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**Critical issues in global geographic information management-
with a detailed focused on**

Data Integration and Interoperability of Systems and Data

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1. INTRODUCTION

The GSDI Association continues its support for the United Nations for taking the initiative on this critical global geographic information issue; and is willing to contribute to new arrangements to improve global geographic information management.

The role of the GSDI Association, in essence, is to facilitate better global outcomes through utilisation of geographic information and spatial data infrastructures (SDIs). This role directly complements the proposal to establish a United Nations Committee on Global Geographic Information Management (UNCGGIM). The GSDI Association's view of the changes now taking place in the geographic information world and these changes exemplify convergence of technologies and disciplines. These changes need to be influenced where appropriate, and leveraged, by the global geographic information community, particularly by the United Nations.

This paper presents some views related to the "critical issues in global geographic information management" and in particular a response to the following issues:

- Governance: is global governance relevant and necessary?
- Interoperability of systems and data
- Data integration and layering, and
- Capacity building and technology transfer

In responding to these issues, the paper however provides a more detailed discussions on "interoperability of systems and data" and "data integration" in particular the technical and non-technical issues and heterogeneity associated with multi-sourced spatial data integration in the context of SDI).

2. SPATIAL INFORMATION AND DATA ACCESS

Ready and timely access to spatial information - knowing where people and assets are - is essential and is a critical tool for making any informed decisions on key economic, environmental and social issues. Spatial information is an enabling technology/infrastructure for modern society. It can be a unifying medium in which linking solutions to location. This can be a response to our increasingly complex and rapidly changing world. In this environment, meeting sustainable development objectives and responding to Millennium Development Goals (MDGs) are also complex and temporal processes which involving multiple stakeholders. The creation of economic wealth, social stability and environmental protection in line with MDGs can be achieved through the development of products and services based on spatial information collected by all jurisdictions and all levels of governments. These goals and objectives can be facilitated through a better management of information and development of a spatially enabled government and society, where location and spatial information are regarded as common goods made available to citizens and businesses to encourage creativity and product development. This requires data and services to be accessible and accurate, well-maintained and managed and sufficiently reliable for use by the majority of society which is not spatially aware. This is inline with the objectives of the proposed UN Committee on Global Geographic Information Management (UNCGGIM) and also it is inline with the current GSDI Association strategy on spatially enabled societies.

Spatial information and technologies are key tools in transformation of our relationships with our physical world by using place and the way we use our social networks which are changing as we deploy technology in new ways to create new ways of interacting with each other. The 'spatial enablement' that these tools create can reshape our lives. Having said that, the user demand has also shifted to seeking improved services and delivery tools. This will be achieved by creating an environment so that we can locate, connect and deliver spatial services.

The effective management and sharing of information across agency boundaries will result in information being used more efficiently and effectively. This will provide significant benefits, including:

- reduced costs of information collection and management through streamlined collection, processing and storage;
- improved decision making for policy and business processes, resulting in more integrated planning and enhanced government service delivery;
- improved timeliness, consistency and quality of government responses –information will be easily accessible, relevant, accurate, and complete;
- improved accountability and transparency for citizens;
- reduced costs and added value for government through reusing existing information, sharing infrastructure and designing integrated, collaborative methods of delivering services;
- improved national and jurisdictional competitiveness; and
- improved national jurisdictional security.

In facilitating this and to improve access, sharing and integration of spatial data and services, spatial data infrastructures (SDIs) have emerged as enabling platforms. SDI as an enabling platform is an integrated, multi-leveled hierarchy of interconnected SDIs based on partnerships at corporate, local, state/provincial, national, multi-national (regional) and global levels. This enables users to save resources, time and effort when trying to acquire new datasets by avoiding duplication of expenses associated with the generation and maintenance of data and their integration with other datasets. However, SDI is an evolving concept and can be viewed as an enabling platform linking data producers, providers and value adders to data users. With this in mind, many nations and jurisdictions are investing in developing such platforms and infrastructures that enable their stakeholders to work together in a more mutual approach and to create distributed virtual systems that support better decision-making. At the same time, these nations and jurisdictions need a system to assess and monitor the development and performance of the platform.

Spatial enablement is one form of interoperability stemming from the capacity of a computer to identify "where" something is. It is, however, far more versatile than a mere organizational tool and offers opportunities for visualization, scalability, and user functionality. The capacity of computers to place information in on-screen maps and to allow users to make their own inquiries has raised the profile of spatial enablement. This is further underpinned by the "open systems" of service-oriented IT architecture that allows governments, enterprises, organizations, and citizens to build their own applications on top of authentic registers and maps and their connected data services.

One of the key objectives of SDIs is facilitating access to a wide range of spatial data from various custodians and agencies and different jurisdictional levels. There is now a need to take SDI to the next level through incorporation of the ability to integrate and respond to the interoperability of the datasets available, specifically built (eg. cadastre) and natural (eg. topographic) spatial datasets.

This integration involves an understanding and documentation of issues and problems within and between jurisdictions within different regions worldwide. Integration of externally sourced spatial data and information has raised many technical problems such as semantic and modeling heterogeneity and there is a need to develop policies, programs, logical and physical architecture and deliverables that removes duplication of effort in attempts to solve these technical problems. There is a need to build a framework for the reciprocal exchange of fundamental infrastructure with the risk of misuse or misapplication of built and natural environmental datasets effectively managed. This includes the creation of models that cater for both high end and highly resourced as well as low end and lowly resourced organizations.

