

Towards key variables to assess National Spatial Data Infrastructures (NSDIs) in developing countries

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Abstract. This research explores how to select a common set of measurable key variables that can be utilised to assess National Spatial Data Infrastructures (NSDIs) in developing countries. The research is based on NSDI case studies of six different developing countries (Colombia, Cuba, Nepal, Indonesia, Nigeria and Ethiopia) and from three different continents (Latin America, Asia and Africa).

A critical review of already existing assessment frameworks, as described in literature, identifies a considerable number of initial variables that can be utilised to assess NSDIs (94 identified variables). The specific, measurable, attainable and traceable variables were filtered out of a list of identified variables to progress to the so-called ‘feasible variables’ (49 variables). Following on from the review of the NSDI initiatives in the three continents, and the critical analysis and comparison of the case study countries, a set of common and relevant case study variables was derived (29 case study variables). Subsequently, a selected group of SDI experts was consulted to provide their opinion on the most important variables for assessing

NSDIs in developing countries. These expert variables were compared and matched with the earlier defined case study variables.

Resulting from the comparison, a set of 14 key variables for NSDI assessment in developing countries could finally be selected as key variables: (1) availability of digital data; (2) capacity building; (3) willingness to share; (4) human capital; (5) SDI awareness; (6) access mechanism; (7) funding; (8) leadership; (9) vision; (10) institutional arrangements; (11) socio-political stability; (12) interoperability; (13) metadata (availability) and (14) initiatives connected to SDI in the respective country. The research was conducted in early 2006.

15.1 INTRODUCTION

Spatial Data Infrastructures (SDIs) are developed by many countries to better manage and utilise spatial datasets (Rajabifard et al., 2003). Although many countries claim that they are involved in SDI development, Masser (2005) asserts that these claims need to be treated with caution. Engaging in SDI development does not necessarily mean that the initiative will translate into a fully operational SDI over time. Nevertheless, during the last few years, considerable resources have been spent creating optimal SDIs (Crompvoets et al., 2004).

Developing countries are initiating projects for NSDI development as well. The main difficulties when establishing and implementing NSDIs in developing countries are likely to be related to the lack of appreciation, the lack of resources and trained personnel, inefficient bureaucratic processes and the lack of data (Rajabifard and Williamson, 2003). Up until now efforts to develop NSDIs have not been audited or systematically evaluated (Crompvoets, 2004). To address this gap, the Wageningen University and Research Centre, Delft University of Technology, and the University of Melbourne in Australia, have embarked on a project to develop a framework for the worldwide assessment of NSDIs. The application of such a framework would support the establishment and implementation of efficient, effective and coherent NSDIs in both developed and developing countries.

Since each country is unique in historical, legal, economic, technological, cultural and institutional terms, the benefits gained and bottlenecks expected for the establishing and implementing NSDIs are also likely to be different. Therefore, not only are effective strategies for establishing and implementing NSDIs be potentially country-

specific, but NSDIs themselves may be different for each country. In order to interpret such differences, this research assumes that a common set of measurable key variables to assess NSDIs is needed. The purpose of determining key variables is to support effectiveness throughout the process of planning, implementation, monitoring, reporting and evaluating — that is, throughout the full spectrum of results-based management (UNDP, 2006). The research problem is, therefore, how to define the set of measurable key variables to assess NSDIs.

The key variables to be selected for the assessment can also be used to enhance and innovate NSDIs in a more strategic and operational way. The determination of a common set of measurable key variables to assess NSDIs could also support the development of the framework for the worldwide assessment of NSDIs as described previously.

Investigating NSDI programmes of six different developing countries, (Colombia, Cuba, Nepal, Indonesia, Nigeria and Ethiopia) from three different continents (Latin America, Asia and Africa) support this research. The selection of the key variables comprises a number of research steps which are explained in the following paragraphs.

15.2 RESEARCH METHODOLOGY

The selection of the key variables comprises a number of research steps. These research steps can be visualised with the following flow chart in Figure 15.1 and the details shall be explained in the following paragraphs.

Critically reviewing existing frameworks as described in literature identifies a considerable number of initial variables that can be used to assess NSDIs. To progress to the feasible variables, those variables that are not measurable are to be removed from the initial list of identified variables. This removal is done after thoroughly describing the identified variables of each of the six selected case study countries.

