

Spatial data infrastructure (SDI) for sustainable land management

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ABSTRACT

This paper elaborates on perspectives presented in the recent literature, which identify increased use of geoinformatics in the design of interdisciplinary geo-information systems and decision support systems for realizing sustainable land management at different scales and for specific user groups. The realization of the potential of geo-information systems in supporting sustainable land management depends on a number of factors. Efficient and reliable access to well-harmonized information is one of these. In this respect, the literature also alludes to an emerging digital geo-information infrastructure and policy framework at global, regional, national and local levels, which will make available, for example, significant soil research output that is now inaccessibly stored in archives and libraries. The paper presents the concept of geo-information infrastructure (GII) or spatial data infrastructure (SDI) as a tool to facilitate access to, and responsible use of geo-information at affordable cost in support of sustainable land management. It presents the notion that a national SDI is composed of networked SDIs which have been designed and implemented to serve very specific application sectors at the national, regional or municipal level. "Sustainable land management" could be such an application sector. The paper traces the history of the development of the SDI concept. It identifies the high expectations of national information infrastructure (of which SDI is a subset), in terms of achieving new economic and social development goals and improved public services, since President Clinton introduced the "electronic information highway" metaphor in his political platform. These expectations have also been expressed in the "information society" initiatives of the European Union. The paper illuminates the necessity of the legal and regulatory changes which will have to be made in order to achieve the open geo-information market that must be at the foundation of the expectations expressed. It will make the case that the technical developments and the institutional, organizational and human resources development in the design, implementation and maintenance of SDIs for a specific application sector must run in parallel. Successful sustained implementation will depend on clear "political" accountability for its integrity, and on a local regulatory environment that is in harmony with the more senior legislation and regulation at, *eg*, the national or supranational levels. The paper concludes with a set of recommended practices in the development of SDI.

To someone outside the field of sustainable land management, performing a rather cursory scan of recent literature, it is comforting to note that the thinking about land management and its professional practice has been at least as demanding as in my own field of surveying and mapping. In the latter, the combination of computer and communication technologies has been the driving force behind the manner in which the tasks of my profession are now perceived. Recognizing the profound changes in the profession, we no longer call it surveying and mapping but geomatics or geoinformatics. Furthermore, these technologic changes have provoked many national surveys to a critical consideration of their historic mandates, their standard activities and products, and their relationships with their clients, the private sector and other levels of government.

It appears that the land management profession has been affected considerably by the concept of sustainable land management (SLM). The evolution of land use planning to land management to sustainable land management shows that new names are reflecting new perspectives. In the operationalization of the SLM concept, the required interdisciplinary approaches demand the integration of many disparate datasets of varying pedigree. Furthermore, a great deal of innovation in the modelling of social and economic phenomena, physical phenomena and their interaction has been associated with this concept. In the management of the datasets, as well as the application of these models, we look to information technology for solutions. Hence, information technology is playing a more critical and complex role than necessary, for example, in the automated drawing of soil maps or other maps.

As these developments are unfolding, it is also becoming evident that efficient access to appropriately structured and spatially referenced data from many different sources is a necessary condition for realizing the full potential of information technology applications. To satisfy this condition, the concept of spatial data infrastructure (SDI) has been developed. The traditional tasks of national survey institutes may have to be considered in this light to ensure their ongoing relevance.

In this paper, I would like to elaborate on the "perspectives" presented by Beek [3]:

"(1) Information Technology will increasingly facilitate the development of integrated quantitative studies of land use systems based on the simulation of dynamic land use interactive processes.

(2) There is a strong tendency towards increased use of geo informatics in the design of interdisciplinary geo information systems and decision support systems for realizing sustainable land management at different scales and for specific user groups. *A digital geo information infrastructure and policy framework is emerging for this purpose at global, regional, national, and local levels. This will make a significant soil research output available that is now inaccessibly stored in archives and libraries*" [2].

The elaboration will concentrate on the part in italics. The concept of spatial data infrastructure (SDI) will be introduced. Although one could perceive of SDI at the global, regional, national or local level, both in government and the private sector they all have a similar structure which also supports their connectivity. This structure will be explained. The design, implementation and maintenance of SDI is not, however, a purely technical challenge.

SDI operates subject to policies that govern access,

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use, pricing of services, sustained financing, quality management and human resources development.