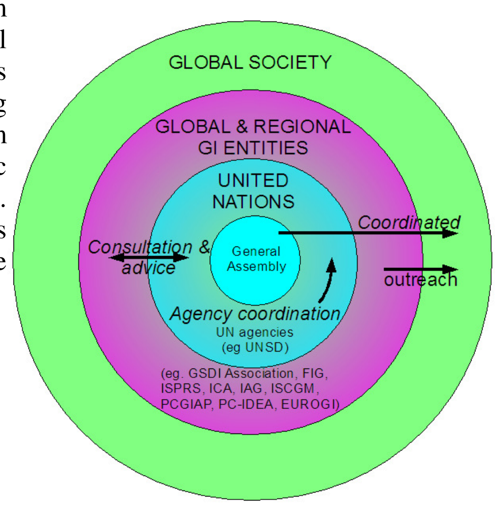
3. GOVERNANCE

The effective management of information requires good governance. Organizational arrangements have long been recognized as a critical enabler and fundamental component of any initiatives and platforms such as this for UNCGGIM. Due to the nature of UNCGGIM committee, the pattern of governance would be characterized as a global and multi-level governance, a system of negotiation between members at several territorial levels with tiers of member states and international organizations involved in policy networks that transcend territorial boundaries. Both vertical interactions and horizontal interaction occur at each level.

Furthermore, Governance which deals with collective decision-making is clearly a function or aspect of organizational arrangements. Given the typically large number and diversity of spatial data and SDI stakeholders linked through multiple overlapping, interacting networks and the need to facilitate the rapidly evolving, and increasingly collaborative approaches to spatial data management and SDI implementation, governance represents a significant challenge. In terms of SDI and spatial data management platforms such as UNCGGIM, the recent emergence of and interest in these governance, reflects the evolving nature of the platform such as SDI, and the socio-political context in which these platform exists.

The primary challenge of governance is reconciling collective and individual needs and interests to achieve common goals through collective decision making. Coordination provides the critical link between the 'steering' processes of governance and the 'rowing' activities of individual actors that move the community in the required direction. In the context of SDI and spatial information management comprising distributed capabilities that are under different ownership, and are developed and operated independently the role of coordination is critical. By differentiating between coordination and governance functions both of which are major aspects of institutional arrangement, we are able to describe the institutional architecture and arrangements of governance - authority structures.

With this in mind, GSDI has presented its overall views on the structure and memberships of UNCGGIM through its scoping paper at the first preparatory meeting for UNCGGIM, October 2009. As suggested, the objective of a UNCGGIM should be three-fold. Firstly, it should aim to facilitate better outreach by both the both the United Nations and the various Global and Regional Geographic Information entities with the global community. From a GSDI Association perspective this aim should be to ensure a coordinated approach to the "spatial enablement of global societies". The United Nations provides a key to facilitating spatial enablement in developing economies and societies. Secondly a UNCGGIM should aim to assist the United Nations in achieving better geographic information management within and between UN agencies. Thirdly, a UNCGGIM should aim to achieve better outcomes from, and coordination of, UN regional forums such as the UNRCC-AP. This idea is illustrated in Figure 1 below.



Common objective
Spatial enablement of global societies

A UNCGGIM should:

- operate in a consultative, advisory and communicative way to meet its objective;
- undertake a manageable and achievable portfolio of projects that demonstrate its ability and effectiveness in meeting its objective;
- be accountable, and regularly report, to the United Nations General Assembly on its activities;
- be adequately resourced by the United Nations,

particularly in ensuring that the interests of the developing world are properly addressed; and
- UNCGGIM should be chaired by the United Nations.

Membership of a UNCGGIM should:
- represent global GIM interests. These interests include both public and private sectors, and both developed and developing economies, and include United Nations agencies and research and education institutions. The latter interest group is often overlooked in GIM arrangements notwithstanding that capacity building is one of the most important and difficult issues requiring attention;
- comprise parties who are legitimately involved in GIM and who are credible in the eyes of the global community;
- have effective links to other global and regional geographic information entities.

4. INTEROPERABILITY OF SYSTEMS AND DATA

Interoperability is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units. In the context of information systems, interoperability is the ability of different types of computers, networks, operating systems, and applications to work together effectively, without prior communication, in order to exchange information in a useful and meaningful way (Inproteo 2005).

In the spatial context, spatial interoperability is "the ability of a spatial system or components of a spatial system, to provide spatial information portability and inter-applications cooperative process control" (Bishr, 1998). Or defined by ANZLIC (2005), as the ability to link together spatial data, information and processing tools between different applications, regardless of the underlying software and hardware system and their geographic location. According to ISO/TC 211, the spatial interoperability is:

- the ability to find information and processing tools, when they are needed, no matter where they are physically located
- the ability to understand and employ the discovered information and tools, no matter what platform supports them, whether local or remote
- the ability to participate in a healthy marketplace, where goods and services are responsive to the needs of consumers.

