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Evaluating the Arctic SDI: An Assessment of the Foundations needed for Success*

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Abstract

The Arctic encompasses eight countries and has a population of over four million people. With datasets produced by private and public stakeholders all over the world and noted gaps in data for many parts of the region, there is an opportunity to collaborate and create a unified Spatial Data Infrastructure (SDI) for the Arctic. This research identified a set of criteria for evaluating the long-term efficacy of the Arctic SDI from an organizational perspective and not from a user's perspective. Through the external assessment, half of the countries were found to be strong contributors - almost equally contributing in terms of deliverables, resources and leadership to the Arctic SDI. These three themes developed based on a critical evaluation of the existing SDI literature. While the other half countries contributed noticeably less - due to a lack of deliverables, less participation in working groups or little or no resource contributions. Complementing theses (external) assessments, also internal reviews were conducted via semi-structured interviews, which obtained the participants' view of the Arctic SDI collaboration potential

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successes and shortcomings. The interviewees identified opportunities, limitations and risks as they perceived them. Most of the issues associated with the opportunities, limitations and risks could be cross-validated with the external assessment criteria. However, the importance of communication was strongly emphasized in the interviews and was not represented by the external assessment criteria. The completion of both the external and internal assessments led to the multi-view framework that can be used to assess the long-term potential of the Arctic SDI. This evaluation tool can also be used for defining tasks and clarifying responsibilities for the next 5-year Memorandum of Understanding (2019-2024) or to assess the Arctic SDI to identify challenges and mitigation measures that would assist in its longevity. This tool can also be used for other regional SDIs to define MoUs and assess the potential for success.

Keywords: Arctic Spatial Data Infrastructure (ASDI), National Mapping Authorities, SDI Evaluation, Assessment, Partnerships, Culture for sharing, Efficacy

1. INTRODUCTION

The Arctic has been a prominent geopolitical area for decades due to its large area size, resource richness and multi-nation claims. The Arctic Circle cartographic boundary, which passes through eight countries, commonly defines the region politically, for resource development, climate monitoring, and environment and species diversity (e.g., Arctic Monitoring and Assessment Programme; Conservation of Arctic Flora and Fauna (CAFF)). The Arctic covers 4% of the Earth's surface representing an area of more than 30 million km^2 (Marsh and Kaufman, 2012). The Arctic is often portrayed as a hostile and barren environment. However, it is home to many species of plants, fish, birds, marine and land animals, as well as, human societies, most of whom are indigenous (Armstrong, et al., 2018). Any data collected from either the environment or its people can help to understand this unique ecosystem and sustain it during this period of rapid change and development.

The Arctic landscape is changing rapidly because of climate variability, change in land-water coverage, and increased human activity such as resource extraction and the expansion of transportation routes (Barry et al., 2016). To better understand these changes, there is a need for data that is accessible, reliable and regionally comprehensive for resource extraction, monitoring, management, emergency preparedness and decision making. The need for centralized data sources and access portal has been recognized for effective management of the region (Arctic SDI Secretariat, 2017). The centralization of Arctic data and information has prompted the conceptualization and development of the Arctic-

Spatial Data Infrastructure (Arctic SDI). The eight countries with land claims within the Arctic Circle (Canada, USA, Finland, Norway, Sweden, Denmark, Russia and Iceland) are working towards a more accurate, unified Topographic Basemap (homogeneous scale, projections, etc.) that is centralized and accessible for the region. They are collecting datasets from the eight National Mapping Authorities, as well as other data providers, to coordinate, maintain and integrate using a geoportal for the Arctic region.

This paper discusses the progress of the Arctic SDI (https://arctic-sdi.org/), as of March 2018, and presents an evaluation tool to assess the long-term efficacy of the Arctic SDI based on multi-faceted criteria. A comprehensive evaluation tool is needed so the participates (those involved in the functioning and operation of the Arctic SDI) can monitor and address any pitfalls that may lead to its early demise. First, a comprehensive review of literature was conducted to identify potential criteria that could be used to develop an assessment matrix to be applied externally† by researchers looking at the Arctic SDI from a third-party perspective. Then, a complementary internal assessment of the Arctic SDI was conducted based on interviews, in order to determine how participants within the Arctic SDI viewed its success to date. Finally, the proposed criteria from internal assessments (interviews) and external assessments (matrix) were combined to develop a multi-view tool for future evaluation of the Arctic SDI's longevity potential. We also used this tool to assess the short-term efficacy of the Arctic SDI in its fourth year of operations, which could be used to inform the development of the next Memorandum of Understanding (MoU).

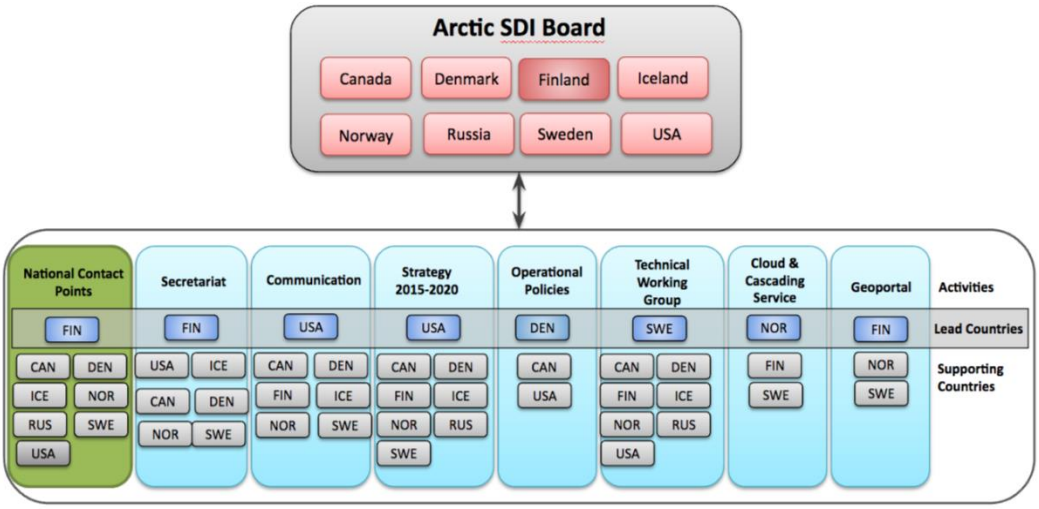
2. THE REGIONAL ARCTIC-SPATIAL DATA INFRASTRUCTURE

The Arctic SDI is a voluntary cooperation between countries with claims in the Arctic region to develop data, standards, applications, policies, and governance to encourage geospatial data sharing in an open way (Arctic Council, 2017). The purpose of the Arctic SDI is to "address the need for readily available spatial data in the northern areas of the globe" (Palmér et al., 2011). The Arctic SDI was conceptualized in 2007, given formal support from the Arctic Council in 2009 and formally established in 2014. The Arctic SDI includes eight national mapping agencies from Canada, Denmark, Finland, Iceland, Norway, Russian, Sweden and the USA. It is composed of a Board, an Executive Board, National Contact Points, the Secretariat of the Chair of the Board, and working groups (Figure 1). Each of

† The use of the word 'external' in this context is meant separate the evaluation of the Arctic SDI by the researchers, who are neither participates in its operations nor current users, from the internal evaluation based on interviews.

the working groups are focused on an individual element of the SDI (e.g., data, geoportal, etc.). Participants often are engaged in multiple working groups and are attempting to ensure that the work is always moving forward to meet mandates. Each group meets separately and then meet collectively to discuss progress,

Figure 1: Arctic SDI organizational structure as of March 2018 (information obtained from Arctic SDI, 2017)



plans, or seek input.