These local policies must operate within national or regional information policy constraints. The field of information policy is evolving from analogue applications (printed products and telecommunications) to digital, and is thus subject to change at this point in time. This, in turn, could in some cases create uncertainty for the elaboration of consistent policies concerning the access, use and financing of a particular SDI application.

This paper explains the conflicting policies many national surveys (including soil surveys) have to cope with in specifying their niche in the national spatial data infrastructure (NSDI). It concludes by suggesting some recommended practices in the design, implementation and maintenance of, for example, an SDI supporting sustainable land management.

SPATIAL DATA INFRASTRUCTURE (SDI)

TERMINOLOGY

The term “spatial data infrastructure” (SDI) is interchangeably used with the terms “geo-information infrastructure” (GII) and “geospatial information infrastructure” (also GII). SDI seems to be the term preferred in the USA literature. In Europe, particularly in Britain, the term “geospatial” is often used. Although I prefer the term “geo-information infrastructure”, its abbreviation can be confused with that of the emerging but generally accepted term “global information infrastructure” (GII). The term “geospatial information” is something of a pleonasm and therefore not preferred. Hence, in this paper, I have used the term “spatial data infrastructure” (SDI).

HISTORY

Since the late 1970s, many national survey and mapping organizations have begun to recognize the need to justify the large public investments they received by improving access, and encouraging a broader use of the information in their custody. They developed strategies and processes to standardize access to this information and its applications. During this process, they were forced to reconsider their traditional tasks. In most cases, they had to redefine their standard production lines, and develop new ones to respond to the demand for specialized products from a growing community of users demanding rapid access to digital framework data. In the 1980s and early 1990s, many countries (*eg*, Canada [7], the United Kingdom [8], the United States [15], the Netherlands [17]) undertook extensive reviews and studies to demonstrate the cost effectiveness of their national survey activities, and particularly to demonstrate how this could be improved using information technology (IT).

In Canada, the area of concentration where the term “geo-information infrastructure” emerged concerned the harmonization of the topographic activities between federal and provincial agencies. Their purpose was to facilitate the exchange of surveyed and mapped information in their respective domains, thereby eliminating duplication and improving the topicality of the maps and associated databases. At first, the standardization was perceived, and also implemented, as a purely technical process: the standardization of the data definitions, the

coding and the exchange formats. Over time, however, it became clear that the parties needed to agree on common policies with respect to the access, use and pricing of their data. Without such common policies, it would be easy for users to select the cheapest supplier and thus deprive the data owners of clientele and, more importantly, of revenue to support the budgets of the survey organizations. Furthermore, the two levels of government had to agree on the terms for users exploiting their respective data and how they would charge for this. Hence, it became increasingly apparent that, in terms of achieving the expected improvements in effectiveness and efficiency, the technical standardization had to be accompanied by standardization or at least harmonization at the institutional levels. This proved far more complex than expected.

INFORMATION INFRASTRUCTURE AND ECONOMIC DEVELOPMENT

The term “infrastructure” was first used in the middle of the 18th century in relation to railway tracks and rights of way for trains. Its meaning has evolved to include a complex of shared structures and services that support broad social participation and economic activity. In this sense, we all recognize roads, electric power, energy transmission, telephone services and networks, etc, as infrastructure. An important characteristic is that “they have significant economies of scale and spillover effects on non-users, particularly as enablers of other forms of economic activity” [18].

When the Clinton administration took office in 1992, the “information superhighway” initiative was announced: “the national information infrastructure (NII)”. It was the centerpiece of a well-orchestrated set of government strategies, including a variety of social, economic and technology policy areas. The superhighway metaphor had immediate intuitive appeal as it created a link with the 1950s, when the government initiative in creating a network of interstate highways was an important component of stimulating economic development. Furthermore, the emerging Internet could be used as an example to explain the metaphor.

The essence of the NII focus was that it “argued for a dramatic shift in US telecommunications policy away from a previously limited role for government as a regulator. Instead, the government’s involvement was seen to be a broader one of promoting the development of new Information and Communication Technology (ICT) structures, services, and products in order to help address major social and economic objectives, *such as improving public services, democratic processes, and national competitiveness.*” ([11], italics by the author).

