Development of a Unified Spatial Infrastructure Status Index for Developing Nations

Mohamed ABDEL-SALAM, Canada and Mohamed MOSTAFA, Egypt

Key words: Spatial information infrastructure, unified index, management, developing countries, USISI

SUMMARY

This proposed research deals with the development of a unified spatial information infrastructure status index USISI that describes and evaluates the conditions of the spatial information infrastructure of developing nations. The proposed unified index takes the technological and socioeconomic factors into consideration. Included in the index is a vector that depicts many criteria for judgment. Among these criteria are the status of spatial reference frames, existence of maps, availability of spatial DB, quality of human resources, cultural awareness of the benefits of spatial information, cultural ability to reform, level of centralism, involvement level of non-governmental organizations, and pricing as well as financing policies. Each element of this index is explained and justified. At the end of the paper an example for two spatial infrastructure indices of two countries are illustrated.

Development of a Unified Spatial Infrastructure Status Index for Developing Nations

Mohamed ABDEL-SALAM, Canada and Mohamed MOSTAFA, Egypt

1. INTRODUCTION

The advance degree of nations is measured by the efficiency by which they use the spatial information. Although it touches many aspects of every day's life such as routing to work, mortgage process(es), flying by plane, booking hotels, choosing cell phone providers and many daily utilities, spatial information, in most cases is hidden and unappreciated. The difference between developing and developed countries is neither the technology nor the people; it is the awareness of the importance of building human skills as well as successful management and planning. Developed countries have been aware of the importance of spatial infrastructure as the basis of Geo-information services and products. Those developed countries are now enjoying the harvest of their early work and planning. Due to political, cultural, and economical challenges, most developing countries lack the acceptable standardized form of spatial information infrastructure or the need to develop and maintain their own spatial infrastructure. Therefore, the development of these countries must first be supported by a powerful spatial information infrastructure as any development is linked to the availability of spatial infrastructure.

As such, this paper investigates and develops an index that describes the status of the spatial information infrastructure. The development of such unified index will help in drawing the priorities and the order of improvement of the spatial infrastructure of developing countries. In addition, this index can help investors and donating organizations to make the right decision concerning the eligible countries for investments as well as funding. Moreover, it helps in choosing the sector in which investments could be directed.

2. SPATIAL INFORMATION INFRASTRUCTURE

Groot, 2000 defined the Spatial Data Infrastructure (SDI) as the processes that enhance the data/information availability and management. It is a set of institutional, technical, and economical arrangements that facilitate access to and responsible use of integrated and timely geo-information at affordable cost.
The institutional component covers socio-political, organizational and legal aspects as well as the establishment of standards. The economical component relates to financing and pricing policies, cost benefit analysis of implementing and maintaining the SDI. The technical components deal largely with distributed database systems including distribution control; security and integrity; updating; global data models for integrating individual databases; networking and protocols; and metadata facilities.
Figure 1 shows the global architecture of the SDI framework. It shows the different levels of spatial data abstractions and operations according to a various predicted user needs. There is a need to evaluate the establishment of such system to compare between different cases (nations) or experiments.