The Arctic SDI is built on a MoU and corresponding governance documents. The MoU for the Arctic SDI was signed on February 20th, 2014 by the eight nations (Arctic SDI Secretariat, 2017). The intent of using a MoU for the Arctic SDI was to foster a good working relationship among the Arctic nations and to support the Arctic Council working groups. Seven points of understanding address “high level” commitment. These seven points are (1) access and distribution of national geospatial data; (2) geospatial data can include cartographic and other types of data in existence or of mutual interests; (3) cooperation in development, maintenance and administration of the Arctic SDI; (4) designate appropriate representatives to identify and implement details; (5) plans and timelines to achieve outcomes; (6) individual countries pay costs incurred unless otherwise agreed upon; and (7) the Arctic SDI is operational upon signing of the MoU (Arctic SDI Secretariat, 2017). The MoU does not provide detailed documentation to cover topic areas such as policy and data license management, technology specifications, etc. The Arctic SDI’s MoU is a five-year voluntary agreement; this

short lifespan allows for countries to become invested, or easily withdraw from the project if they feel it the collaboration does not benefit them. The voluntary commitment can help to encourage every partner to participate to their full capabilities, as each partner relies on another to move the project forward in a timely manner. A disadvantage of the MoU is that there are no legally binding timelines or legislations in place to ensure that each member is properly contributing to the project. When the MoU expires in 2019, the Board hopes to sign another MoU to extend the lifespan of this project.

The MoU led to a 5-year strategic plan for creating a base map and a digital database of the Arctic region as a proof of concept and to begin making this data accessible through a geoportal. The strategic plan also outlines the responsibilities and roles of each country, for example, a schedule of leadership as Chair(s) of the Board and of the working groups. The Arctic SDI Board has identified priorities including thematic data, sustainability, protecting the marine environment, working with CAFF (flora and fauna), and utilizing the SDI for emergency preparedness and response (Arctic SDI Working on Strategy, 2015). The overall goal of the Arctic SDI is to provide a rich sharing data environment, which allows data managers to publish data in a standardized manner. Although a regional SDI, the Arctic SDI provides methods for data sharing at all levels, from local to global. There are numerous stakeholders involved in the Arctic SDI (e.g., Arctic Council Working Group, NGOs, research and university groups, government, media and the public) as well as potential stakeholders who will be impacted by its creation and use. In the end, the Arctic SDI is a tool that should enhance data accessibility for decision-making and Arctic monitoring because its main agenda is to distribute spatial data among public and private sectors.

3. METHODS

SDI evaluations of success are often based on achievements of the individual components of the project rather than evaluating all aspects of the project as a collective. Many SDIs are implemented through a phase-basis approach to evaluation that ensures each component of the SDI is given attention thus allowing for any recommendations to be greater than just the data or geoportal itself (Grus, Crompvoets and Bregt, 2011; Giff and Crompvoets, 2008). For example, the people and the organization around an SDI are just as important as the actual functioning geoportal, if not more so. Researchers suggest that a multi-view framework is the best approach to assessing SDIs and especially those involving international collaboration (Grus, Crompvoets and Bregt, 2011; Giff and Crompvoets, 2008; Vandenbroucke, Dessers, Crompvoets, Bregt, Van Orshoven 2013).

In this study, a hybrid approach that incorporates quantitative and qualitative data collection and analysis was applied to enable a multi-faceted evaluation. The review of literature provided the current state of art in defining the external assessment criteria for any SDI, while semi-structured interviews provided an internal assessment of the Arctic SDI. An alignment between the externally and internally identified criteria was carried out in order to define a more comprehensive evaluation tool for evaluating the success of the Arctic SDI.

The long-term efficacy of the Arctic SDI cannot be assessed at this time; but the potential for its short-term efficacy is evaluated as it is in its fourth year of operations. Documentation from the Arctic SDI Board, working committees, member countries, the Arctic Council and peer-reviewed articles that focused on SDI assessments were used to develop the themes to evaluate each countries contribution to the Arctic SDI (external assessment matrix). The themes identified in the literature were then linked to the seven points of understanding from the Arctic SDI MoU as introduced above.

A point system was developed to evaluate the contribution of each of the participating countries to the Arctic SDI in the fourth year of operations (Table 1). The weight of points assigned to various responsibilities was influenced by their specific time commitment. Resources heavy components, whether monetary or personnel, were given a higher value on the scale. If the countries were meeting the base requirements, as defined in the MoU, then no points were assigned. If nations were engaged in working group committees, which requires communication and coordination responsibilities that fall outside of the annual board meeting commitment, they were assigned one point. Two points were allocated towards leadership roles as these individuals have additional responsibilities for communicating, organizing and executing tasks[‡].

After the development of the external assessment matrix, semi-structured interviews with participants on their perceptions of the current state of the Arctic SDI were conducted. These questions (Table 2) were approved by an ethics committee and all confidentiality protocols were followed as per the University Senate Committee on Ethics in Human Research and Scholarship. The interviewees were selected based on their nation representation and active

[‡] Rotation of Leadership - The Chair is a board member representing the National Mapping Agency of each country. The leadership rotation of the Arctic SDI is outlined in the Arctic SDI Governance (2017). It outlines an agreed schedule, which correlates to the country who is the Chair of the Arctic Council. It is the current Chair's jobs to ensure that rotation of leadership occurs within the terms of the governance. In the second year of the term, from February 1 onward the lead secretary role transitions into the next leader's candidate.

participation in the Arctic SDI, and acceptance of an interview request. Six people participated in the interviews from three of the eight countries involved[§]. Questions ranged from understanding the participant's role in the Arctic SDI (contributor or end-user); the future of the Arctic SDI and its alignment with their home-organization needs; the opportunities and obstacles they perceived within the Arctic SDI; and use of data for policy and the development of Arctic SDI from the working groups perspective. The semi-structured interview process allowed the participants to provide in-depth discussions based on the value they personally attached to topics. The inductive approach allowed a narrative to emerge without preconceived hypotheses from the researcher (Goddard and Melville, 2004). The interview responses were transcribed and coded to identify themes of importance to the participants. After the completion of both the external and internal assessments, the contributions of each country (external assessment matrix) and the interview responses were cross-referenced to align priorities and see if different priorities emerged through each assessment. If priorities arose that were not represented in both evaluations, then additional literature research was done to better incorporate this knowledge. This assessment explored the current state of the Arctic SDI but provides the foundation for assessing the longevity of the Arctic SDI as it matures.