Although the information superhighway metaphor served to put the NII clearly on the political agenda, the term was seen by some people as being too oriented towards the hardware and not enough towards the societal, social and economic elements of the NII. For example, Talero [18] states that “... there are several information systems that have such strategic importance to the economy that they can be considered infrastructure.” One of the eight types he mentioned was “to facilitate general economic activity: national statistics, geographic information,” His definition of NII is: “the telecommunications networks and strategic information systems necessary for sustainable economic development.”

In 1989, the Commission of the European Communities (CEC) issued its guidelines for improving the synergy between the public and private sectors in the information market. These guidelines, which are only advisory, “were considered essential to help the public sector in decision making related to making information available for external use and supporting the development of the information market; and to establish ground rules for avoiding possible unfair competition” [9].

It was a clear message that, at the highest levels in the European Community, the economic importance of free access to databases created by public funds and the role of the private sector in adding value to the information production were recognized. The European Union followed in a similar vein with the *Bangemann Report*, a wide-ranging set of recommendations as to how the EU would provide leadership to its member countries for their entry into the information society [1]. Although not exploiting the superhighway metaphor, the EC, like the Americans, focused on social and economic objectives in, *eg*, healthcare delivery, continuing education and the “information market place”. In other words, the EC emphasized the emerging information society.

Within the context of these initiatives, the European geographic information infrastructure had to be addressed. In 1994, work started on a working document *Towards a European Policy Framework for Geographic Information*, in the context of the Info 2000 programme, under DG XIII (the Directorate General responsible for information technology in the EU). In this document, the overtone is that of the commercialization of government-owned geo-information to stimulate economic development and support a variety of policy initiatives. In 1995 and 1996, the European workshops “Geodata for All” were held as the first two of a planned ongoing series. A first description of the concept was presented by Brand [4]. The coordination of institutional activities has since been carried out by the European Umbrella Organization for Geographic Information (Eurogi), which was created in 1993.

The significance of these initiatives at the national and supranational levels is that the design and implementation of local SDI can no longer be performed only from the bottom up, so to speak, between survey and mapping organizations at different levels of government as in the Canadian example. Now the technology, standards and the policy framework governing the local application, especially if it is government-owned, must be harmonized with the higher-level policy framework. Thus, issues concerning the protection of intellectual property and privacy, the electronic and legal protection of data, and competition policy will affect the design, implementation and exploitation and/or financing of a local SDI.

Hence, local developments must take into account what has come to be known as national, and increasingly international, information policy. It has been defined by information scientist Peter Hernon as “a set of laws, regulations, directives, statements, and judicial interpretations that direct and manage the life cycle of information. That life cycle encompasses planning, and the creation, production, collection, distribution and dissemination, and retrieval of information” [14]. As technologies converge, it is expected that previously distinct and separate policy areas related to information will also con-

verge [6]. For a concise explanation of the dimensions of the policy debates, see Dutton [11].

The literature suggests that the proposals for an information infrastructure illustrate the departure from the national outlook to an international approach, driven primarily by a market-oriented attitude and the interests of transnational corporations as opposed to public interest ideology [5].

In conclusion, SDI supporting SLM will contain what Talero has termed “strategic datasets”, which should be defined and implemented with a view to making them available to a broader audience than simply land managers. Thus the SDIs for SLM cannot be implemented from only the scientists’ perspective on sustainable land management.

Against this background, the question of course is how can we implement local SDI in such a complicated environment that is also extremely dynamic and subject to local (and national) interpretation? The rest of this paper aims to explain the basic components of the SDI structure and to recommend some guidelines for its design, implementation and sustained operation.

THE PURPOSE AND COMMON STRUCTURE OF SDI

The Purpose

The purpose of SDI is:

- to save time, effort and money in accessing spatial data and using it responsibly
- to avoid unnecessary duplication in the harmonization and standardization of required datasets by promoting the sharing of available data.

Of course, the fact that government departments or different levels of government can share data effectively does not guarantee that better public services are being provided to the citizens. It is therefore important at the start of an SDI implementation to clarify who will be the ultimate beneficiaries at citizen level. For example, will environmental issues be addressed more effectively or building permits issued faster and more objectively? Unless the implementation of SDI results in this type of progress it is not worthwhile. Or will SDI facilitate access to, and the responsible use of spatial data at affordable prices?

“Facilitate access” means letting the user know what information is available and where, what the conditions of access and use are, and how much it will cost. The reference to “responsible use” implies an obligation on the part of the data suppliers to include qualitative information about the data which lets the user determine how fit the data are for use in his/her application. The reference “affordable price” signifies that a degree of price differentiation is possible depending on what the user is prepared to pay for the information or the associated information service. The economic characteristics of government-owned geo-information as an “imperfect public good” strongly influence this process [10].