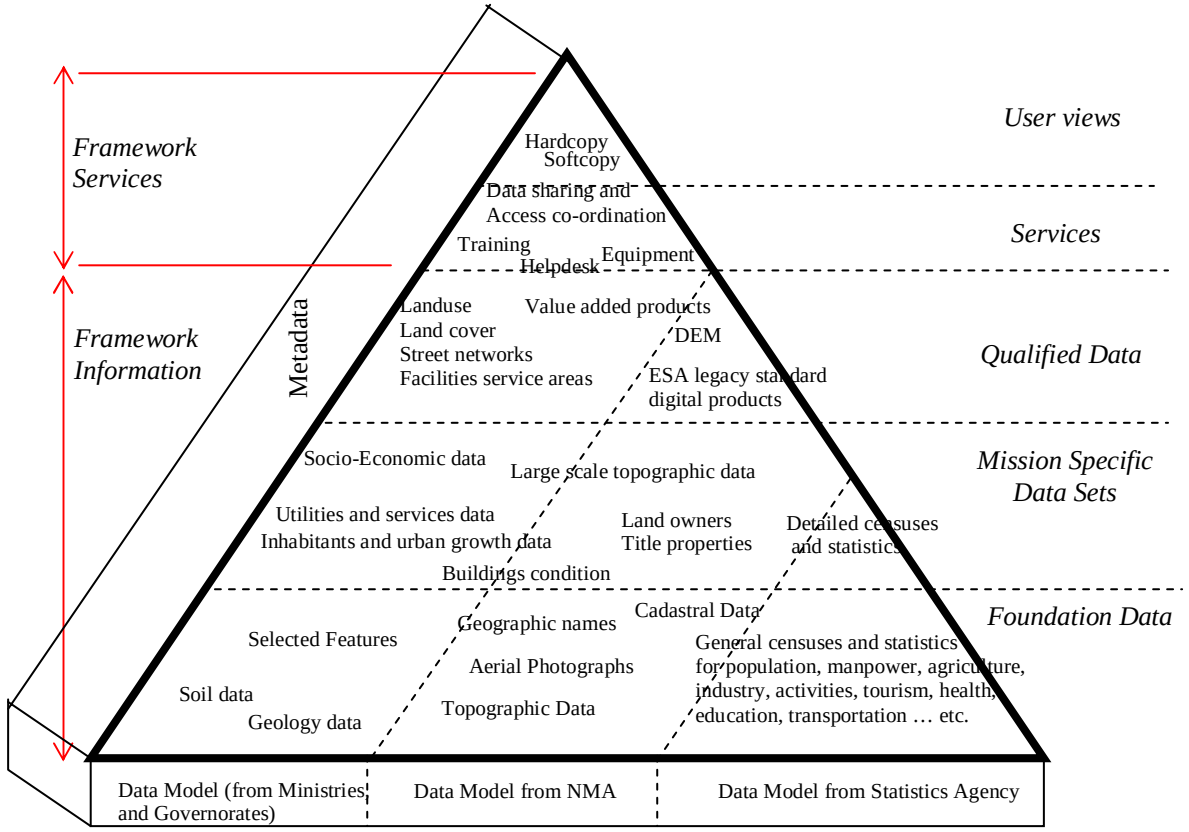

Figure 1: SDI System Framework

3. ELEMENTS OF THE USISI

The elements of the USISI are twofold. The fist describes the technical and geospatial aspects such as the status of reference frame, existence of maps, availability of spatial DB, and existence of unified data model as well as metadata. The second fold of the USISI deals with the institutional as well as socioeconomic parameters such as the quality of human resources; cultural awareness of the benefits of spatial information; cultural ability to reform; level of centralism; involvement level of non-governmental organizations; transparency Index; and financing as well as pricing policies.

3.1 Geospatial and Technical Aspects

3.1.1 Status of Spatial Reference Frames (G1)

The accuracy in which the national spatial reference frame can be determined in a country, expresses the level of accuracy in which topographic and cadastral features can be determined. Fours cases are considered herein. Spatial reference systems with positioning accuracy better than ten centimeters are granted six points. Spatial reference frames with 10 to 50 cm positioning accuracy are granted four points and those with accuracy between 50cm and two meters are assigned three points. Finally, reference frames with positioning accuracy worse than two meters are assigned one point. The availability of the reference frame parameters and their relation to any version of the International Terrestrial Reference Frame (ITRF) can also expresses the ability of national mapping organizations to communicate and interact with other international authorities. Reference frames with known parameters as well as relation to famous ITRF system are granted two points. Less point is granted if these transformation parameters are inaccurate. Spatial reference frames can be accessed through several forms. Among these forms are satellite positioning, laser ranging, and precise control points (monuments). Two points are assigned to the type of spatial reference frames that uses satellite navigation system. Accessibility to reference frames through control points is granted one point, whereas other methods can be assigned scale value less than 1 based on the ease of use. Table 1 depicts the structure of this element.

Index element (G1)	**Status of spatial reference frames**		
sub index	Accuracy of reference frames	Availability of conversion parameters	Method of accessibility
value	6-0	2-0	2-0

Table 1 Status of spatial reference frames elements

3.1.2 Existence of Analog Maps (G2)

Maps are a famous form of spatial data. Abundance of national maps with different types and scales reflects the existence of well defined spatial infrastructure. As such, nations that have abundance of topographic and cadastral maps with scale 1:50,000/1:20,000 and 1:5,000/1:2,500 respectively that cover more than 90 % of the inhabitant areas is assigned ten points. Nations with maps covering 70%-90% of the inhabitant areas can be assigned 7 to 4 points. Four points or less are granted to nations with map covering less than 70% of the inhabitant areas.

3.1.3 Availability of Spatial DB (G3)

With the emergence of computers and digital era, maps became digital in either vector or raster format. This digital spatial information is kept in databases for the purpose of retrieving, manipulation, and analysis. Similar to the existence of analog maps, nations that

have abundance of topographic and cadastral maps with scale 1:50,000/1:20,000 and 1:5,000/1:2,500 respectively that cover more than 90 % of the inhabitant areas are assigned ten points. Nations with maps covering 70%-90% of the inhabitant areas can be assigned 7 to 4 points. Four points or less are granted to nations with map covering less than 70% of the inhabitant areas.