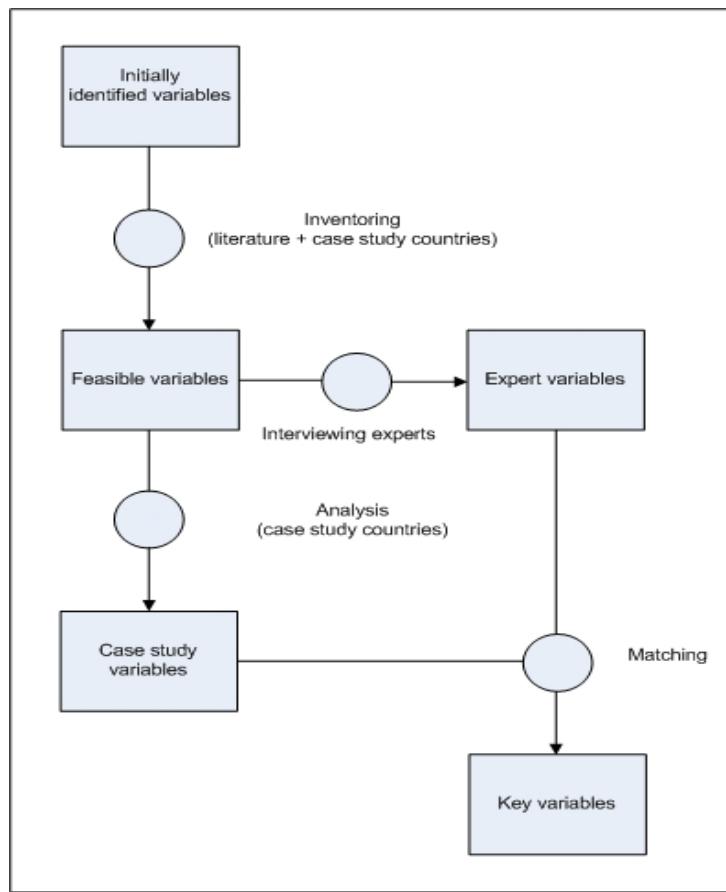


Figure 15.1: Flowchart of the research methodology

The World Bank (2006) has listed all the selected case study countries (Colombia, Cuba, Nepal, Indonesia, Nigeria and Ethiopia) as developing countries. The reason to focus on complementary case study countries during this research is to take into account the business requirements and driving forces that have shaped the purpose, scope, design, implementation and technical aspects of NSDIs. An appreciation of these business requirements and driving forces could assist in improving the establishment and implementation of NSDIs.

Ethiopia was selected as the first African country for further investigation. The United Nations Economic Commission of Africa (UNECA) has been strongly promoting the development of the Ethiopian NSDI. As described by Lance (2003), in many cases foreign

donors drive the initiatives in developing countries instead of the respective governments. The second African country, Nigeria, has been working hard on the NSDI initiative and a policy document was recently submitted to the government for acceptance.

Colombia has played an important role in promoting SDIs in the region; for example, Colombia did play a role in setting up the Cuban NSDI — a workshop on SDI principles was organised in Cuba by the Colombians. Next to Colombia, Cuba was selected as the second Latin country for further investigation. Cuba has recently launched a portal and appears to be speeding up its NSDI development considerably.

Indonesia has been selected as the first country from the Asian continent for further investigation. This developing country started very early with the NSDI initiative. Nepal, the second Asian country, only started the NSDI initiative in 2002 and had the support of the European Commission (EC) during the first three years.

Following on from the review of the NSDI initiatives in the three continents, and the critical analysis and comparison of the case study countries, a set of common case study variables is being derived. Subsequently, a selected group of SDI experts were consulted for their opinion on the most important variables for assessing NSDIs in developing countries, out of the list of feasible variables. These expert variables are compared and matched with the earlier defined case study variables. Resulting from the comparison, a set of key variables for NSDI assessment in developing countries is selected.

15.3 INITIALLY IDENTIFIED VARIABLES

As described by De Man (2006), SDIs require a multi-faceted way of monitoring and evaluation. Therefore, several assessment frameworks describing different evaluation aspects have been investigated.