It is interesting to note that one of the first geo-information infrastructures in operation was not a government but a private sector one. In 1990, a number of oil and gas companies in western Canada had determined that their exploration geologists and geophysicists spent more than 60 percent of their time searching for information and only about 20 of their time doing something useful with it. They decided to create a shared facility, called the Canadian Oil and Gas GIS (Canoggis), in

essence an SDI, which would help them to know what information is where, who owns it, how and under what conditions it can be used, and at what price. A similar SDI is being implemented in Britain, under the name Common Data Access, jointly for the oil and gas industry and government. The implementation of Canoggis reduced access costs by a factor of about 10 within three years of its creation. Its successful implementation had many secondary effects, including:

- The initial partners in the SDI venture were joined by many others who felt that they could benefit from the facility. They became partners under a variety of conditions, in relation to what they had to offer to the facility and the benefits they derived from it.
- Most of the partners are data suppliers as well as users. The SDI made it possible to offset their cost of data use by charging for their data supply.
- Participation in the SDI improved the overall quality management of the data.
- The facility management was contracted to a private company and was fully financed by its use (pers comm with QC Data Ltd, Calgary, Canada).

The Common Structure of SDI

National spatial data infrastructure (NSDI) can be thought of as a set of networked SDIs, each set up to serve a certain sector of applications, in terms of the objectives stated above. These sectors of application lie in the fields of, *eg*, environment and physical planning, agriculture, transportation, etc. Furthermore, a particular application sector may require data from the municipal, provincial or national level and data connectivity and harmonization between those levels. This implies a requirement for data at a different resolution or scale. This, in turn, has consequences for the relationship of the data definitions and semantics from the larger-scale level to the smaller-scale level. It should not always be assumed that it is possible to derive the smaller-scale level from the larger-scale level by automated means. It is expected that in many cases this will remain, for the foreseeable future, a bottleneck that can only be alleviated by human intervention.

Spatial integration of the data is based on consistent geometric referencing systems and on reasonable compatibility in the resolution of the different datasets. This means that the same coordinate system must be used for the spatial referencing, while excessive variations in the resolution of the datasets must be avoided if meaningful analytical applications are to be achieved. The semantic aspects of the data definition depend greatly on the application context. It is therefore almost impossible to rely entirely on data produced for other purposes. The same geographic feature may be called something different in different application sectors or even in different applications within a particular application sector. Hence, in addition to data that can be shared with others, there will always be datasets which are so application-specific that they are, in the first instance, single-purpose (see Figure 1). (Note, however, that the Canoggis experience indicates that use can expand unpredictably with previously unforeseen applications.)

Figure 1 will be discussed in three parts:

- (1) the datasets according to a rough classification of foundation, framework and application-specific
- (2) the set of policies which govern the SDI
- (3) a description of the main tasks within the “spatial information center” that controls the operation and maintenance of the SDI.

(1) Foundation, framework and application-specific datasets

The Mapping Science Committee of the US National Research Council argued for the classification of datasets by foundation and framework [16]; the author has added application-specific datasets. An attempt was also made to define core data needs for environmental assessment and sustainable development strategies [12].

Figure 1 recognizes foundation datasets such as geodetic data (which determine the spatial reference system), fundamental topography (used by many applications as an additional geometric reference represented in the terrain), the digital elevation model, administrative boundaries and postal codes (essential to link socio-economic data to physical data), and official geographic names (still the most used reference for many applica-