3.1.4 Existence of Global Data Model and Metadata (G4)

It might look strange to isolate global data model and metadata from the availability of spatial DB but this is the case in developing nations. In many cases, there are spatial DBs developed by different authorities within the same country or even the same district without any kind of coordination. As such integrating different spatial DBs becomes essential and the consistency of data models in these different spatial DBs becomes inevitable. A developing nation that adopts a common data model is granted five points. Existing of metadata will participate towards the other 5 points.

3.2 Institutional and Socioeconomic Aspects

Among the important issues that effect the development and implementation of spatial infrastructure are the socioeconomic factors. Socioeconomic factors include those related to human resources quality, institutional and economic issues. The next subsections deal with these factors.

3.2.1 Quality of Human Resources (S1)

Quality of human resources can be attributed to education, training, research and ability to develop. The best representative factors that describe the quality of human resources are the most recent human development and the technical indices developed by the Unit Nations Human Development Program (UNDP, 2003). These two indices take value from 0 to 1 and are well designed and trustworthy. The average of these two indices mapped between 0-10 represents the quality of human resources element of the proposed unified index. An example of these two indices is shown in Table 2.

Rank	Country name	Human development Index	technical Index
7	Finland	0.930 ==> 4.65	0.744 ==> 3.72
6	New Zealand	0.917 ==> 4.59	0.548 ==> 2.74
72	China	0.726 ==> 3.63	0.299 ==>1.50
97	Algeria	0.697 ==>3.49	0.221 ==> 1.11

Table 2 Human development and the technical indices (source: UNDP, 2003)

3.2.2 Cultural Awareness of the Benefits of Spatial Information (S2)

The level, in which a nation uses spatial information in forms of maps, navigation, or any other forms, facilitates persuading decision makers to support spatial information infrastructure projects. An example for that is the ambitious project for real state financing

that has been initiated by the Egyptian government a few years ago. Due to lacks of sufficient cadastral spatial DBs and other financial and institutional issues, the project was hindered and several years of work towards updating the available cadastral industry is still needed. Therefore, at this moment the Egyptian decision makers have developed more awareness of the benefit and feasibility of spatial information in the cadastral field than several years ago. Quantifying the cultural awareness can be overseen through the maps and handhold GPS receivers' sales normalized by population and mapped between 10 and 0.

3.2.3 Cultural Ability to Reform (S3)

We have to confess that quantifying the cultural ability for reform is something tough. Therefore we will consider several factors for developing this element. The first element is the political system of the nation under consideration. Any nation with democratic regime will be granted 6 points of the scale. The remaining 4 points are distributed among the democracy age and the level of educations of their citizens. Two points are granted to nations with democracy older than 5 years whereas the remaining two points are granted to the citizens' educational level. The latter can be obtained from the UNICEF adult education statistics for males and females (UNICEF, 2004). The weighted average is used to combine male and female statistics to produce one value mapped between 0-2.

3.2.4 Level of Centralism (S4)

Level of centralism is one among the obstacles of the growth in developing nations. Less level of centralism expresses a flexible and fast level of work flow, whereas more centralized work environment architecture dictates a slow and bureaucratic style of decision making. Quantifying the level of centralism can be expressed by studying the style of political administration of the country under considerations. A credit of 5 points is given to countries with federal style where each district operates its activities and fund without returning to the corresponding nation headquarter. Another credit of 3 points is assigned if the districts have the ability to implement their own plan that meets the national and district interests. The remaining two points will be assigned to the ability of local districts to apply for external funding.

3.2.5 Involvement Level of Non-Governmental Organizations (S5)

The higher the level in which the private sector invests and contributes towards the spatial infrastructure, the better is the status of the spatial information infrastructure. An effective appraisal is chosen to be the ratio of private sector investment in the spatial information field compared with the government investment mapped to 10-0 scale.

3.2.6 Transparency Index (S6)

Corruption is an obstacle to sustainable development. The most recent transparency international corruption perceptions index (TI, 2004) can express how mature and professional are the managerial and administrative policies. This index is based on several statistic sources from prestigious organizations such as World Economic Forum, World

Markets Research Centre, International Institute for Management Development, World Bank. Therefore, this index is a trust worthy scale and has a scale from 1 to 10. An example of this index is given in Table 3.

