. Following **Erreur ! Source du renvoi introuvable.**, comprehensive geodatabase can be undertaken as shown by examples of **Table 10** and **Erreur ! Source du renvoi introuvable.**

Aggregated Spatial Data (Country)	Disaggregated Spatial Locations	SACU Mandate	SACU Mandate Envisaged Geospatial Products
Botswana	Province, Districts,	Agreement and Trade	Reporting, production of maps on:
Eswatini	Municipalities,	Commodities	1. Policies: Fairness, Traceability, Empowerment,
Lesotho	Cities, Towns,	1. Agricultural	Sustainability, Environmental issues: Erosion,
Namibia	Villages, Farms,	2. Mining	Desertification, Soil Suitability, Climate Variability,
South Africa	National Parks,	3. Manufacturing	Pollution,
	Rivers, Origins,	4. Macroeconomic	2. Mining: licensing, Mineral Exploration, Trans-
	Areas, Destinations,	Factors	boundary
	Boarders Posts,		3. Industries: Number, Types, and environmental issues
	Transportation		4. Imports, Exports, Inflation
	Routes		5. Densities: Population, Revenues, Imports, Exports

Table 9: Conceptual geodatabase considerations for SACU Data

To construct **Table 10** and **Erreur ! Source du renvoi introuvable.**, country as geospatial data is unique in **Table 2, Table 7** and **Table 8**, hence it is used as the basis of integrating data for area, population, traded commodities, revenue, inflation and imports. In **Table 10**, SACU traded commodities as discovered from its website and presented in **Table 7** are rearranged in a geodatabase development approach. **Table 7** focuses on exports, but in the same vein another table focusing on the import component of the traded items can be downloaded and re-created in a similar format to **Table 10**.

Country	01	02	03	04	05	06	07	08
Botswana	869	45359251	11		20			
Eswatini			137902					25566709
Lesotho			6,20		145535	27307	69136	775422
Namibia	167	25114656	350932760	3064	167486	312645	2999669	14419414
South Africa	580920	8859806	257621025	98567	644717	45165589	23964297	1504849736

Table 10: SACU traded commodities geodatabase focusing on exports – Year 2017

To construct **Erreur ! Source du renvoi introuvable.**, results extracted from **Table 2** and **Table 8** are presented and additional items derived. Therefore, further attributes derived are Population Density (Person/Km²), Revenue Density (Rand/Km²), Intra-Imports Density (Rand/Km²), and Inflation sustained as is. The objectivity of **Erreur ! Source du renvoi introuvable.** is to demonstrate the relevance of geographical space to demographics and SACU macroeconomic factors. In this case geospatial data is essential as foundation frameworks for demographics and macroeconomic factors.

Country	Area (Km ²)	2020 Population Estimate (Million)	Revenue 2018/2019 (Billion Rand)	2018/2019 Inflation Rates (%)	2017/18 Intra-SACU Imports (Billion Rand)	Population Densities (Person/Km ²)	2018/19 Revenue Density (Rand/Km ²)	2017/18 Intra-Imports Density (Rand/Km ²)
Botswana	586000,00	2352000,00	23,00	3.2	57,985	4	39249	98951
Eswatini	17353,00	1160000,00	7,10	4.8	17,962	67	409151	1035095

Lesotho	30355,00	2142000,00	6,20	4.7	20,494	71	204250	675144
Namibia	834295,00	2541000,00	19,60	4.3	55,052	3	23493	65986
South Africa	1219912,00	59309000,00	43,70	4.6	40,885	49	35822	33515

Table 11: Geospatial densities of SACU data on Revenue, Inflation and Imports

Erreur ! Source du renvoi introuvable., Table 10 and **Erreur ! Source du renvoi introuvable.** are preliminary in nature of what is developable into a comprehensive geodatabase for visualization and support of decision-making. The geodatabase can be used to inform policy development and knowledge on economic and environmental issues. This SACU geodatabase can further be developed into SDI to expose impacts of SACU economic practices with environmental mapping, audits and governance. From **Erreur ! Source du renvoi introuvable.**, maps reflecting calculated densities are shown in **Figure 3** so as to demonstrate their spatial dimension. A further disaggregation of the data used can be done and more informative map products derived. The maps in **Figure 3** are meant to demonstrate that it is possible to bring out the spatial dimension associated with SACU trade data as useful means to support evidence-based decisions within SACU that gravitate towards improved considerations of trade along environmental issues. The above scenario can be considered in the context of what Maser (1998) summed as the objectives of SDI. According to Maser (1998) SDI is essential in economic development, facilitating better governance and addressing environmental issues. Therefore, an RSDI will be important in facilitating SACU mandate within the frameworks of suitable and sustainable environmental analytics.