Interoperability aims to overcome the inconsistency between diverse systems. In addition, there are different drivers and needs for interoperability including:

- Reduce costly data acquisition, maintenance and processing.
- Provide direct, on-demand access that reduces time and cost. On-demand spatial information means being able to access the desired spatial information in its most current state, with correct representation when we need it.
- Encourage vendor-neutral flexibility and extensibility of products. Vendor-neutral products comply with open standards and are independent from underlying software/hardware.
- Save time, money and resources.
- Enhanced decision-making.

Along this line, data interoperability may also be described as the ability to transfer and use data and information in a uniform and efficient manner across multiple organizations and information technology systems. Improving the capability of governments to confidently manage, transfer and exchange information is critical to achieving the benefits of today's societies. There is a need to identify those components that support an environment where information that is generated and held by governments and systems delivering services will be valued, worked and managed as part of national strategic assets. There is also a need to develop a framework to provide the principles that underpin sound information management and establishes the concepts, practices and tools that will drive the successful sharing of information across countries and also government's boundaries.

In general, there are different interoperability perspectives; information, technology and processes. In this line, and in order to facilitate data sharing and integration to assist government business processes, the Australia Government has developed an interoperability framework which contains the three perspectives, as represented in Figure 2 blow (AGIMO 2006):

- the Information Interoperability Framework;
- the Technical Interoperability Framework; and
- the Business Process Interoperability Framework.

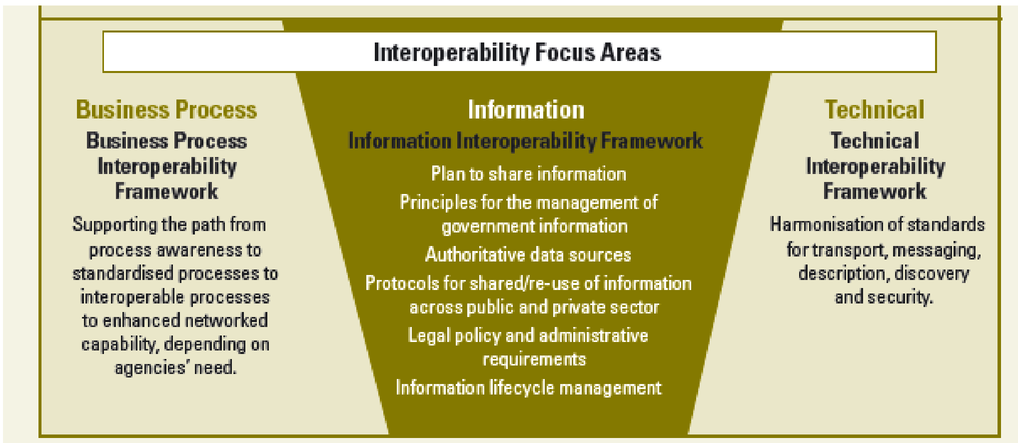


Figure 2: Interoperability Focus Areas

This framework provides a platform for the development of Information Interoperability capacity. It will also help to establish a shared understanding of information barriers, enablers, principles, and practices. This understanding then will underpin improved ability to share information across agencies. However, information interoperability across governments requires a commitment by agencies to the information management principles; a culture of collaboration; and the adoption of agreed standards for managing and sharing information.

Having said that, the activities that individual agencies then can undertake to build capability in this area would include:

- assessment of the agency's information management capability;
- assignment of responsibility for information management and information interoperability to decision makers;
- collaboration with other jurisdictions and agencies in the same portfolio/sector to develop governance arrangements, plans, standards, and practices for improving information exchange across the sector;
- compliance with the standards used widely across country and government;
- active participation in appropriate national and international forums;
- adoption of tools to facilitate effective information sharing across jurisdictions and agencies;
- provision of specific training to officers at all levels; and introduction of regular audits of information capability across the jurisdiction and agency.

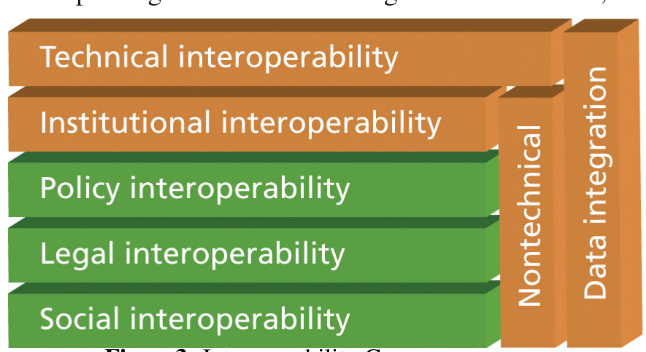


Figure3: Interoperability Components

Having these interoperability perspectives in mind, interoperability covers different aspects as illustrated in

Figure 3. An essential feature of a successful SDI is the interoperability of systems and information. The SDI shares reliance on interoperability with other information platforms. In this context, and in the context of data integration as part of SDI platform, there are also different technical and nontechnical issues such as legal, policy, institutional, and social factors that affect interoperability.