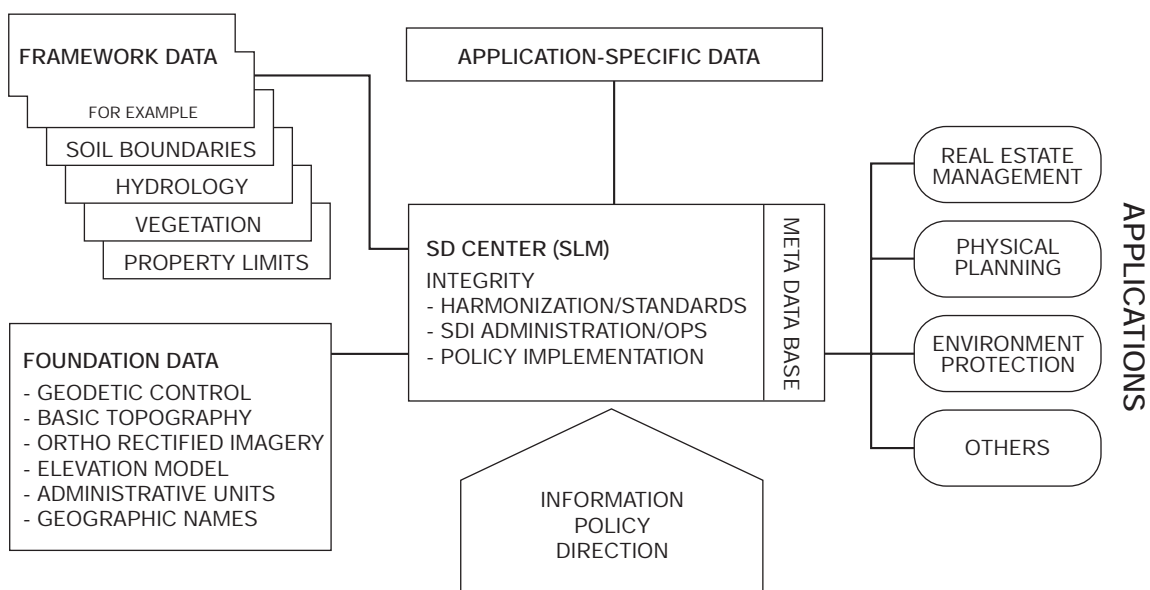


FIGURE 1 Structure of the spatial data infrastructure (SDI)

tions). Sometimes digital orthophotos are part of the foundation data, but these require skilled interpreters—not frequently encountered among the users.

It should be recognized that the fundamental topography is not necessarily a digital copy of the topographic maps. For example, in the Netherlands the national topographic survey produces a topo database in vector form at scale 1:10,000 (TOP 10 Vector). This contains approximately the density and attribute values of the 1:25,000 topographic maps—far too much information for most users. There is now a major debate with the user community to define the content and density of attribute values for a suitable and affordable core topographic dataset, although it will be based on the TOP 10 Vector product.

With the possible exception of the administrative boundaries, it will be recognized that the foundation data are produced by the national geodetic/topographic survey organization. Administrative boundaries are often produced and maintained by the national statistical organizations, *ie*, those responsible for the national census and a variety of social and economic surveys.

Figure 1 also recognizes framework datasets. These are datasets which usually provide thematic information in a national context. This information (*eg*, on vegetation, land use, land cover and hydrology) may be surveyed directly in the field or by means of remote sensing. Or it may be derived information, such as land suitability for particular purposes. Population distribution and population density by geographic area are also important framework datasets. At any rate, framework datasets provide the thematic geographic framework of the country. The data are produced, maintained, published, distributed and safeguarded by national survey organizations, such as the national soil survey institutes, geologic surveys, hydrologic and climatologic organizations, etc. Although in most countries these organizations are subject to severe budgetary pressures and questioning of their ongoing mission, it is clear that they make a very significant contribution to a country's historical record, and that they supply and maintain reliable "strategic information" on which sustainable economic development depends.

The application-specific dataset is the last class indicated in Figure 1. These contain information surveyed specifically for a particular application, such as pollution measurements, water chemistry, smog indices, etc. Although these may be useful in a national context to show, for example, the occurrence of smog across a country, they are mostly relevant to only a particular application area.

When we think back to one of the objectives of SDI, the reduction in duplication of harmonizing and standardizing data for applications, we can conclude that:

(1) data-sharing opportunities are very high for foundation data, decrease somewhat for framework data and are even less for application-specific data

(2) national survey organizations must be encouraged and give high priority to defining the foundation and framework data with the user community, and to ensuring that these are produced and maintained to appropriate SDI standards.

(2) The policy framework

Access to and responsible use of the above data files at an affordable price is administered through a spatial

data (SD) center (see Figure 1). This is done according to a set of transparent policies which ensure that all users know and understand the conditions for access to and use of the data, how much it costs, how their own data will be protected through the SD center, etc. This section of the paper deals with the associated policies.

One can differentiate between imposed legislation and information policy at the national government level or from the more senior administration of which the SD center is a part, and the set of related or complementary policies appropriate to the local SD center (see Table 1 for examples of "senior" policy and "local" policy).