Table 1: Point system to evaluate nation contribution using external criteria

Point Value	Participation	Deliverables	Resources
0	No positions exceeding MoU requirements held	Base map provided (Required in MoU)	Nothing
1	Holds a seat on a Working Group	Documentation	Cash
2	Lead country in working group	Results from Third-party funded research	Intangible's (ex. servers, software, employees)

[§] All participating nations, where contact information was available (7 of 8 nations), were contacted seeking participation in the interviews. Of the eight member nations, three responded to requests for participation (total of six interviewees), three did not respond, and one responded but was unable to make a formal commitment to an interview. Two of the six participants, who engaged in interviews, were unable to sign a consent form, therefore, only the information cited in documents could be referenced in place of their statements when official documents and their answers aligned. Statements used in this research best represent the majority view of the interviewees.

Table 2: Semi-Structure Interview Questions

Introduction

- What is your role in the Arctic-SDI?
- If a contributor: do you use the system as well? Is your data available to others?
- If a sole user: how effective is this database as per your needs?

General Questions

- Where do you see the direction of the Arctic-SDI heading?
- Does this align with your organization's needs?
- What do you feel is the biggest obstacle that the Arctic-SDI contributors and developers need to or are currently overcoming?
- What opportunities currently exist for organizations looking to contribute or collaborate with the Arctic-SDI working committee?
- How does the Artic SDI impact/benefit your organization?
- Does the Arctic-SDI have any negative impacts on/to your organization?
- Have you used the Arctic-SDI in any projects or policy-making decisions?
- IF yes,
- how effective was its use?
- Is there room for improvement and how?

For Working Committee Members

- How is the committee measuring the use of the SDI (in terms of its effectiveness)?
- What is your biggest challenge to storing, accessing and updating your geospatial data?
- What are the criteria for data to be included in the Arctic-SDI?
- What policies are currently in place to handle Arctic-SDI data?
- What level of government/industry/organization dictates these policies?
- Are there policies that govern data harmonization/standardization?
- In terms of historical data, will data prior to the creation of the Arctic-SDI be included? If so how far back will it go?
- Does each data set have its own license?
- How is that being handled/taken into consideration?
- How is licensing verified to ensure it is not violated?
- Why does each data set have its own license? Should they not all be the same?

Arctic-SDI Interface

- Beyond the data itself how is the actual interface managed to ensure reliability, up-to-dateness?
- Have there been considerations for "bulk" users to build alternative routes of access (such as direct FTP)

The Data

- Is there an individual or group responsible for data upload into the SDI or is that the responsibility of each data provider?
- If data provider, is there a process to verify data uploads?

Conclusion

- Are there any examples of the impacts of the Artic SDI on the public to date?
- Such as legislation?
- Crown-corporations project planning affecting groups of people?
- Other?
- Do you see the Arctic-SDI in existence in 5, 10, 15, or more years?
- Do you have any concluding thoughts or comments?

4. RESULTS

4.1. Literature Review of SDI-Assessment Criteria

Regional-SDIs started to appear in the early 1990s (Figure 2). Some regional-SDIs have had a long conceptualization period, leading to legalisation that binds the participants to the project to ensure reliable and quick data updates (e.g., INSPIRE). Some were conceptualised but never operationalized, with extensive research and planning completed to begin the ground work of the project. (e.g., PCGIAP, a regional SDI was planned but never came into physical existence). The failure to advance beyond conceptualization or non-sustainable operations further emphasizes the importance of identifying criteria to assess the longevity of a regional-SDI and address these challenges early.

Figure 2: Examples of regional SDI initiatives (1985-2020) as identified in the literature, the life or evolution of the specific SDI identified in the table is graphed. The purple colour identifies conceptual period of SDI, the blue represents a fully operational SDI, and the green represents an SDI in transformation

Concept/Planning, Product/Functioning, Transition into New Project

Note: Concept/Planning indicates the initial proposal for an SDI but no viable solution has been developed yet. Product/Functioning indicates a viable product that is accessible. Transition into New Project identifies those initiatives that morphed over time into something else. When a bar stops it means that project came to an end.

From 2001 to present, there have been approximately 30 journal articles that assessed the potential of an SDI or evaluated a current or conceptualized SDI (Table 3). Topics covered included assessments of technical infrastructure, cost-benefit analysis, and how to support operations and governance.

Performance measures are identified as top priorities for service providers, government or public-sector agencies (Bouckaert and Halligan, 2008) as performance evaluations are considered key to understanding the effectiveness of government (or agencies) and their public responsibilities. Performance is defined using effectiveness or sustainable results that have high quality (Van Dooren et. al., 2010). One of the criticisms of past evaluations is the focus on a single factor, such as technical aspects, legal structure, organization or cost- benefit (Vandenbroucke et al., 2011). Each evaluation is valid, and if used collectively and in sequence throughout an SDI lifespan, the project would be monitored effectively for decision-making purposes (Vandenbroucke et al., 2011). However, to evaluate an SDI effectively, it requires the monitoring over the projects' lifespan, which can be quite costly to develop as several evaluation frameworks will be needed. For example, the *Arctic SDI Evaluation Report* 2015-2016 was used to develop the Arctic SDI, address the need for data and defined a unified standard for the Arctic SDI development (NRC, 2017). In this evaluation of the Arctic SDI in its fourth year, the focus is on factors that will lead to the project's longevity.

Although much of the literature identified traditional categories of evaluation (technical, legal, organizational, cost), the actual foundations of success were never explicitly defined. Based on literature, we have identified the three criteria for success as (1) participation, (2) deliverables and (3) resources (Table 3). These terms were directly or indirectly used when discussing evaluation processes or development of SDIs in literature, provided below, based on SDI and project management literature, for effective evaluation of SDI success.