With regard to the technical interoperability, many types of heterogeneity arise because of differences in technical systems supporting data sharing - for example, differences in databases, data modeling, hardware systems, software, and communications systems. The differences in database management systems (DBMS) largely come from data models, which have direct influence on data structure, constraints, and query languages. Moreover, in order to satisfy market needs, the data must be reliable and timely for all users. In order to minimize data duplication, data-sharing partnerships among data producers are coordinated so that there are fewer conflicts in data standards (Tuladhar et al. 2005). Technical interoperability issues also arise when Web services are built - for example, for cadastral information. Technical interoperability is maintained by continued involvement in the development of standard communications; construction of data exchange, modeling, and storage as well as access portals; and interoperable Web services equipped with user-friendly interfaces.

Also, there are different critical enablers underpin the successful achievement of interoperability:

- Infrastructure (governments and agencies need to develop appropriate infrastructure and adopt relevant standards and protocols).
- Business Agreements/MOUs (forming partnerships that work in a spirit of collaboration and business models);
- Establishing appropriate governance arrangements;
- Using a 'create once, use many ' approach, with authoritative sources of information;
- Privacy and copyright (understanding the policy and legal framework governing the exchange of information);
- Adopting a common business language and standards (spatial data standard interchange formats (eg., SDTS and GML)
- Security and information assurance;
- Quality, Metadata and Network.
- Developing and using tools that facilitate the transfer of reliable information across jurisdictions and agency boundaries (Geo-web Services; network, etc).

4.1 Information Management Principles: the foundation for Information Interoperability

Information that is shared needs to be managed. The following information management principles provide the foundation for Information Interoperability and will serve to support a culture of reusing existing information within government.

- Manage information as an asset and a strategic resource.
- Standardize information management practices.
- Generate information to support decision making.
- Collect quality information.
- Re-use information from single authoritative source.
- Promote trust and confidence, rights and responsibilities.
- Achieve a net social benefit.

Effecting strong information interoperability across jurisdictions and agencies may call also for multiple levels of governance as discussed above and the level of governance required will also reflect the policy/business driver, the interest of government and the number of participating jurisdictions and agencies.

5. SPATIAL DATA INTEGRATION

Most data providers use their own approaches to coordinate spatial data, especially for data integration purposes with focus on a limited number of areas/disciplines. Single-disciplinary approaches suit a particular group of stakeholders and do not satisfy the needs of different disciplines. However, the ideal situation is that different stakeholders from different disciplines can interact easily with other stakeholders for sharing, access and the integration of datasets. In a single-disciplinary approach, a particular group of users is targeted and most policies and initiatives are developed to meet their needs. This leads to inconsistency among datasets and causes more inconsistencies among multi-sourced data sets. On the other hand, a multi-disciplinary application of spatial datasets forces the service beyond a single discipline.

Spatial data applications rely heavily on multi-sourced spatial data, however the number of heterogeneous multi-sourced spatial datasets is growing rapidly. This hinders effective data integration. In order to deal with the heterogeneity, much time and cost is spent by users to investigate the problems and develop the necessary tools and guidelines in order to effectively integrate multi-sourced spatial data. Effective data integration can be achieved more efficiently if both technical and non-technical issues associated with data integration are addressed and investigated within a holistic framework. This aim can be facilitated within the context of SDIs.

One of the aims of an SDI initiative is to integrate multisource spatial datasets. Many reports highlight the heterogeneity and inconsistency of these initiatives and activities and attempt to address these impediments by documenting the technical inconsistencies (Fonseca 2005; Jones and Taylor 2004; Hakimpour 2003). Technical inconsistencies tend to arise from nontechnical aspects and fragmentation of the social, institutional, legal, and political arrangements affecting individual data custodians and organizations.

It was identified that effective spatial data integration does not only require providing technical mechanisms to facilitate integration including the geometrical and topological match of data and a correspondence of attributes (Usery et al., 2005). It also includes the establishment of appropriate institutional, policy, legal, and social mechanisms which is required to facilitate the integration of multi-sourced spatial data as illustrated in Figure 4 (Mohammadi et al. 2006). The 17th UNRCC-AP's Resolution 4 (2006) also insisted and highlighted legal, policy, social, and institutional issues of integration.