The work of Abdel-Salam et al. (2005), Crompvoets et al. (2004; 2006), Delgado et al. (2005), Georgiadou (2005), Kok and Van Loenen (2004), Masser (1999; 2005), Onsrud (1998), Orshoven Van (2003), Steudler et al. (2004), and Rodriguez-Pabon (2005) contributed to the identification of 94 variables. The reviewed articles all give indications of variables to be investigated and to be taken into consideration when evaluating a NSDI. Articles describing situations in both developing and developed countries have been taken into consideration in order to identify initial variables. The table 15.1 below presents 94 identified variables to assess NSDIs. The table

follows the five dynamic components of the SDI: data, people, access network, policy and standards (Rajabifard et al., 2003). One extra item, called ‘other’, has been added to the table. This item mentions those variables that do not fit in one of the five ‘traditional’ SDI components as defined by Rajabifard et al. (2003).

15.4 FEASIBLE VARIABLES

This research attempts to define a common set of measurable key variables however not all 94 identified variables are easily measurable. The criteria for selecting key variables is assumed to be similar to selecting indicators as described by the United Nations Development Programme (UNDP, 2006); as in they should be Specific, Measurable, Attainable, Relevant and Trackable (acronym ‘SMART’).

During this research a case study approach is used. As explained by Van Loenen (2006), case study research allows for a more complete understanding of NSDIs by examining behaviour in context (Yin, 1994). In this stage of the research, literature is consulted intensively to fill out the tables with identified variables of the six case study countries. The purpose of the case study research is twofold; (1) to identify the feasible variables and (2) to identify the case study variables (see Figure 15.1). Not all required information on the identified variables can be found in literature and/or the Internet. Interviews with the national SDI coordinators (phone, e-mail) have been a good option to retrieve further information on the NSDIs of the case study countries.

Table 15.1: Variables to assess NSDIs based on existing assessment frameworks

IDENTIFIED VARIABLES	Data component	People component
	Core data sets Data format Maintenance Quality Accuracy Updating – adding of new data Resolution Language Availability of digital data Relevance Reliability Data content Uniformity (country reference system)	Driving forces (data acquisition, SDI) Definition of core data sets Language Number and type of suppliers Number and type of users Number of participating institutes in network Capacity building Education (type, availability) SDI (GIS) related conferences/journals/ stakeholders Research (to support NSDI) User satisfaction (SDI & approach) User involvement Private/commercial participation SDI awareness Human capital SDI culture Involvement professional organisations (NGOs etc.) Size of user involvement Willingness to share Uncertainty avoidance
	Access network component	Policy component
	Access mechanism (availability, search, procedures) Network architecture (type, telecom, Internet) Data volume / data sets Response time Number of visitors Number of web references Number of language(s) used Frequency of web updates Status Preview possibility Implementing body E-business Performance (usefulness) Reliability	Executing coordinating body SDI directive (existence) SDI directive (freedom of info act / copyright) Funding (source) Funding (amount) Funding (model) Funding (stability) Intellectual property Privacy Pricing (data & access to services) Institutional arrangements Access privileges Legal arrangement Leadership (who, power) Vision (political, long-term) Partnership arrangements Public/private partnerships Data collection body Member of regional organisation Liability Commercialisation of data Policy of preview Nature of spatial information market E-government existence Socio-political stability
	Standards component	Others component
	Data transfer Metadata (availability) Type and use of metadata standard (ISO, CEN, FGDC) Services Interoperability WMS WFS WPS WCS	SDI coverage (local, global) Status Development approach (bottom-up, top-down) Decentralisation/centralisation Communication channels SDI complexity Hierarchy (vertical & horizontal relationships) SDI maturity, SDI history (years of existence) SDI impact visibility Initiatives connected to SDI (country's activity) NSDI definition (goal) Main challenge (e.g. implementation or maintenance)

The following set of rules has been applied to reduce the list of initially identified variables: (1) for some of the variables no information is available — even after consultation with the national coordinators, the variable appears to be not measurable; (2) some of the variables appear to be sub-variables of a larger variable — sub-variables can be removed and, furthermore, (3) some of the respective countries have already arranged a number of the variables — no differentiations can be noticed or are to be expected. The resulting list of feasible variables is Specific, Measurable, Attainable and Trackable.