The legislation may, in many cases, be in conflict. For example, a balance needs to be found between free access to government data and the need to protect state information concerning the protection of the realm, the safety of citizens, relationship to other governments, etc. Furthermore, the legislation governing the privacy of the individual and corporations may conflict with that dealing with the commercialization of government information.

TABLE 1 Local policy in relation to "senior" information policy

<i>Legislation and senior policy</i>	<i>Regulation/local policy</i>
Freedom of access to government information	Access and use
Data protection	Pricing and financing
Privacy	Liability
Copyright and intellectual property	Standards
Commercialization of government information	Integrity, quality
Role of government vs private	Accountability

Currently, many national survey organizations are expected to generate revenue in order to reduce the financial burden of survey activities on the taxpayer. But if this means increasing the prices of data files, or becoming involved in value added information production, there may be conflicts with the legislation governing free access, commercialization, and/or competition.

One can conclude that for the development of the regulations and policies of SDI at the national, provincial or municipal level, the more senior level of legislation needs to be kept in mind. The need for clear regulation and policy at these levels stems from the fact that producers and users of data must know the conditions for access to, use of and prices of the data. The transparency and predictability of these rules is essential for the integrity and smooth operation of the spatial data infrastructure, and the success of the geo-information market place.

(3) The spatial data center for sustainable land management

The availability of the foundation, framework and application-specific datasets is not enough to ensure access to and responsible use of the data at affordable costs. An organization is required to carry out some very specific tasks which require specialized expertise not normally available in, *eg*, national survey organizations. These tasks are indicated in Figure 1 under what has been termed the spatial data center for the sustainable land management (SLM) application sector. The

tasks are as follows (this is not a definitive list and may be enlarged with experience).

- Development and maintenance of data standards, data quality management and other performance standards for the SDI:

This is a field for which expertise needs to be resident in the center. First, it will be necessary to define the data standards in the application sector with the application specialists. This is a tedious and time-consuming task. They need to decide how the application sector classifies (or names) the geographic features of its interest, while taking into account the evolving standards in the field at, *eg*, the (global) level of the International Standards Organization (ISO) or the level of the Comité Européen de Normalisation (CEN), or standards that may already exist at the national level. The data standardization process is akin to the elaborate conventional process of agreeing on the legend of, *eg*, a regional vegetation map based on national classification systems, in sympathy with legends agreed upon by international societies. However, in the digital information era the standardization processes are more complicated because of the demands for data sharing by electronic means imposed by the expectations of the information market place and, for example, the European Community's commitment to it [1].

The term "evolving standards" is being emphasized here because in the geoinformatics area, as in other fields related to information technology, this is a fact of life. At the same time that we are implementing SDI in a number of countries and organizations, the related standards are still undergoing technical development and are in a consensus-forming process. Furthermore, the standards are dynamic and will continue to evolve in response to the realities of practice.

The second example stems from the necessity to assure the integrity of the sustained functioning of the SDI. This requires standards for the quality management of the data production in each of the organizations supplying data. Hence, there must be expertise in spatial data production processes to advise data suppliers on how to deal with quality management in their organization. As a minimum, the resident expertise should be able to judge the processes in order to pass judgement as to whether the quality assurance is of a sufficient level to support the integrity of the SDI. An important issue here is that standard methods need to be well defined to identify clearly the "fitness for use" of the various datasets.

- The financial and administrative integrity of the SDI:

The SDI and the local SD center need to be financed in some manner. It is unlikely that governments will entertain the idea of providing funds beyond their responsibility for creating and updating the fundamental, framework and application data. All other expenses should be borne by the users of the infrastructure. In this respect, the SDI is no different from the road infrastructure, for which a user fee system has been designed taking account of the user's fixed costs (vehicle type and license fee) and variable costs (tax on petrol).

In some cases, governments may decide that the costs for updating the databases must also be borne by the users. But this may fly in the face of universality of access as it may make the data too expensive for the financially weaker members of society, such as a start-

up value added information production company.

The center must be administered in a professional way. Contracts between data suppliers and users must be developed and entered into the system regulating access and use. Billing for data and services must be carried out in a timely and reliable fashion. Associated revenues to data suppliers must be transferred on time and reliably. Hence, the center must have professional expertise in these areas as well.