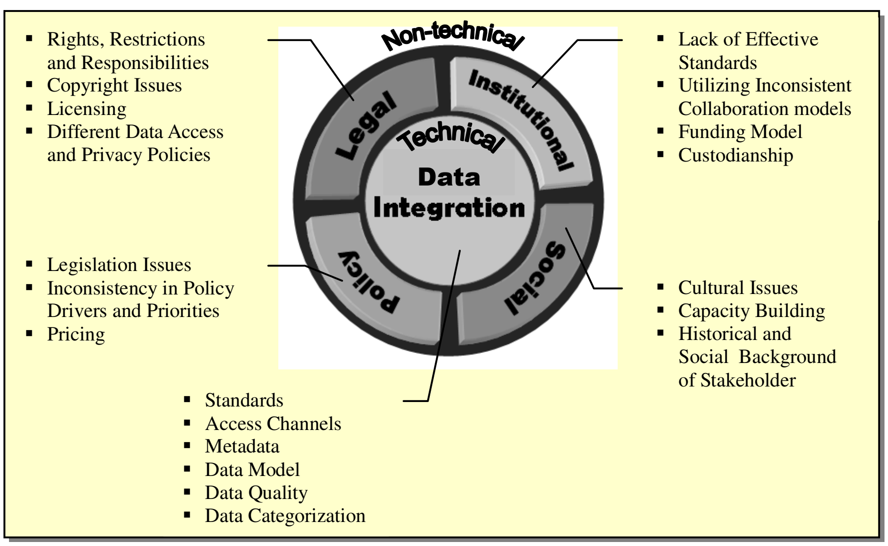


Figure 4: Technical integration and associated non-technical considerations

With this in mind, the development of integrated datasets for a nation or a jurisdiction is a cultural and institutional challenge more than a scientific one. Therefore, there is a need to develop a data model, framework and strategy to facilitate organizations to better tackle this challenge and be more proactive in developing relationships at all levels of government. This includes a critical examination of philosophies, structures and processes and is significant to both industry and governments alike. The design of an integration platform requires development of a set of concepts and principles that facilitate interoperability.

Efforts to establish a sharing platform such as SDI will fail unless a coordinated approach is used to address all the issues and inconsistencies associated with multisource data integration, summarized in Table 1 (Williamson et al. 2009).

Table 1 – INTEGRATION ISSUES			
TECHNICAL ISSUES	**NONTECHNICAL ISSUES**		
Institutional issues	**Policy issues**	**Legal issues**	**Social issues**
Computational heterogeneity (standards and interoperability) Maintenance of vertical topology Semantic heterogeneity Reference system and scale consistency Data quality consistency Existence and quality of metadata Format consistency Consistency in data models Attribution heterogeneity Utilization of consistent collaboration models Funding model differences Awareness of data integration	Existence of supporting legislation Consistency in policy drivers and priorities (sustainable development) Pricing	Definition of rights, restrictions, and responsibilities Consistency in copyright and intellectual property rights approaches Different data access and privacy policies	Cultural issues Weakness of capacity-building activities Different backgrounds of stakeholders

To create such an environment in which different datasets can be integrated across applications, the infrastructure should provide a suite of tools and guidelines, including standards, policies, and collaboration requirements.

The technical, institutional and policy issues concerned with integrating framework datasets are recognized internationally as a major priority by UN conferences in Asia-Pacific and the Americas [Resolution 5, 6th UN-Regional Cartographic Conference for the Americas, New York 1997 (E/CONF.90/3); Resolution 5, 7th UN-Regional Cartographic Conference for the Americas, New York 2001 (E/CONF.93/3)]. For example, Resolution 15 adopted by the 14th UN Regional Cartographic Conference for Asia-Pacific (UNRCC-AP) calls for an investigation into "issues, problems and solutions concerned with integrating digital cadastral mapping with large-scale topographic mapping within the context of a wider national spatial data infrastructure" (14th UNRCC-AP, 1997). An approved strategy for this investigation requires exploration and justification of associated conceptual, institutional and technical issues (16th UNRCC-AP, 2003).

For example, use of integrated cadastral and topographic data to deliver sustainable development objectives was identified in the UN Bogor Declaration on Cadastral reform- section 4.7 (FIG, 1996) and the UN Bathurst Declaration on Land Administration for Sustainable Development (FIG, 1999). These declarations also highlight the need for sharing of integrated data among nations, particularly to address common ecological problems.

The amount of heterogeneous multi-sourced spatial data sets is growing dramatically. Users spend much effort and money to identify and overcome the inconsistencies in order to integrate data sets. In order to effectively integrate heterogeneous data sets, SDIs can play a role in providing the necessary technical and non-technical tools. From a technical perspective, capitalizing on interoperability and state-of-the-art technologies, Geo-web services are able to assist users in the development of tools. Incorporating guidelines and standards proposed by SDI can also facilitate the integration of heterogeneous data sets. SDIs assist practitioners in addressing non-technical and technical issues within a framework of policies and standards.

Demands and requirements of new and emerging spatial services are also expanding beyond framework datasets. Single-purpose value-added datasets and collaborative products meet some of the needs of spatial services across spatial data value change (fundamental/framework data collection, value added data, collaborative product, integrated data product), however many services and applications now rely on multi-sourced spatial data. In this regard, multi-sourced data integration has become a significant issue as it ensures effective use of spatial data by many spatial users and applications. This creates many opportunities and possibilities for using and applying spatial datasets in a broad range of services including emergency services.

Technical issues related to multisource data integration can be addressed by appropriate standards and compliances. As part of this, a lack of vertical topology will hinder the capacity to analyze datasets. Consistent data models permit effective analysis. The quality of data, including accuracy, coverage, completeness, and logical consistency, is important both for integration of data and to avoid mixing high-quality and low-quality data. Good metadata improves users' ability to integrate data. Lack of a reference system and format heterogeneity hamper efficient data integration.

Non-technical issues and interaction between people and data can be achieved through the policy component.

5.1 Data Integration Challenges

There are many issues hindering effective data integration from both technical and non-technical perspectives. In order to effectively integrate spatial data, standards and specifications are required to deal with technical inconsistencies including metadata, quality, attribution and logical inconsistency. If not standardized, any attempt to integrate spatial data is confined to the framework of single initiatives. Integration at the attribute level is required for some levels of analysis which is based on joint queries and non-spatial analysis, hence, inconsistencies of attributes including inconsistencies in attribute type, attribute specification and content need to be addressed. However, this task can be done at logical data modeling, but still needs attention if practitioners are reluctant to get their hands dirty with data modeling. Spatial and non-spatial accuracy is also an issue if integrated products are used for non-spatial queries and metric spatial analysis including area and distance calculations.