In summary, based on investigating all the identified variables of the six case study countries, and applying the rules as explained in the previous paragraph, the initial list of identified variables can be reduced to a smaller list of 49 variables, which are called the feasible variables in this research. Table 15.2 presents the list of feasible variables.

15.5 CASE STUDY VARIABLES

The list of feasible variables is still very extensive, (49 variables) and is therefore not very operational. This research attempts to select a common set of key variables with the challenge in selecting the key variables being to find measures that can meaningfully capture key changes (UNDP, 2006). Therefore, to identify the common variables, all the feasible variables of the six case study countries have to be compared with each other.

It might very well be that the three continents require different sets of key variables to be effectively assessed. Accordingly, based on a literature review, the NSDI developments in the three continents under investigation (Latin America, Asia and Africa) are being reviewed. By reviewing the developments in the continents, important variables might become apparent and the criteria for selecting key assessment variables can already be identified.

As summarised by Masser (2005), the driving forces behind the initiatives in the three continents are, in general, similar, that is: promoting economic development, stimulating better government and fostering environmental sustainability. Primarily in Africa, driving forces are related to modernisation and environmental management. In the developing world, international donors are playing an important role in implementing (N)SDIs and, in several cases, the donor drives the initiative instead of the respective government (Lance, 2003).

Table15. 2: Feasible variables

FEASIBLE VARIABLES	Data component	People component
	Data format Maintenance Quality Updating – adding of new data Language Availability digital data	Driving forces (data acquisition, SDI) Language Number and type of suppliers Number and type of users Capacity building Education (type, availability) Research (to support NSDI) User satisfaction User involvement Private /commercial participation SDI awareness Human capital SDI culture Willingness to share
		Policy component
FEASIBLE VARIABLES	Access network component Access mechanism Response time Number of visitors Number of language(s) used Preview possibility E-business Performance (usefulness) Reliability	SDI directive (existence) Funding Institutional arrangements Legal arrangement Leadership Vision (political, long-term) Partnership arrangements Public/private partnerships E-government existence Socio-political stability
	Standards component	Others component
	Data transfer Metadata (availability) Services Interoperability	Development approach (bottom-up, top-down) Decentralisation / centralisation Communication channels SDI complexity SDI maturity SDI impact visibility Initiatives connected to SDI (country's activity)

In Latin America most data is available in digital format but the lack of standardisation and harmonisation is often a barrier. The main obstacles are institutional rather than technical in nature (Masser, 2005). In Asia, next to the absence of standards, a lack of culture to share data exists. Not all data is available digitally yet (Rajabifard, 2003). In Africa, the absence of widespread telecommunication and Internet access, and the lack of digital data, are still limiting NSDI developments. Main challenges with respect to NSDI development are related to political support, legal status and leadership (Lance, 2003). Although many African countries have NSDI initiatives, it is not prominent on the political agenda due to more critical issues such as poverty, HIV/AIDS, drought, flooding etc. (Lance, 2003). From research carried out by Crompvoets (2006) on implementing clearinghouses, it can be concluded that Latin America has considerably more clearinghouse initiatives (implementation plus initiatives) than Asia and Africa.

In all continents, the awareness to realise NSDIs is growing and initiatives are (slowly) progressing. With respect to the limitations, as described earlier by Rajabifard and Williamson (2003), developing countries appear to be working on problems related to data, organisational issues and skilled human resources.

The analysis and comparison of the different SDI components of the six case study countries, ('the search for key changes') and the identification of criteria for the selection of key variables, ('literature review') assisted with reducing the list of 49 feasible variables to a smaller, common set of 29 case study country variables, called the case study variables in this research. Table 15.3 presents the case study variables.