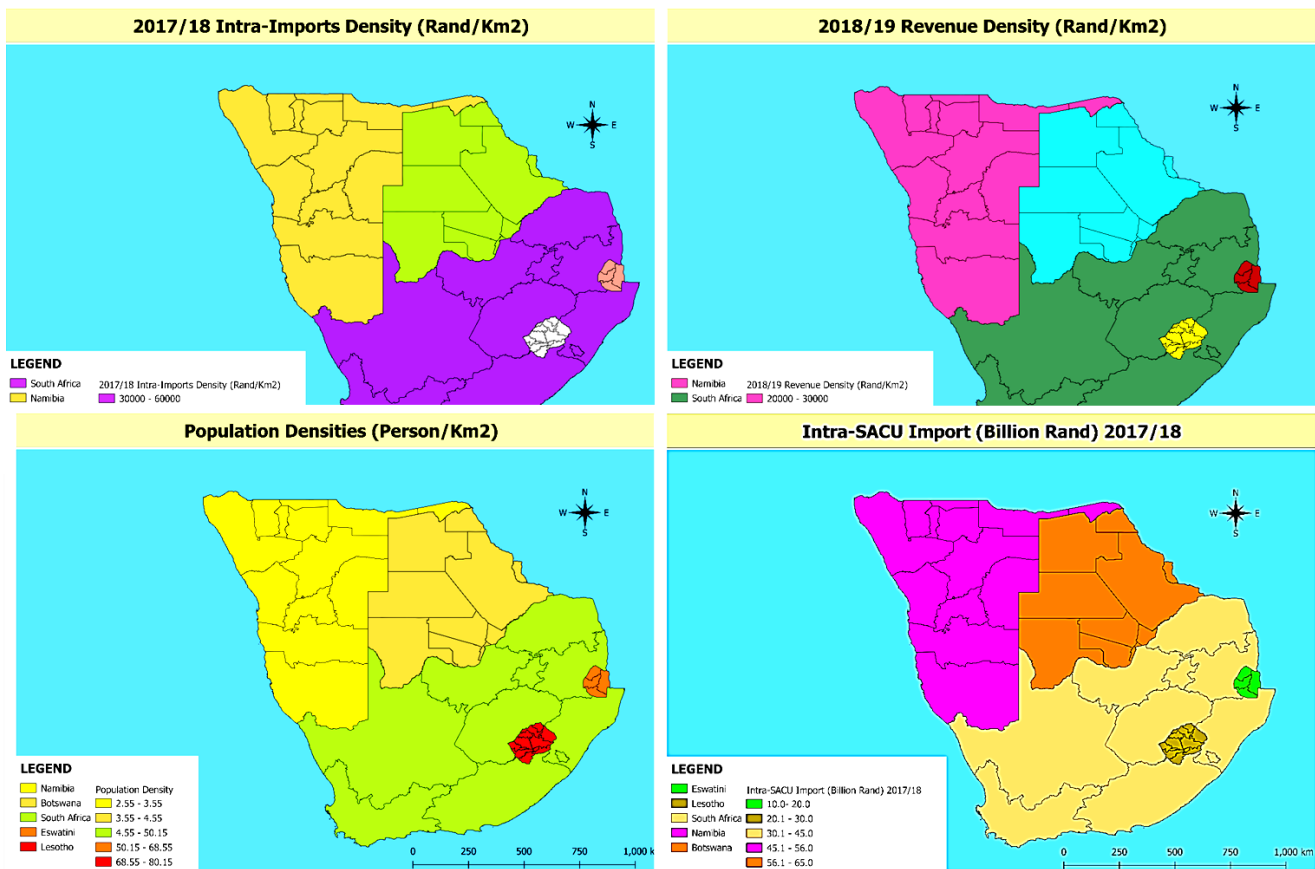


Figure 3: SACU Trade Maps (a) 2017/18 Intra-Imports Densities (b)2018/19 Revenue densities (c) Population densities and (d) 2017/18 Intra SACU Import

4.4 Geospatial Database Creations and Maps Output

At threshold, SDI adventure must have political support and material resources. In **Table 5**, a number of propositions have been put forward to suggest how geospatial information can be of some use to the SACU mandate. It is recommended for SACU to further consider these propositions and interrogate them with possibilities of establishing a Regional SDI. The RSDI is recommended with a need for a sponsor and champion. Sponsoring this RSDI idea is important for it to kick-start. It will be incumbent upon SACU as a political and economic power house to muster political will with adequate financial resources to facilitate feasibilities and preliminary preparations of such an endeavor through its institutions. SACU RSDI has to be viewed as a necessity and a mission-critical infrastructure capable of aligning the economic activities of the union with the environmental and social settings of the region. This will require some adjustments on some operational, tactical and strategic world views of SACU. As such, it is recommended that authorities and responsibilities be properly sanctioned among the existing institutions of SACU. In so doing, a champion institution be identified.