The conclusion is that setting up an SD center within an SDI requires new kinds of expertise which must be available in order to ensure the financial and administrative integrity of the operation. Finally, the SD center will be responsible for developing the catalogue of meta data necessary to facilitate the process of identifying what data are available through the SDI and under what conditions they may be used. It will also provide the data and possibly provide services to combine datasets or perform reference transformations, etc—all of course for a fee.

Hence, an SD center is an organization with very specific tasks and the capacity to fulfil those tasks. In some cases, a question arises as to the regulatory or ownership status of such a center: should it be government owned and operated, government owned and privately operated, or privately owned and operated? Next, what kind of ownership should be? It could, for example, be a partnership, or an incorporated company, or a special agency directed by government at arms length. Each of these constructions has advantages and disadvantages, and they should all be considered in the light of local culture and circumstances, when choosing the most appropriate.

CONCLUSIONS

The design, implementation and maintenance of SDI is multi-dimensional and complex. It has technical, organizational and institutional implications that affect the way in which the traditional government data collection organizations perceive their mission, how they relate to users, how they are financed, etc. Organizations responsible for environmental or land management programmes will also find that, with the introduction of information technology, their working methods and organizations will be affected. The conventional information flow through organizations may no longer be adequate, and may therefore require changes. Consequently, the associated (social) structure of the organizations can be expected to change as well [13].

It is imperative that the design and implementation of SDI be carried out in a well managed way, *ie*, focused on the end user. Otherwise the complexity will tend to drive the development into an academic or impractical direction, whereby organizations will be able to exchange data efficiently but without any impact on the end user, *ie*, the tax-paying public. This essential focus will also help in managing the apparent complexity.

The data and technical components, the policy and institutional components, and the SD center component demand specific expertise and knowledge about what happens in the related, surrounding and adjacent institutional environments. This suggests that there is a significant component of human resources development in SDI development, which needs to be dealt with prior to, or at least in parallel with the SDI development.

Few SDIs exist as operating entities as yet. A number of government development initiatives are underway in several countries, but success stories are mainly from the private sector, such as the oil and gas industries. It will be difficult to implement SDI in governments because of the shifts in bureaucratic power that will be associated with it. Hence we do not have much experience to fall back on. In almost all cases, the development process must therefore be managed in a careful, businesslike way, with achievable goals meaningful to the end user.

Therefore, we should expect that:

(1) the goals and realization of SDI will gradually be achieved in spite of the hype

(2) this will require technical, organizational and institutional changes, which will take time

(3) the implementation must take place in a businesslike fashion, while recognizing that it will be a carefully managed learning process

(4) flexibility, adaptability and common sense (to distinguish between the "flavour of the month" and significant developments) will be required to deal with the flux in the policy environment, ongoing technologic innovation and, in particular, end-user input.

These conclusions lead to a set of recommended practices.

RECOMMENDED PRACTICES FOR THE DEVELOPMENT OF SDI

(1) SDI development needs a champion at the highest political level. This individual needs to be known to all stakeholders in the project.

(2) The beneficiaries of the SDI must be well defined and actively involved in its development and implementation. From the beginning, all the stakeholders must be involved, *ie*, data owners and suppliers, users, SD center and financiers, as well as the beneficiaries in the whole development process.

(3) The competence of the development team in all aspects mentioned in this paper needs to be developed rapidly and be beyond question among the stakeholders.

(4) The development must be broken up into "success blocks", each requiring low financial commitments and time lines of no more than six months, but with an end product able to generate among the stakeholders and end users a growing confidence in its usefulness.

(5) SDI development has few precedents and must therefore be managed as an innovation/technology transfer process.

(6) The "success blocks" should be the building blocks in the development of the SDI.

(7) The product should not be over-sold until it can be shown to work routinely.