Table 15.3: Case study variables

SDI COMPONENTS	Case study variables 2005 - 2006	Case study countries					
		Latin America	Asia	Africa			
Colombia	Cuba	Nepal	Indonesia	Nigeria	Ethiopia		
Data	<ul style="list-style-type: none"> ▪ Availability of digital data ▪ Quality ▪ Updating — adding of new data ▪ Maintaining data sets 	Considerable Good Yes No	Some Acceptable No Yes	Some Acceptable No Yes	Some ↔ None -- Yes No	Some ↔ None -- -- No	Some ↔ None -- -- No
People	<ul style="list-style-type: none"> ▪ Willingness to share ▪ Human capital ▪ Capacity building ▪ Research ▪ SDI education ▪ User involvement ▪ User satisfaction ▪ SDI awareness 	-- Sufficient Yes Yes Available No Moderate Moderate	-- Not sufficient Yes Yes Available No Not good Moderate	Moderate Not sufficient No Not sufficient Not available Yes	No Not sufficient Yes Not available No	No Not sufficient -- -- -- Not good	No Not sufficient -- -- -- Not good
Access network	<ul style="list-style-type: none"> ▪ Access mechanism ▪ Reliability ▪ Performance 	Yes Reasonable Reasonable	Yes Reasonable Reasonable	Yes Not working well Bad	Yes Not working well Moderate	No --	No --

	<ul style="list-style-type: none"> ▪ SDI directive ▪ Funding ▪ Long-term strategic vision ▪ Institutional arrangements ▪ Legal arrangements ▪ Leadership ▪ Socio-political stability ▪ E-government existence 		Not present	Present	Present	Present	Not present	Not present
Policy		Yes	Yes	Yes	Yes	No	No	
	No	No	No	Yes	Yes	Yes	No	
	No	--	No	No	No	No	No	
	No	--	No	No	No	No	No	
	Not present	Present	Present	Present	Present	Present	Present	
	Unstable	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	
	Yes	Yes	No	Yes	Yes	--		
Standards	<ul style="list-style-type: none"> ▪ Adoption of standards ▪ Metadata (availability) ▪ Interoperability 		Yes	Yes	Yes	Yes	Yes	Yes
	Yes	Partly	Partly	Partly	No	No	Partly	
	No	Yes	No	No	No	No	No	
Other	<ul style="list-style-type: none"> ▪ Communication channels ▪ SDI maturity ▪ Initiatives connected to SDI (country's activity) 		Acceptable	Acceptable	Not good	--	--	--
	Ex change	Ex change	Ex change	Ex change	Ex change	Ex change	Stand alone	
	GIS for land use planning	National Society Inf Prog	--	Grant Japan Gov.	(Active part. in conf')	--		

5.6 EXPERT VARIABLES

In order to validate the resulting list of case study variables, in March 2006 twenty-six SDI experts were asked to give their opinion on the ten most important key variables for assessing NSDIs in developing countries (out of the list of feasible variables). Twenty-two experts responded to the question (a response of 85%). The opinions of the experts have been compared with each other and ranked.

The following Figure 15.2 presents the selection of the SDI experts.

When reviewing Figure 15.2, three groups of expert variables can be noticed: (1) the group with the most frequently selected variables (selected between 15 and 7 times – indicated by the red box); (2) the group with an average selection (selected between 6 and 4 times) and (3) the group with variables only selected three, two or one time(s). The boundary limits were selected by looking at the breaking points.

The variables of the first group (most often selected variables) may be qualified as the most important for assessment of NSDIs in developing countries and are called the expert variables in this research.