Diversity in spatial reference systems (datum and projection systems), scales and formats hinders easy data integration and requires time and cost to cope with data preparation. Integration of data models facilitates a greater degree of cross-data set analysis from both spatial and non-spatial perspectives.

Some spatial analysis depend on data sets which monitor features at a certain point of time, hence currency of data becomes a critical issue for mentioned analysis. Completeness of data sets also assists more accurate results; however the latter two issues (currency and completeness) together with issues including geometrical and logical consistency are crucial for integration and also other purposes. But, different datasets with different currency and completeness are more problematic. Metadata and its content can play a key role in data integration as it can provide information on consistency of data sets. Information on some of the above mentioned issues including accuracy, geographical extent, spatial reference systems etc are included in most common metadata standards.

The non-technical problems including institutional, policy, legal and social issues are also major concerns, as highlighted by Syafi'I (2006) and Mohammadi et al (2006). Therefore, Effective multi-sourced data integration requires the provision of a number of technical and non-technical prerequisites. Data preparation for integration is not achievable easily unless these prerequisites are identified and coordinated under a single holistic framework. Without the establishment of standards, policies and technical tools, multi-sourced spatial data integration is problematic.

SDI can provide guidelines and standards together with policy frameworks to address non-technical issues associated with integration. It also can help practitioners to develop integration technical tools based on standards and guidelines.

Each of the technical and nontechnical inconsistencies and challenges impeding data integration needs to be identified and resolved. In most countries, each dataset is managed by a data custodian that follows unique strategies and policies for data creation, coordination, sharing, and usage. Thus, most of the integration steps are not technical. Data integration involves much more than the geometrical and topological matching of data and ensuring that feature attributes correspond (Usery et al., 2005). It also requires addressing all nontechnical legal, policy, institutional, and social factors that affect interoperability. These integration issues need to be framed in the context of the SDI model and the history and priorities of the jurisdiction. Each part of an SDI, including the cadastral layer, needs to be based on national organizational, economic, social, and other priorities.

Practitioners put much effort and time to investigate the data and accompanying documents including metadata to find out the characteristics of the data and inconsistency with other data sets. They sometimes also go through the actual data to identify the characteristics of the data including spatial and non-spatial accuracies. Beside this, the assignment of the best solution in form of guidelines or standards is another challenge which should be addressed properly (Figure 5).

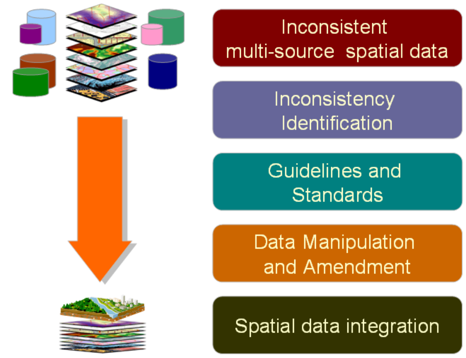


Figure 5: Steps for spatial data integration

Most applications that rely on integrated data suffer from a lack of automatic mechanism to identify the inconsistency among datasets and a mechanism to assign available solutions to overcome the inconsistency. Therefore a tool can sit between data provider and user and takes the responsibility of validating data against the integrability measures (Figure 6).

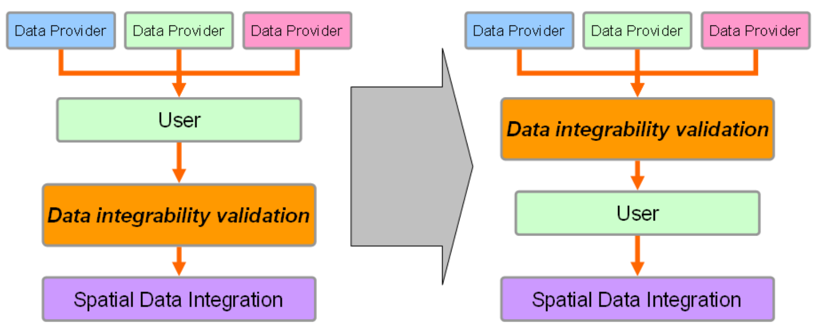


Figure 6: New approach for data integrability validation

Based on this approach, the tool provides access to multi-source data and validates data against measures of integrability and facilitates the effective data integration. Based on the requirement of any particular application of jurisdiction, any measurable technical and non-technical integrability measure can be adopted by the tool. Many technical characteristics of data sets can be investigated and extracted from data and accompanying documents including metadata and privacy policy. This includes format, scale, geographical extent, accuracy (spatial and non-spatial), currency, datum and projection system. Also, other information like access method, restrictions on data, pricing policy and availability of metadata can be found to some extent. This provides bases for data comparing and validating.