Participation is "the process through which stakeholder's influence and share control over priority setting, policy making, resource allocations and access to public goods and services" (The World Bank, n.d.). It embraces inclusion, equal partnership, transparency, sharing power, sharing responsibility empowerment, and cooperation (Meng and Berger, 2011; Rajabifard and Coleman, 2012; Watt, 2014). Participation encompasses those who contribute to the development and operations of the SDI in some manner and the end-users, whose request will affect the focus of the SDI (Giff, 2017). To avoid the collapse of an SDI or decrease the potential for a major redevelopment later in the project, it is important to receive a high level of participation from all current and potential stakeholders. "Participation of (potential) allies in the early phase of an SDI initiative not only makes them 'problem owners' but also may convert them into (co-) proponents of the initiative"

(De Man, 2006). Through inclusion in the conceptualization phase, participation allows fundamental relationships to be built, which further creates active involvement.

Evaluation of the participation success can be used to show benefit of an SDI to current and potential participants; it is hoped that this will lead to an increased participation based on assessed value (Lance et. al, 2006). The goal of many SDI evaluation frameworks is also the recruitment of new stakeholders as end-users. In order to properly appeal to this audience, it is equally important to observe participation and how this participation network functions. “Proponents of the SDI initiative need to seek participation from other actors within the spatial-data community in its design and operation” (De Man, 2006). This can be a difficult task to accomplish in early conceptualization or development of an SDI so many evaluations focus on actively participating stakeholders at this stage. Although this internal evaluation can be used to help pitch the SDI to potential participants, active participants can also greatly bias results in favour of the SDI success (Lance et al., 2006).

Deliverables are defined as a tangible or intangible good that is produced and is provided to active contributors or potential new stakeholders (Watt, 2014). In SDI literature, deliverables are specifically defined in the planning process and may include items such as manuals, presentations, documentation, and exploratory services available to the client (Lance et. al, 2006; Rajabifard and Coleman, 2012). Often, deliverables are associated with the final products or services rather than progress-outputs regularly provided by the participants. The perspective of input datasets classified as deliverables is often overlooked and assumed to be a resource in most SDI evaluations (Lance et. al, 2006). However, in many cases, there are third-parties that produce the dataset to be implemented into an SDI, thus the datasets are considered as deliverables by those mapping agencies and should also be considered deliverables by the SDI.

According to the Arctic SDI MoU, each participating nation’s mapping authority is required to provide the data for a base map for their country and may, at their own discretion, contribute other additional datasets. The base map and datasets are classified as a deliverable with the client being the Arctic SDI. When input data is defined as a deliverable, any additional research that results is considered outputs of the lead organizations (aka Arctic SDI), and therefore fall into the deliverable category of the external assessment. Deliverables therefore are either inputs into the Arctic SDI, or impact the decision making of the Arctic SDI.

Resources include tangible and intangibles that are required to carry out project tasks. Funding is usually a resource, which has fluxes, as the organization or

nations priorities are constantly evolving (Rajabifard and Williamson, 2002; Craglia and Campagna, 2010; Rajabifard and Coleman, 2012). Intangible resources include, for example, services, software, or human resources. Most evaluations do not address consequences that arise during a project's conceptualization and life span such as loss of resources or inadequate resources to meet the project scope (Mayne and Rist, 2006). Resources should be expanded outside direct or tangible outcomes to include, for example, teaching an organizational team to effectively work together.

SDIs can be described as a common-pool of resources (De Man, 2006). Groups of data holders come together to share spatial data, and the resources needed to manage this data for a common good. However, simply coming together over a common good may not always have longevity (De Man, 2006). Human resources, in particular, are an intangible resource that encompasses qualified personnel who will dedicate their time to an SDI, personnel who are crucial to its implementation and maintenance (Arctic SDI Framework, 2017). However, qualified personnel are not always available, and it takes considerable effort to have the "centres" of power contribute. De Man (2006) identifies social capital as a resource; for example, a participant with more societal means, such as labour capacity or their network of relationships, can contribute a form of intangible resources or expertise.

Capacity building is an important challenge that SDI's face, especially for an international collaboration for a large region where partners come together with different agendas. To create an effective and sustainable SDI, specifically for a non-profit organization, it is crucial to create actions and strategies that ensure the resources and knowledge are available to assist in the progression of the project. The interview questions did not incorporate capacity building, but most respondents identified it as essential (Williamson et. al, 2006; Rajabifard and Coleman, 2012). Table 3 includes a review of literature that incorporates evaluation of capacity building for resources, deliverables and participation; literature that recognizes this capacity building still needs to be formalized.

4.2. External Assessment

In our external assessment, the current success was evaluated based on the extent to which each member country was contributing to the Arctic SDI; an underlying premise is that a successful SDI can only be achieved if there are equitable contributions, real or perceived. Table 1 identified how the system was used to assign points to each country to ascertain their contribution in the fourth year of operation. Table 4 shows the results of applying this point system along with the linkages between the three criteria identified in literature and the MoU seven points of understanding.

Table 3: Themes for SDI evaluation based on literature. "Defined" represents the parameters/criterion/concepts as they relate to each theme and as identified by the literature review. "Capacity building" refers to specific tasks that can be accomplished as they relate to the "defined parameters" in each theme.

Themes	Journal Articles	Defined[1]	Capacity Building[2]
Participation	Rajabifard & Williamson, 2001, Rajabifard & Williamson, 2002, GSDI, 2004, Lance et. al, 2006, De Man, 2006, Meng & Berger, 2011, Rajabifard & Coleman, 2012, Giff & Crompvoets, 2013, Watt, 2014, Oloo & der krapf, 2015, KPMG & Natural Resources Canada, 2016, Giff, 2017	• Participant influence and shared control • Set priorities and policies • Allocate resources • Access public goods & services	• Inclusion • Equitable partnerships • Transparency • Empowerment • Cooperation • Relationship building
Deliverables	GSDI, 2004, Lance et. al, 2006, Giff & Crompvoets, 2008, Grus et. al, 2011, Li et. al, 2011, Vandenbroucke et al., 2011, Rajabifard & Coleman, 2012, Watt, 2014, KPMG & Natural Resources Canada, 2016	• Tangible and intangible goods • Manuals, presentations, documentation, exploratory services • Final products or services • Input datasets • Impact decision making	• Defined in the planning process • Recognize both input and output resources
Resources	GSDI, 2004, Holland, 2001, Rajabifard & Williamson, 2001, Rajabifard & Williamson, 2002, Williamson et. al, 2006, De Man, 2006, Mayne & Rist, 2006, Lance et. al, 2006, Craglia & Campagna, 2010, Grus et. Al, 2011, Li et. al, 2011, Rajabifard & Coleman, 2012 Laxmaiah & Govardhan, 2013, KPMG & Natural	• Funding • Services • Software • Human resources • Common-pool resources (data, management of this data) • Social capital contributions	• Qualified personnel • Time allotted to SDI tasks (implement, maintenance) • Teach an organizational team to effectively work together

To comply with the MoU, each participating country must provide a base map, and have a representative on the board, so no/zero points were assigned for this task (Table 4). The MoU does not outline any further contributions in terms of resources or participation in the working groups; groups of participants achieving tasks needed to develop a fully-functioning Arctic SDI organization. Each country is expected to Chair the board in the order outlined in the governance document (Arctic SDI Secretariat, 2017).