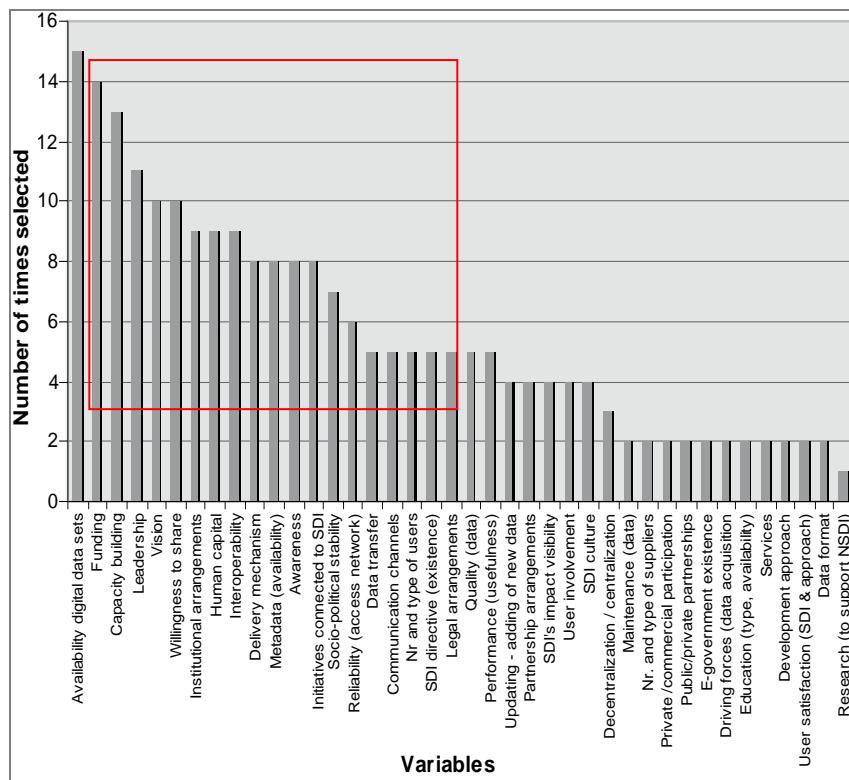


Figure 15.2: Key variables to assess NSDIs in developing countries – SDI expert opinion

15.7 KEY VARIABLES FOR DEVELOPING COUNTRIES

The common set of the measurable key variables selected were based on the comparison and matching the case study variables with the expert variables (see also Figure 15.1) and it was checked if the expert variables are part of the case study variables. As demonstrated in Table 15.4, the most frequently selected expert variables that are part of the case study variables were selected as the key variables.

Specific for developing countries

Fourteen key variables for assessing NSDIs in developing countries have now been selected. In the following sections, whether or not the key variables for assessing NSDIs in developing countries are different from those of developed countries are checked and described.

Table 15.4: Selection of key variables

Case study variables		Key variables	
Data component		Data component	
Availability of digital data		1. Availability of digital data	
Quality			
Updating — adding of new data			
Maintenance			
People component		People component	
Willingness to share		2. Willingness to share	
Human capital		3. Human capital	
Capacity building		4. Capacity building	
Research (to support NSDI)			
SDI education			
User involvement			
User satisfaction			
SDI awareness		5. SDI awareness	
Access network component		Access network component	
Access mechanism		6. Access mechanism	
Reliability			
Performance			
Policy component		Policy component	
SDI directive		7. Funding	
Funding		8. Vision	
Vision		9. Institutional arrangements	
Institutional arrangements			
Legal arrangements			
Leadership		10. Leadership	
E-government existence			
Socio-political stability		11. Socio-political stability	
Standards component		Standards component	
Adoption of standards			
Metadata (availability)		12. Metadata (availability)	
Interoperability		13. Interoperability	
Other component		Other component	
Communication channels			
SDI maturity			
Initiatives connected to SDI (country's activity)		14. Initiatives connected to SDI (country's activity)	

15.7.1 Availability of digital data

From the case study research the conclusion could be drawn that all six countries have difficulties with the availability of digital data. The African case study countries are particularly struggling with the availability of digital data with both case study countries (Nigeria and Ethiopia) are undergoing major efforts to convert their analogue data to digital data. One may assume that the 'availability of digital data' variable specifically counts for developing countries. Developed countries (mostly) have their data available in digital format.

15.7.2 Willingness to share

Rajabifard (2003) described a lack of culture to share data in Asia. The challenges related to the willingness to share spatial data can be noticed in both developed and developing countries.

15.7.3 Human capital

With the exception of Colombia, all national coordinators have mentioned the lack of well-trained human resources. The ‘human capital’ variable is specifically valid for developing countries. One may assume that in developed countries sufficient well-trained human resources are available.

15.7.4 Capacity building

Masser (2005) described that the need for capacity building activities to be developed in parallel with the processes of NSDI implementation is often underestimated. This is particularly important in developing countries where implementing NSDI initiatives are often dependent on a limited number of staff that have the necessary geographic information management skills. With the exception of Nepal and Nigeria (on Ethiopia no information is available), the case study countries are carrying out capacity building activities (such as short courses, workshops etc.). Nevertheless, a lack of human capital (resources) is mentioned by almost all national coordinators (with exception of Colombia).