5.2 Data Integration Project in Asia-Pacific

Due to the importance of data integration and in particular integration of natural and built environment datasets in the context of a National SDI, a project has been defined through the Working Group 3 (Spatially Enabled Government) of the UN sponsored Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). The project also was supported by the Australian Research Council (ARC) and was managed through the Centre for SDIs and Land Administration, The University of Melbourne in 2005-2009 (Rajabifard and Williamson 2006). This project primarily aimed to better understand and describe the technical, jurisdictional, institutional, legal and land policy perspective surrounding the two foundation datasets (cadastral and topographic) in a National SDI. In order to achieve this aim, the project has investigated the justification for integrating multi-source spatial data in support of sustainable development. It also developed a guideline and associated tools for integration capable of being used in diverse jurisdictions.

The project relied on new and cutting edge technologies in ICT to develop opportunities for data integration and access. The project advanced knowledge and understanding of the ability of National SDIs to deliver sustainable development objectives in a modern information society. This was achieved through the development of new concepts and policies to integrate multi-source spatial datasets. Increasingly, SDIs use the latest information and communications technology (ICT).

The project has adopted the SDI model (Figure 7) suggested by Rajabifard et al (2006) which consists of five major components including spatial data, stakeholders, policy framework, standards and access mechanisms which has been illustrated in Figure 8. The model underpins the interaction between spatial data and spatial data stakeholders in a general sense. Based on this model, the project has developed a detailed model for SDI to illustrate the required elements for data integration. Figure 8 illustrates an SDI detailed model with its components which have aimed to facilitate spatial data integration to serve multi-disciplinary applications.

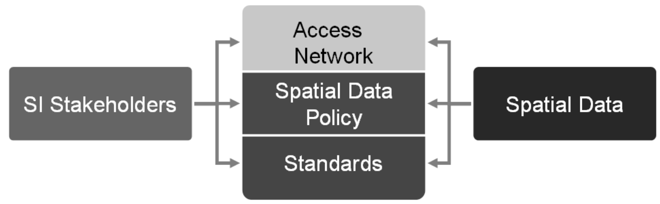


Figure 7: SDI and its technological components

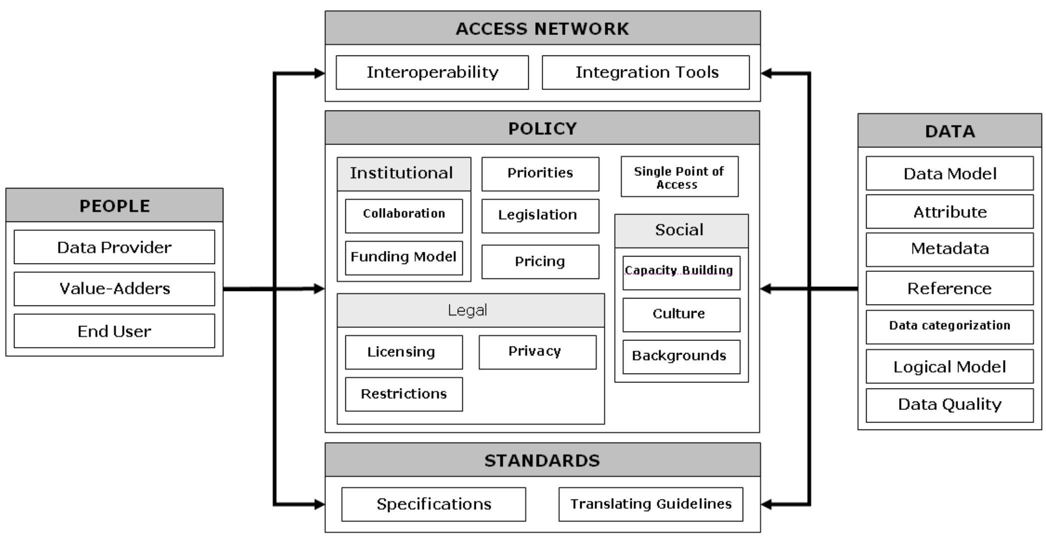


Figure 8: Integration elements in the SDI model

The expanded SDI data integration model highlights and identifies different issues involved in data integration. This model assists practitioners to consider the spatial data integration issues in a holistic view and in relation to other elements. In this model, the technical issues of data integration have been considered alongside with non-technical issues. Using this model and as part of the project, an Integration GeoWeb System (Integration GWS) for testing the integrability of datasets for the integration has been developed and delivered Asia-Pacific member nations. The Integration GWS is a desktop application which can crawl distributed datasets through the internet. GWS is able to read data and get information from data including reference system, attributes, geographical extent etc. Metadata also provides a suitable source of information about data.

The Integration GWS then compare information and look for items of inconsistency. If there is no inconsistency and no restriction of use data is displayed at next phase, otherwise user is provided with report on inconsistency and also instruction to resolve inconsistency. Figure 9 outlines the main components of the Integration GWS as a whole (Mohammadi et al. 2010).