The purpose of the champion institution should be to look at the value addition that can be made by geospatial information in facilitating the SACU mandate. To that end, any of the SACU institutions making the Council of Ministers as presented in **Table 6** can champion this noble idea. But it is worthwhile to note that Namibia among them, has inserted the SDI law within its Statistics Act which is directly under

their Ministry of Finance (NSA, 2017). This is considered a precursory positive indicator, as such, the proposed SACU RSDI championed by Namibia Ministry of Finance could gain momentum and direction from the experiences of Namibia Statistics Agency's National SDI. Another reason that makes this recommendation plausible is that of place since SACU Offices and Namibia Ministry of Finance are in Windhoek. The neighborliness of the two offices will make consultation and coordination of ideas much easy to undertake especially where physical interactions between the sponsor represented by The SACU Secretariat and the Champion become mandatory.

5. CONCLUSION

SACU is a regional partnership in itself, as such, its available decision-making resources should be reflective of the current times and trends where geographic data is integrated with attribute data to produce a whole range of products and support new opportunities. As demonstrated in the Section 3, SACU has a lot of data which is appearing in tabular form and has been shown in Section 4 that the data is developable into a geodatabase. As such, visual impressions that can support a number of activities operationally, tactically and strategically are possible. The major import in this study, has been to demonstrate resourcefulness of integrating economic data with geospatial information to support evidence-based decisions. Regions such as the European Union, have undertaken their own efforts in building purposive geo information infrastructures to facilitate their economic activities and environmental management (Craglia and Johnston, 2004; Craglia and Annoni, 2006; Craglia and Campagna, 2009). The European Union's SDI effort is referred to as Infrastructure for Spatial Information in the European Community (INSPIRE). INSPIRE is a product of the regional economic grouping but it has played a part in influencing the development of NSDIs within European Union member states (Jakobsson and Vauglin, 2001; Craglia and Johnston 2004; Craglia and Annoni, 2006; Craglia and Campagna, 2009; Crompvoets et al, 2018). Crompvoets et al (2018) advances sound arguments relating to grounded issues in using SDI to facilitate governance. SACU Mandate and Governance stand to benefit from a SACU RSDI. The maps developed as examples in Section 4.3 have been used to demonstrate that RSDI is possible if appropriate political, financial, sponsor and champion are put in place. The SDI products can be used among others to support evidence-based decisions of SACU mandate relating to aspects such as: (a) Trade and the environment; (b) Intra-boarders geospatial mapping with analytics and (c) Regional integrated governance in general. The SDI products will further foster research and collaborations among several organizations in SACU. In conclusion RSDI anchored on the SACU platform must be considered and implemented to move towards exploitation of geospatial data for the benefit of the economic system and environmental management.

In conclusion, SACU Regional SDI is possible and to coin a strategy towards it, is to start geospatial data needs assessment within the SACU Secretariat. The needs assessment should be started by undertaking a robust awareness and appraisals on the propensity of geospatial information to improve decision-making processes and policy development within SACU. The needs assessment and awareness then lead to establishment of a geospatial information unit or section within SACU Secretariat. The established unit or section must be mandated initially to gather any discoverable data, propose, design and develop

a geospatial database to support the activities of SACU as a social system. The proposed section, should further be mandated to develop a broad-based policy and strategy geared towards a comprehensive SDI within SACU as a region. Data discovered from RCMRD geoportal is evident that the SACU countries do provide spatial data to support development of a data management infrastructure they view as prudent to their interests. When these geo data sets are compiled together with SACU data, a Regional SDI will germinate.

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8. AUTHOR CONTRIBUTIONS:

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11. KEY TERMS AND DEFINITIONS

Champion: An organization with requisite vision and mission capable of adopting, directing and adapting a Spatial Data Infrastructure implementation.

Customs Union: A group of countries or regional trading block in pursuit of common economic aspirations and interests.

Geographic Information Systems: An information system that collates geographic and attribute data

into a functional outfit capable of improving evidence-based decisions.

Geospatial: refers to absolute and relative positions of features and themes on the earth surface.

Regional: A collaborative adventure between countries in order to create opportunities in fundamental and various interests.

Spatial Data Infrastructures: A technological platform capable of integrating GISs into a pervasive entity capable of appealing to policy, organizational remits and evidence-based solutions across geographical hierarchies (local, national, regional and global) enabling data sharing and exchange.

Sponsor: A technological pundit with capabilities of promoting an introduction and assimilation of a technological undertaking to support improved operations, services and policies.