Although developed countries also require capacity building activities, the GSDI Cookbook (2004) rightly states that capacity building activities can be used to foster the implementation of an SDI. One may assume that the ‘capacity building’ variable specifically counts for developing countries.

15.7.5 SDI awareness

Understanding and being aware of the concepts and benefits of a (N)SDI is very important before and during its implementation and establishment. For example, looking at the NSDI initiative in Ethiopia, the concepts were not well understood when the initiative started in 2002. It was believed that a NSDI was just a ‘tool’ to prevent data duplication — people were not aware of, and did not understand, other SDI components and principles.

The level of awareness needs to improve in all case study countries and that the ‘awareness’ variable is very important in developing countries.

15.7.6 Access mechanism

The access network is one of the key features of an NSDI (Crompvoets, 2006). This variable is important in both developed and developing countries.

The discovery and access mechanism in the case study countries all require improvement. Through the portals of Colombia and Cuba, data of only one provider can be retrieved ('product portals'). The portal of Nepal is almost never operational and the portal of Indonesia is rather slow. Nigeria and Ethiopia do not yet have established discovery and access mechanisms.

15.7.7 Funding

To secure funding is a relevant issue not only in developing countries as NSDIs require constant accomplishments and financial input over a long period of time. However, chances to obtain funding for an SDI is limited in developing countries. Although many countries have NSDI initiatives, it is not prominent on the political agenda due to other critical issues. The stability of the variable 'funding' is particularly important in developing countries. Mostly, stability cannot be guaranteed.

15.7.8 Vision

In the dynamic NSDI environment, a long-term strategic vision is considered as very relevant. From the case study countries, only Indonesia has developed a long-term, political vision towards (future) NSDI development. The 'vision' variable is considered very important for developing countries.

15.7.9 Institutional arrangements

Almost all national coordinators have mentioned the institutional arrangements as challenges. This variable is challenging and important in both developed and developing countries.

15.7.10 Leadership

In terms of leadership for example, in Africa one of the main problems facing SDI development is leadership. While the national mapping agencies are the key contributors to SDI development, other entities have the political influence and funding that drives the initiatives. In Colombia, NSDI leadership is not well defined, which

slows down the progress. In Ethiopia, SDI principles might not be well understood by the leader. The ‘leadership’ variable seems to be very important in developing countries.

15.7.11 Socio-political stability

A continued political, administrative and technological commitment is needed to develop a NSDI. It is not always easy to maintain policy continuity in a developing country. This variable seems particularly important in these countries with almost all national coordinators mentioning the social-political instability.

15.7.12 Metadata (availability)

One of the challenges faced by users of data is the lack of information about information sources that might be relevant to their needs. Appropriate metadata services can help them to find this information. Although this variable is not specific for developing countries, the use of metadata services needs to be encouraged in almost all case study countries.

15.7.13 Interoperability

The ability to successfully understand and share various data, software and hardware across a broad spectrum of organisations and users is relevant for any SDI. Therefore, this variable is not specifically important for developing countries — it is a challenge for all countries.

15.7.14 Initiatives connected to SDI (country’s activity)

If countries undertake actions to increase SDI understanding, a greater willingness to participate in the initiative might be achieved. This variable is specifically important in developing countries. Most developing countries do organise activities supporting the NSDI initiative.

15.8 CONCLUSIONS

Based on a number of research steps as visualised in Figure 15.1, a set of 14 key variables for NSDI assessment in developing countries was selected in 2006. These variables are: (1) availability of digital data; (2) capacity building; (3) willingness to share; (4) human capital; (5) SDI awareness; (6) access mechanism; (7) funding; (8) leadership; (9) vision; (10) institutional arrangements; (11) socio-political stability;

(12) interoperability; (13) metadata (availability) and (14) initiatives connected to SDIs in the respective country. Almost all of the variables are specifically important for developing countries.

The purpose of determining key variables is to support effectiveness throughout the processes of planning, implementing, monitoring, reporting and evaluating — that is, throughout the full spectrum of results-based management (UNDP, 2006). Looking at the selected set of key variables one may conclude that the selected ones are crucial for the enhancement and innovation of NSDIs in developing countries that is in a more strategic and operational way.

NSDI coordinators in developing countries are suggested to take the key variables for assessment into consideration when initiating and developing their national SDIs.

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