Rank	Country name	Corruption Perceptions Index (CPI)
1	Finland	9.7
2	New Zealand	9.6
71	China	3.4
97	Algeria	2.7

Table 3 CPI index (source: TI, 2004)

3.2.7 Financing and Pricing Policies (S7)

Depending on the source of funding of the national mapping organizations, several measures can be drawn. Mainly, three forms of funding exist: solely governmental funding; mixed governmental and sales funding; and cost recovery policy. National mapping agencies with cost recovery policy control the pricing of its products and interact much with citizens as well as other international funding organizations. This is the most flexible and successful form. As such 10 points are granted to NMOs operate on this policy. Mixed government and sales funding organization will granted 7 points as the pricing policy and products may be controlled by the government. The last form is the solely governmental funded mapping organizations and is granted 4 points due to the lack of flexibly and pricing polices.

3.3 Index Example

Presented in this section are two simulated examples of the USISI. The purpose of showing these two examples as shown in Tables 4 and 5 is to demonstrate how helpful is this index for donating organizations as well as high level decision makers. An example for that is the preference of an international organization to train cadastral stuff at country X or Y. according to the proposed index. Country-Y lacks Spatial DB and needs to adopt metadata. On the other hand country X looks promising because it has spatial DBs, global data model, and metadata. So, based on the type of training that is offered by this donating organization, the right decision can be taken.

Geospatial Aspects							Socioeconomic Aspects												
G1			G2	G3	G4		S1		S2	S3			S4			S5	S6	S7	
4	2	2	4	2	5	5	0.2	0.15	0.00001	6	0	0.9	5	1	1	2	0.4	7	

Table 4 USISI for country X

Geospatial Aspects							Socioeconomic Aspects												
G1			G2	G3	G4		S1		S2	S3			S4			S5	S6	S7	
4	0	2	2	4	0	0	0.3	0.2	0.0001	0	0	1	0	0	0	1	0.4	4	

Table 5 USISI for country Y

Keys:

G1	- Status of Spatial Reference Frames
G2	- Existence of Analog Maps
G3	- Availability of Spatial DB
G4	- Existence of Global Data Model and Metadata
S1	- Quality of human resources
S2	- Cultural awareness of the benefits of spatial information
S3	- Cultural ability to reform
S4	- Level of centralism
S5	- Involvement level of non-governmental organizations
S6	- Transparency Index
S7	- Financing and pricing policies

3.4 Summary and Conclusions

The purpose of this paper was to develop a unified spatial infrastructure status index to help decision makers and funding organizations to direct their priorities and funds toward the most appropriate country (ies) or spatial infrastructure sector. The preliminary elements of the proposed index have been developed. More revision for these elements will be done and a case study gathering several developing nations will be applied.

REFERENCES

Groot, R. and McLaughlin, J. (2000), GeoSpatial Data Infrastructure, Oxford University Press.

Transparency International, 2004 URL http://www.unicef.org/infobycountry/index.html

UNDP, 2003 2003 Arab Human Report 2003, Building a Knowledge Society, A.03.III.B.9 ISBN 92-1-626000-9.

UNICEF, 2004 URL: http://www.unicef.org/infobycountry/index.html

BIOGRAPHICAL NOTES

Mohamed Abdel-salam obtained B.Sc. and M.Eng. as well as M.Sc. from Cairo University, Egypt, and ITC, the Netherlands, respectively. For the last three years he has been a PhD candidate in the Department of Geomatics Engineering at the University of Calgary, Canada, where he has been involved on different research projects, among them is the use of GPS for precise point positioning and atmosphere sensing. He is currently applying GPS and remote sensing knowledge toward the enhancement of spatial information infrastructure of developing nations.

Mohamed Mostafa obtained B.Sc. and M.Sc. from Ain Shams University, Egypt, and ITC, the Netherlands, respectively. For the last year he has been a PhD candidate in the Department of Civil Engineering at Ain Shams University, Egypt. For the last four years he has been managing the GIS, Scientific Department and R&D at the ITI, Egypt. His research focuses on the development of spatial information infrastructure of developing nations.

CONTACTS

Mohamed Abdel-salam
The University of Calgary
Department of Geomatic Engineering
2500 University Drive N.W.
Calgary, AB, T2N 1N4
Canada
Phone (403) 399-5014
Fax (403) 284-1980
mabdel@ucalgary.ca
www.ucalgary.ca/~mabdel

Mohamed Mostafa
Information Technology Institute
R&D Department
241 Al-Haram Street.
P.O. box 12111, Giza
Egypt
Phone +20 2 386-8420
Fax +20 2 386-8429
mostafam@iti-idsc.net.eg
http://www.iti.gov.eg/itiprofile/Staff/ResearchUnit.shtm