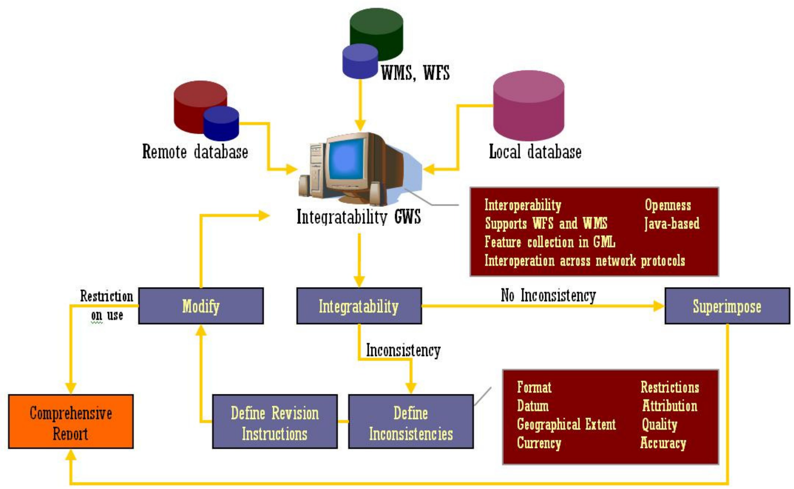


Figure 9: Components of integration GWS

For more detailed information about the Integration GWS system and also access to the software visit PCGIAP-Working Group 3 website (www.pcgisp.org).

6. CAPACITY BUILDING AND TECHNOLOGY TRANSFER

Capacity building and technology transfer is one of the important and a key issue for designers of any spatial and geographic information management. Traditionally, capacity building focused on the short term by means of staff development through formal education and training programs to meet the lack of qualified personnel. But capacity building measures must be seen in the wider context of developing and maintaining institutional infrastructure in a sustainable way. Only then can capacity needs be met and adequate responses at the societal, organizational, and individual level be made.

However, the wider concept also diagnoses a serious lack of institutional capacity in many countries to undertake spatial data and management activities in an adequate and sustainable way. Especially in developing countries and countries in transition, national capacity to manage and use spatial information and in particular manage land rights, restrictions, and responsibilities is not well developed in terms of mature institutions and the necessary human resources and skills. This new approach to capacity development is influenced by today's globalization of the acquisition of knowledge. Capacity development and technology transfer is arguably one of today's central development challenges, since continuing social and economic progress will depend on it.

With this in mind, therefore there is a need for a global agenda for capacity building and technology transfer for countries in the context of spatial information and this can be developed and managed by UNCGGIM. This element is also very inline with the objective of GSDI which promotes international cooperation and collaboration in support of local, national and international spatial data management and infrastructure developments that will allow nations and their citizens to better address social, economic, and environmental issues of pressing importance. The Association also promotes the informed and responsible use of geographic information and spatial technologies for the benefit of society (GSDI 2010).

Capacity building is not a linear process. Whatever the entry point and the issue in focus, it is frequently necessary to incorporate the conditions and consequences at the upper or lower level as well. Capacity building should be seen as a comprehensive methodology aimed at providing sustainable outcomes through assessing and addressing a wide range of relevant issues and interrelationships.

Strategies for capacity assessment and development can be focused at any level, provided they are based on a sound analysis of all relevant dimensions. Capacity issues are often first addressed at the organizational level. Organizational capacity - such as the capacity of the national cadastral agency or the cadastral infrastructure and processes - is influenced not only by the internal structures and procedures of the agency, but also by the collective capabilities of the staff on the one hand and a number of external factors on the other. These external factors may be political, economic, or cultural issues that constrain or support performance, efficiency, and legitimacy.

Capacity development takes place not only within individuals, but also between them and in the institutions and networks they create - through what has been termed the social capital that holds societies together and sets the terms of these relationships. Most technology-building cooperation projects, however, stop at addressing the individual skills and institution building - they do not consider the larger societal level (UNDP 2002, Enemark and Williamson 2004, Rajabifard and Williamson 2004).

The United Nations Development Program (UNDP) offers this basic definition:

> *"Capacity can be defined as the ability of individuals and organizations or organizational units to perform functions effectively, efficiently, and sustainably." (1998)*

This definition has three important aspects:

1. it indicates that capacity is not a passive state but a continuing process;
2. it ensures that human resources and the way in which they are utilized are central to capacity development;
3. it requires that the overall context within which organizations undertake their functions will also be a key consideration in strategies for capacity development. Capacity is seen as two-dimensional: *capacity assessment* and *capacity development*.

Capacity assessment is the essential basis for formulating coherent strategies for capacity development. It is a structured and analytical process that assesses the various dimensions of capacity within a broader systems context, as well as evaluating specific entities and individuals within the system. *Capacity development* goes beyond HRD, because it emphasizes the overall system, environment, and context within which individuals, organizations, and societies operate and interact.

These ideas led to the UNDP offering an even more complete definition of capacity development (Williamson et al. 2009):

> *"… the process by which individuals, groups, organizations, institutions, and societies increase their abilities to perform core functions, solve problems, and define and achieve objectives; and to understand and deal with their development needs in a broader context and in a sustainable manner." (2002)*

FINAL REMARK

As a final word, the GSDI Association looks forward to the creation and effective operation of a UNCGGIM operating in close collaboration with, and with input from, international geographic information organizations. The author hopes this scoping paper provides some background information and justification to respond to the critical issues in global geographic information management and would also like to suggest further components such as the role of society in global geographic information management and also the impact of UNCGGIM on society and also the role of SDI and enabling platform to facilitate UNCGGIM objectives.

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BIOGRAPHICAL NOTES

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