The points system in Table 4 works as follows. The maximum number of points that can be awarded for participation are 16. One point is awarded each time a country sits on a working group, and two points are awarded each time a country is the lead for a working group. The weights are reflective of the workload and commitment associated with the level of participation. There is no maximum number of points for deliverables. For deliverables every piece of documentation produced a point is given to the publishing country, and for every research funded by a third-party two points are awarded. The maximum number of points that can be awarded for resources are two. One point is awarded if a country provides funding to the project, and two points are awarded for each country, which provides intangible resources, such as servers and or software that require employees to deploy.

The Arctic SDI's working group's leadership or "Lead Country" and supporting countries work to meet their mandates (Arctic SDI Secretariat, 2017). For instance, the Geoportal working group is led by Finland, with support from Norway and Sweden. Arctic SDI uses Oskari, an open source GIS platform used for WebGIS and eGovernment services (Kokkonen et al., 2017), that is provided by Finland, so

Table 4 – Points assigned for contributions for each Arctic nation (as of March 2018)

Country	Participation[1] (MoU 3,4,5,7)	Deliverables[2] (MoU 1,2,3)	Resources[2] (MoU 5,6)	Total
Norway	7	2	2	11
Canada	5	5	0	10
Finland	8	0	2	10
USA	7	2	0	9
Sweden	7	0	0	7
Denmark	6	0	0	6
Iceland	4	0	0	4
Russia	2	0	0	2

*Points were assessed based on official documentation defining each nation's contributions in the three areas to date

it makes sense they would lead this working group. The Cloud and Cascading Service working group is led by Norway who are providing resources to house the servers (Arctic SDI, 2017). Leadership of working groups and resource contributions are assigned two points, as these are voluntary roles. External research that benefits the Arctic SDI is also valued (two points). For example, the United States Geological Survey (USGS) and Natural Resources Canada (NRCan) came together with the OGC as a sponsor to develop the Arctic Data Pilot. This 18-month project was externally funded, and the results were presented as recommendations to the Arctic SDI board.

Using this external assessment criteria, Norway is the top contributor, followed closely by Canada and Finland (Table 4). These nations have participated as Board or working group Chairs, met deliverables and have contributed additional resources to the Arctic SDI. Half of the countries (Sweden, Denmark, Iceland and Russia) were ranked lower as they did not contribute with any deliverable, have not participated as Chairs or offer additional resources in the first four years of operations.

4.3. Internal Assessment

SDI evaluation of success also requires input from participants as first-hand experience is required to complete the evaluation (Crompvoets, 2006; Giff and Crompvoets, 2008; Vandenbroucke et al., 2011). The interview questions (Table 2) were developed to allow for participants to explore any perspective they felt were important to highlight. Along with interviews, any documentation produced by the Arctic SDI participating countries and working committees was referenced to ensure the validity of the interview responses. After coding the interview responses from participants, three themes emerged as important: opportunities, limitations and risks. SDI documentation was used to validate only factual information. These themes emerged through frequent identification by most, or all the participants.

4.3.1. Opportunities

The Arctic SDI has presented many opportunities for stakeholders that contribute to the development of the SDI, or that use its services. The overall vision of the Arctic SDI is to “facilitate access to geospatial information in support of social, economic, environmental, monitoring, decision-making and other needs in the Arctic” (Arctic SDI WGS, 2015). The overall mission of the organization is “to promote cooperation and development of a Spatial Data Infrastructure that enables discovery, visualization, access, integration and sharing of Arctic geospatial data, while pursuing best data management practices” (Arctic SDI WGS, 2015).

All interview participants clearly saw the benefit of the SDI to their home organizations:

> *It is important to have this kind of international collaboration, we need it. We learn a lot about what is going on in the international area, and as a country we get the opportunity to use our national data coverage for stakeholders.* (Interviewee 1)

The collaboration at the international stage was universally identified as 'high value return' by all those interviewed. The interviewees recognized that having eight countries work together on a project, and successfully have a product (the geoportal, a business plan) in such a short amount of time should be celebrated and valued as it is a rare occurrence. Most interviewees saw the commitment that every country has shown to the Arctic SDI as an opportunity to begin conversations that carries this project forward, ensuring its future. The participants emphasized that the Arctic SDI is a positive opportunity for international cooperation because of the support and collaboration from the Arctic Council, their working groups, the Open Geospatial Consortium (OGC), and other organizations involved. The interview participants emphasized that the early perceived success of the Arctic SDI is attributed to effectiveness of the international collaboration. This good working relationship was achieved, in part, because of the clarity of product deliverables defined by the MoU; interviewees believed that this method of deliverable definition is useful and essential to all future regional SDIs. This international collaboration allows countries to learn from one another, to share ideas and data (e.g., Norway and Finland both share geodata technology and policy expertise).

Although identified as a specific purpose of the Arctic SDI, collaboration over a large regional area was identified as a great opportunity to have enhanced datasets available and data management. The opportunities at this point in the project are, as per the interviewees, tremendous for stakeholders. The Arctic SDI has been able to communicate these opportunities through attending symposiums such as Arctic Biodiversity Conference (Arctic SDI, 2018). Additionally, all eight nations within the Arctic have indigenous people in their regions with various levels of autonomy. It was identified in the interview process that incorporating indigenous place names into the Arctic SDI was essential to encourage indigenous participation:

> *Currently, the geoportal has English, French and Russian. We are wanting to put the indigenous names; however, this does require special symbols. This is something we are looking to assess so that the names can be placed properly and depicted correctly through the portal.*

> *Informing the northern communities about the Arctic SDI will help advance this step.* (Interviewee 2)

In addition to developing relationships, the indigenous community involvement would promote two-way education. The indigenous people would teach the Arctic SDI participants about their language, history and culture, and the SDI could teach the indigenous people about the benefits of the geoportal. Voluntary Geographic Information (VGI) is the term used by the Arctic SDI to identify participants by end-user groups, which would be kept in their language when added to the geoportal. The interviewees considered the indigenous language and knowledge an untapped resource.