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RESUME

Cet article est élaboré sur les perspectives présentées dans la littérature récente, qui identifie une utilisation croissante de géoinformatique dans le développement de systèmes d'information géographique interdisciplinaires et de systèmes d'aide à la décision pour réaliser une gestion durable des terres à différentes échelles et pour des groupes spécifiques d'utilisateurs. La réalisation du potentiel de systèmes d'information géographique pour soutenir une gestion durable des terres dépend d'un certain nombre de facteurs. L'un d'eux en est l'accès efficace et fiable à une information bien organisée. Dans ce cadre, la littérature fait allusion à une infrastructure d'information géographique naissante et à un cadre politique aux niveaux global, régional, national et local qui pourra par exemple, rendre disponible, une partie importante des travaux de recherche sur les sols, stockés de manière inaccessible dans les archives et les bibliothèques. L'article présente le concept de l'infrastructure de l'information géographique (GI) ou l'infrastructure de données spatiales (SDI) comme un outil permettant l'accès et l'utilisation responsable d'information géographique à un coût raisonnable pour une gestion durable des terres. Cet article présente aussi, la notion qu'une infrastructure nationale (SDI) est composée de réseaux SDI qui ont été développés et implantés pour servir des secteurs d'application spécifiques au niveau national, régional et municipal. Une "gestion durable de terre" pourrait être un tel secteur d'application. L'article retrace l'histoire du développement du concept de SDI. Il identifie les hautes attentes d'une infrastructure d'information nationale (dont SDI est une composante) en termes de réalisation d'objectifs nouveaux de développement économique et social et une amélioration des services publics, puisque le Président Clinton a introduit la métaphore "d'autoroute de l'information électronique" dans sa plateforme politique. Ces attentes ont également été exprimées dans la "société d'information", initiative de l'Union euro-

péenne. L'article met en lumière la nécessité de changements légaux et de régulation devant intervenir afin de réaliser le marché ouvert de l'information géographique qui est à la base des attentes exprimées. Ce qui exige que les développements techniques et institutionnels, le développement de l'organisation et des ressources humaines dans l'étude, l'implantation et la maintenance de SDI pour un secteur spécifique d'application soient menés en parallèle. Une implantation durable réussie dépendra d'une responsabilité "politique" claire pour son intégrité, et d'un environnement local, régulateur en harmonie avec une législation et une régulation plus anciennes, par exemple aux niveaux national et supra-national. L'article conclue avec une série de recommandations pour le développement de SDI.

RESUMEN

Este artículo analiza perspectivas presentadas en literatura reciente, donde se identifica un uso creciente de la geo-informática en el diseño de sistemas interdisciplinarios de información geográfica y de sistemas de soporte a la decisión para el manejo sostenible de las tierras a diferentes escalas y para grupos específicos de usuarios. La realización del potencial de los sistemas de información geográfica en apoyar el manejo sostenible de las tierras depende de un número de factores. Uno de estos factores es el acceso eficiente y confiable a información bien armonizada. En este sentido, la literatura se refiere a una emergente infraestructura de información geográfica digital y un marco de políticas al nivel global, regional, nacional y local, que permitirán el acceso, por ejemplo, a resultados de investigación de suelos, que hoy en día están almacenados

en archivos y bibliotecas. Este artículo presenta el concepto de la infraestructura de información geográfica (GII) o de la infraestructura de datos espaciales (SDI) como una herramienta para facilitar el acceso y el uso responsable de la información geográfica a un costo abordable en soporte al manejo sostenible de las tierras. Presenta la noción que una SDI nacional está compuesta de varias SDI interconectadas, que han sido diseñadas e implementadas para servir sectores de aplicación muy específicos al nivel nacional, regional o municipal. "El manejo sostenible de las tierras" podría ser un tal sector de aplicación. El artículo traza la historia del desarrollo del concepto de SDI. Identifica las grandes expectativas de la infraestructura de información nacional (de la cual la SDI es una parte) en términos de alcanzar nuevas metas de desarrollo económico y social y de servicios públicos mejorados, desde que el Presidente Clinton introdujo la metáfora de la "autopista de información electrónica" en su plataforma política. Estas expectativas están también expresadas en las iniciativas de la "sociedad de información" de la Unión Europea. El artículo realza la necesidad de los cambios legales y reglamentarios que deberán hacerse a fin de llevar a cabo el mercado abierto de información geográfica, que debe formar la base de las expectativas expresadas. Esto demostrará que los desarrollos técnicos, institucionales, organizacionales y de recursos humanos deben ir en paralelo en el diseño, la implementación y el mantenimiento de las SDI para un sector de aplicación específico. Una implementación prolongada exitosa dependerá de una clara responsabilidad "política" para su integridad, y de un ambiente reglamentario local que esté en armonía con la legislación y regulación más antiguas, por ejemplo, al nivel nacional y supranacional. El artículo concluye con una serie de prácticas recomendadas para el desarrollo de la SDI.