An opportunity, as a direct result of the Arctic SDI creation, but is generally considered a secondary benefit, is the ability to gain funding for research. The interviewees discussed contributions from the Arctic Council and the OGC, and academic participation that aided the Arctic SDI agenda. Collaboration between the OGC, USGS and NRCan resulted in the Arctic SDI OGC Pilot (OGC, 2016). This 18-month project was developed to demonstrate the diversity and richness of SDI to Arctic stakeholders. The researchers of the Pilot project concluded there was a need for data (seeking data providers and datasets), standardization, open data and usage policies, and sustainability (OGC, 2017). A result of this project was the OGC recommendations for standardization and usage policies, which were also emphasized by the interviewees:

> *Current efforts focus on technology rather than communication and education. The long-term value to stakeholders, which include data owners and users of "create once and use many times" data, cannot be overstated. To achieve this new type of data communication, all users, i.e. data providers, services operators, or catalogue providers need to implement the best practices mentioned in this report, need to provide appropriate descriptions for their product and categorize their information, and need to establish links between data, information and services*. (OGC, 2017)

Communication to both active participants and (potential) end-users was essential to the Arctic SDI's success. The Pilot report was considered a valuable opportunity by the interviewees as it met the new stakeholder engagement agenda of the Arctic SDI but also provided a point of progress for the Arctic SDI. It was also felt that the Pilot report aided in the efforts to meet the full capabilities under the current MoU agreement (Arctic SDI, 2017). Additional projects that have received funding include the Arctic 2030 program for "Better Access to Geodata for Arctic Marine Areas" (Norway) and the ArcticDEM produced by Polar Geospatial Center at the

University of Minneapolis, which has also supported the Arctic SDI mission by providing data. These projects emphasize the importance of externally funded research and show the overlapping benefit to other organizations.

Beyond data provision, an opportunity to speed up development has resulted from the creation of a prototype geoportal. With the working geoportal prototype, it is easier for active participants and potential stakeholders to see the benefit of the Arctic SDI. Additionally, a committee has been working quickly towards a functioning business model that has met major milestones including developing communication manuals for potential end-users and publishing a technical evaluation of the platform. The interviewees felt the prototype geoportal and business plan will open doors by allowing new data providers to be included in the project. It will also quicken the timeline needed for completing the business planning and implementation of the SDI.

4.3.2. Limitations

The phase-based approach of the Arctic SDI also contributes to challenges for developing a fully-functioning SDI in a timely manner with some interviewees stating that this approach slowed the process down. The development of a prototype geoportal followed by the business plan did allow the Arctic SDI to prove their value to the participating countries, stakeholders and potential funding sources. However, the prototype geoportal does not have significant users, no projects developed, no ability to evaluate the end-user experience and no ability to assess the full technical performance at this time. Interviewees suggest that continued development of the business model and upgrading to a full geoportal should be done in parallel, rather than in phase.

The formal establishment of the Arctic SDI in 2014 means there are data limitation, which is to be expected for this brief time period. The Arctic is a large area with detailed information and historical data not considered a priority at the beginning, which has resulted in a base map of low-level fidelity. Data currency and lack of archived data, except for a time-series data set requested by CAFF, does not meet the needs of future end-users who often identify the longitudinal data importance (climate, habitat, sea ice, wildlife migration, etc.). These end-users would see more value in the Arctic SDI if it contained such archived sources. Additionally, there is a gap between the large amounts of data collected versus the amount of data that is organized, pre-processed and ready for use. This current issue will continue to become a threat as technology improves and the ability to generate data becomes increasingly easier. The latter requires more equitable resources distribution (funding, labour and time) compared to data collection. The ‘protype’ geoportal means limitations in the data manipulation abilities, which has resulted in a

reduction in the potential for information discovery. Licence agreements also limit the way users can manipulate and share the data they access. Some nations have made open and free data a priority, such as the INSPIRE SDI, however, other nations have not made open-source data a priority. Due to the lack of big data, Oskari software is not being used to its full potential.

Participants have also been challenged to meet data standards and harmonization between all eight country mapping agencies. Since everyone has their own mapping and data systems, a great deal of effort goes into cleaning and managing data:

> *We have struggled a lot with getting a strong base map with full coverage. Each country has their own standards so harmonizing the data to create a base map that, for example, lines up rivers properly has been difficult. We are almost there with achieving the harmonized specification for the base map, which does not have much detail because of the scale*. (Interviewee 2)

Although this is an essential first step for data integration, few of the national mapping agencies can prioritize harmonization with existing resources (e.g., labour, time, money). Funding and other responsibilities usually limit the ability to prioritize data harmonization for the Arctic SDI. Funding and collaboration priorities may also change with political leadership, which leads to insecurity to the Arctic SDI. Regardless of the priority commitments, international collaborations create a demand for resources with some participating countries not able to accommodate requests from third-parties. If the participant mapping agency does not have similar data systems in place, or processes for data harmonization already integrated into their everyday workflow, it is an additional task for current or new staff. In addition to data harmonization, the development and implementations of standards and policies have been identified as key issues that will pose challenges in the next year for Arctic SDI. Standards can hinder the growth or even change the entire course of the collaboration. The interviewees said it was important to create standards and policies that are sustainable and can encourage capacity building.

As with any international collaborations, there are challenges to working relationships due to diverse languages and cultures:

> *Language is an interesting dynamic and I think we do a really good job because everyone is committed to doing this. We don't always hear what each other are saying. We have to take the time to ask each other to clarify. So, when we talk about 'how are we going to develop a performance measurement to be put in place' therein lies the challenge*. (Interviewee 3)

The interviewee goes on to say that language and culture challenges are often overlooked in research, documentation and operational collaboration projects:

> *It is interesting when you all come to the table from eight different countries, all with different perspective personalities, and speaking different languages. Like any time, there is the amount of time you need to take to have a high functioning team […] If you don't take that time to build the foundation amongst the members, so they can trust each other and figure out how each other work, you can't have a successful team, and this is more difficult when culture and language are a part of it*. (Interviewee 3)

In addition to addressing clarity of ideas, approaches or priorities from different cultural perspectives, the ability to achieve deliverables in a quick and timely manner, which will help to determine the future of the project, is very difficult to achieve for a team of collaborators who are newly formed. This is considered especially so for collaborators that are located a great distance apart and operating in different time zones, as both these aspects make meetings and organization more complex. However, it is felt that with capacity building, these limitations can be mitigated, and other potential limitations avoided.

One of the challenges identified is that VGI and SDIs live in two different environments (Oloo and der Krapf, 2015). Although most felt that VGI, especially indigenous group integration, would provide many opportunities to both communities if they could cooperate effectively. The interviewees recognized that the Arctic SDI will need to look beyond adding indigenous place names in the geoportal. It needs to include indigenous knowledge in numerous ways so that these communities can use the data to meet their own needs (OGC, 2016). Some possible scenarios identified by the interviewees were food security, safety in the indigenous communities, and environmental changes.

4.3.3. Risks

With every international project there are risks involved. One of the biggest risks identified for the Arctic SDI was the voluntary and non-binding nature of the MoU; the project participants felt they were working with a great deal of insecurity. The governance document and the MoU outline expectation of data contribution and sharing, however there is no mechanism to ensure that data is uploaded consistently and in a timely manner. This responsibility falls completely on the individual nations or data providers who view the obligation differently (Arctic SDI Secretariat, 2017). For instance, Denmark, Finland, and Sweden are all member of the European Union (EU) who are required by law to participate and update their data to INSPIRE on a regular timeline (Bernard et. al, 2005). Members of European

Free Trade Association (EFTA), which include Norway and Iceland, also participate in INSPIRE but they are required to update their data three years after the rest of the EU (de Vries et. al, 2011). The identification of a strict schedule for essential data is deemed very important by some participant interviewees. It is felt that without a schedule, there is risk that end-uses will lose interest because of outdated and incomplete datasets.

Because the Arctic SDI has focused on developing a working prototype of the geoportal and developing a business plan, the actual organization structure and details around data policy have not been addressed. The development of data licensing policy is a current focus with some interviewees expressing a desire for the Arctic SDI to adhere to open data standards, which is currently not the case. Norway's data provided to the Portal is open source while Canada, for example, often uses data with imposed restrictions on data use by the provider. The Arctic SDI response is to place warning banners when licenced-data is used in the geoportal (Natural Resources Canada, 2016); however, this puts the end-users at risk of understanding the implications of the data licencing restrictions. There is the potential of data violation and the Arctic SDI will ultimately be responsible.

The governance documents and MoU state that each nation must provide a representative, data for the base map and possible volunteer positions (Arctic SDI Secretariat, 2017). For example, Finland and Norway have contributed significantly to the technical aspect of the infrastructure and led several working groups. There will always be groups with specialization (knowledge, technology) who can put in additional effort to take on leadership roles, but if there is a significant lack of participation from others, and this will can lead to frustration and possible withdrawal of important resources. More explicit participation roles is desired by the interviewees to overcome this risk.

A significant risk perceived by all interviewees was the ability to have effective communication between eight nations, all with their own languages and customs. National representatives do meet face-to-face once a year as per the MoU and governance documents. The representatives also regularly correspond over email, phone and video chat. However, beyond the mandated annual meeting, all other communication is due to proactive participants, which is a risk as it is based solely on individual choice and additional effort. Even with the effort to be proactive, the participants also experienced short-term delays in the project due to miscommunication over terminology, purpose or deliverables. Delays are also experienced with variable perception of Arctic SDI importance with changes in national priorities.

In summary, the opportunities of the Arctic SDI are “high value returns” from the international collaboration including enhanced datasets, learning from each other’s expertise, building relationships with indigenous people and identifying third-party research and funding sources. The technical limitations identified by the interviewees include phase-based management that led to project slowdowns (now and expected in future); limits to the protype geoportal to meet user needs due to data amount, quality and type; historic data that is valued but costly to incorporate; harmonization of data products; and meeting the end-users needs that fall outside of scientific inquiry (e.g., indigenous knowledge exploration). Concern was also raised about insecurity of the Arctic SDI, which included prioritizing the project needs within national mapping agencies; provision of funds and long-term commitment by all eight nations; addressing language and cultural differences that led to delays; and the challenge of geography (distance, time zones) that make meetings more difficulty to schedule. One of the risks identified was the non-legally binding participation and obligations including lack of timely data input and quality. Policy and organization structure have not been addressed because of the phase-based approach, which leave participants unsure of the future agendas and framework definitions. Inequitable participation, suppling resources or other commitments also poses a major risk to the future of the Arctic SDI. And finally, risk was strongly associated with poor communication planning that may lead to a breakdown of progress due to inaction by participants.

4.4. Combining External and Internal Assessment Criteria

Through the process of aligning the external and internal assessment criteria, a multi-view approach validated both the literature themes and the participants’ priorities and identified emerging patterns. The second column titles in Table 5 were derived from topics that most or all the interviewees deemed important and using their language. The topics were validated using support documentation produced by or for the Arctic SDI, as well as from the literature review.

Some of the topics that reflect opportunities, limitations or risks fall into one or more of participation, deliverables and resources themes from literature. Importance of external communication was identified in SDI literature (without effective implementation) but internal communication was identified by participants as extremely important but not in literature (Table 5). As per section 4.3, the interviewees noted that communication and relationship building were essential to have a strong Arctic SDI, and that developing these past relationships allowed the Arctic SDI to be conceived. Communication is strongly associated and enhanced with participation, especially at meetings or working groups, increases the efficacy of the Arctic SDI by encouraging member engagement, and is considered essential to reduce the limitations and risks. Further literature exploration of internal

communication for project management or collaboration was done for the discussion. The alignment identifying Communication & Relationship becomes a critical addition for assessing the efficacy of the Arctic SDI.

When there is an overlap between the two criteria, a checkmark was used to indicate external and internal assessments validated each other. For example, Data Sharing is an opportunity that exists internally to the SDI, as discovered through the interview analysis, and is classified as a deliverable based on the literary review and MoU developed by the Arctic SDI. Since data sharing meets the definition and criteria for both the internal and the external assessment, a checkmark is given. Time & Resources classified within Limitations is not assigned a checkmark because providing any cost is mandatory by the participating nations agreed upon in the MoU.

5. DISCUSSION

The *Arctic SDI Evaluation Report 2015-2016* was focused on immediate returns to the project (i.e., data, SDI development) while this paper documented the evaluation of the Arctic SDI in its fourth year to inform the development of the next MoU or project planning. Additionally, it can assist the Arctic SDI in addressing hurdles that would hinder its longevity, a consequence that would be detrimental to the region. Based on SDI literature, the external assessment matrix revealed the contributions of each country, as of March 2018, using participation, deliverables and resources criteria. Norway, Canada, Finland and USA are the top active participants as they have well-developed national mapping agencies; have national level support to develop and maintain spatial data; are well-funded in research and have initiatives to improve spatial data standards, development and accessibility. These four nations actively lead different working groups and have been crucial in the development of the SDI with the production of third-party funded research, supply of intangible resources and overall expertise.

Table 5 – An evaluation tool for assessing longevity of Arctic SDI: A multi-faceted framework based on external and internal assessment criteria.

			EXTERNAL			
			Participation	**Deliverables**	**Resources**	**Communication & Relationships**
INTERNAL	**Opportunities**	International Collaboration	✓		✓	✓
		Data Sharing		✓		
		Complete Base View	✓	✓		✓
		Indigenous Language	✓		✓	✓
		Research & Development		✓	✓	
	Limitations	Time & Resource (Cost)	✓		✓	
		Language/Cultural Constraints	✓			✓
		Standardization Differences	✓	✓		✓
		Operational Set Up	✓	✓		✓
		Base Map Clarity	✓	✓		
	Risks	Responsibilities Unclear	✓			✓
		Ability to withdraw	✓			✓
		Internal Communication	✓	✓		✓
		Data Licensing		✓		

Some of the Arctic SDI countries also participate in INSPIRE but with different levels of involvement, thus has variable impact on progress in their national mapping agencies. As member states of the EU, Finland, Sweden, and Denmark are required to create, maintain and update spatial data on a strict schedule (de Vries et. al, 2011), and must meet common standards to improve harmonization for the INSPIRE geoportal (Bernard et. al, 2005). Norway and Iceland are EFTA members with a schedule for implementing the INSPIRE Directive that is 3 years behind the EU member states (de Vries et. al, 2011). Because these five countries are involved in INSPIRE, it helps to explain some of their enhanced level of participation in the Arctic SDI, although not equally. Iceland and Russian, were

ranked lower in terms of their contribution as they have not led any working groups, provided additional research or resources to the Arctic SDI. Although Iceland participates in INSPIRE, this has not translated into active contributions to the Arctic SDI, possibly because Iceland has a small population (340 000 people; The World Bank, n.d.). The National Land Survey of Iceland (NLSI) is comprised of 28 employees who may have to prioritize INSPIRE because of EFTA requirements while the Arctic SDI is voluntary. Russia's contributions may be due political transitions and change of organizational structure for the national mapping agency. They merged three mapping agencies (the Federal Registration Service, the Federal Agency for Real Estate Cadastre and the Federal Agency for Cartography) into the Rosreetr agency (The Federal Service for State Registration, Cadastre and Cartography, n.d.). Under taking significant changes to organizational structure will have an impact on the efficiency and effectiveness of the organization to participate in international endeavours. Overcoming unequal contributions may be addressed by partnering the mapping agencies with more capacity with those with less capacity, to identify contributions needed for long-term success.

Semi-structured interviews informed the internal assessment with participants identifying opportunities, limitations and risks as well as a strong emphasis on communication for success of the project. The Arctic SDI was felt to bring many positive impacts to nations with Arctic claims, including new areas of research, funding and development, collaboration on an international stage, and the sharing of data, ideas and expertise. The importance of qualified and available personnel to ensure that the Arctic SDI tasks are a priority in each national mapping agency was recognized. In the interview process, the Arctic SDI was not seen as an additional project, but rather an extension of the current work being performed by the mapping agencies. Limitations were identified but most thought the issues could be overcome if contributions increased or were more equitable. Time and resources are constraints to create an operational SDI, but clarification of ideas and the development of standards were considered equally or more important. If the limitations are not addressed, there is an increased risk of failure of the Arctic SDI. Risks included in-equitable responsibility and the voluntary nature of the Arctic SDI, which results in a lack of detailed guidance and potential for participant withdrawal. Without all eight Arctic nations, the project can collapse entirely. Overcoming these risks and limitations were linked to better internal communication and relationship building.

Communication involves both eight nations and end-users. Internal communication between the countries was noted in Arctic SDI documentation for working groups and external communication with end-users has been essential for receiving research funding and resources, creating a user base, production of tangible case

studies, and demonstration of the Arctic SDI to public and private sectors. In project management literature, communication has a direct impact on the realisation of a project goal as well as a driving force for its long-term survival (Middleton and Wedeyer, 1985; Mazzei, 2009; Meng and Berger, 2011; Watt 2014). Through active communication, the working environment becomes welcoming, creating a space for open dialogue where all members feel comfortable (Mazzei, 2009). Large, international projects need “collaborative relationships” to better identify participant roles that are equally valued in the decision-making process, and develops strong relationships based on trust (Mazzei, 2009). Techniques outlined in literature include the development of a communication analysis matrix to create a communication plan (Mazzei, 2009; Meng and Berger, 2011; Watt 2014).

A communication matrix is used to outline the appropriate paths of communication, based on project situations, to ensure that communication is clear. It is also used to promote responses to inquiries in a reasonable amount of time to not delay the project timeline. It should include the forms of direct communication that are expected to take place, who should receive such formats, and how the information will be stored (e.g., regularly scheduled face-to-face meetings, skype or telephone calls; email and discussion forums). Communication also includes status reports, meeting agendas and minutes, manuals, recorded presentations and tutorials. Outlining a communication matrix, developing a communication plan, educating participants of communication protocol, and encouraging an environment that is open to dialogue can help to foster active communication (Mazzei, 2009).

Whether directly stated or implied through challenges identified, communication between the eight nations is underdeveloped and needs to be improved to reduce limitations and risks to the Arctic SDI longevity. Frustration were due to poor communication protocol, lack of response, uncertainty of the route of communication or not effectively communicating ideas. These frustrations create hostile working environments with groups feeling isolated or overworked. which may lead to ‘teamicide’, the destruction of team work environment, and the prevention of other teams to blend or achieve high-performance (DeMarco and Lister, 2003). A communication plan should be a high priority for internal communication effectiveness, but also to show benefits of the Arctic SDI to potential users and data providers.

6. CONCLUSIONS AND RECOMMENDATIONS

An SDI does not happen by accident but through a strong vision, specific and tangible objectives, and support and commitment from human, organizational, and financial resources. The Arctic SDI is first and foremost the people, policies and processes that make the SDI a success. The foundations of success do exist in

the Arctic SDI with the Board, and its participating members in developing a working geoportal based on a clearly defined business plan and self-governance. The results of this research indicate that these foundations exist, in addition to areas that can quickly become potential threats if not corrected early.

The members are confident that another MoU will be signed, all providing tangible signs of success. It was felt that the MoU is an essential tool to establishing high-level commitment and formal communication; however, the MoU is only effective when the participants involved are empowered to build relationships and commit to active communication. Countries involved can choose a level of participation and self-govern those initiatives with some autonomy.

It is recommended that the Board continue to evaluate the Arctic SDI as it evolves to strengthen the potential for longevity. The short-term focus should be on internal communication (matrix, plan, protocols) and regular assessment of its effectiveness (annually or in the third year of every 5-year MoU). By explicitly outlining the forms of communication, and how to properly use those channels, it will facilitate a collaborative relationship for the working participants and reduce frustrations; a healthy working environment that results in increased commitment, reduced limitations and risks, and progress of the project. Continued business plan development, fully operational geoportal, connecting with third-party stakeholders (as potential new end-users) and improving internal communication should be developed in parallel paths, with equity (Grus, Crompvoets and Bregt, 2011; Giff and Crompvoets, 2008). The potential impacts of the Arctic SDI, both positive and negative, should be researched as there is the possibility that it may have unintended consequences (e.g., cultural appropriation of indigenous knowledge). The sooner the SDI can include potential new stakeholders, the sooner the current and historical data can be incorporated, which will further enhance the attractiveness of the SDI to other stakeholders and fortify the longevity of the Arctic SDI. Further research into operational policy development is needed for the evolution of the Arctic SDI as it, hopefully, will outgrow the development phase MoUs.

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