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MANAGING RELIABILITY OF SPATIAL DATA INFRASTRUCTURES: CONCEPTS AND IMPLICATIONS

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Abstract

Infrastructures – both technical and social - are considered to play a key role in facilitating the resumption and acceleration of growth in developing countries. Well performing infrastructure services are crucial for enabling countries to participate in and benefit from such developments as the globalisation of trade. A (geo)spatial data infrastructure (SDI) can be considered a domain specific infrastructure. As such it carries the characteristics of other infrastructures, with peculiarities of the (geo)spatial data domain. This paper examines and defines what sort of infrastructure SDI is, and what the implications of this view are for its management. It is argued that in analogy with other infrastructures success depends not only on operational performance but also on the demand for the service: if effective demand is lacking or other services are desired, consumption will be less than expected. Effective demand is however dependent on reliability. For users, reliability means that a service has a high probability of being available in the quantity, quality, and at the time required. Substantial changes in reliability will induce changes in users' behaviour. Users demand different levels of reliability depending on their particular usage activity, and adopt reliability-enhancing strategies when the levels provided do not meet their needs. The reliability, capacity, and cost of infrastructure services at any point depend on the management and maintenance practices of infrastructure suppliers and the dynamic response of all users to infrastructure unreliability.

Managing SDI's involves therefore assessing the extent to which users adopt such reliability-enhancing strategies. These strategies can in particular be found when comparing business and revenue models of commercial users of spatial information with public providers of spatial information. It is argued that incorporation of real time spatial data use, forceful and diverse business models and interrelated services provision are examples of reliability-enhancing strategies adopted by private users. SDI providers and contributors would need to respond to these strategies. Such a response would need to include management of 1) Maintenance & condition of technical infrastructure; 2) Demand & supply performance; 3) Competitive markets & financial performance; 4) Degree of government intervention; 5) Operational performance. The paper concludes by reviewing what this management would entail from these various perspectives, and which performance indicators would need to be measured to support management.

Introduction

Infrastructures – both technical and social - are considered to play a key role in facilitating the resumption and acceleration of growth in developing countries. Well performing infrastructure services are crucial for enabling countries to participate in and benefit from such developments as the globalisation of trade. A (geo)spatial data infrastructure (SDI) can be considered a domain specific infrastructure. As such it carries the characteristics of other infrastructures, with peculiarities of the (geo)spatial data domain. This paper examines and defines what sort of infrastructure SDI is, and what the implications of this view are for its management. The emphasis will be on the reliability of infrastructure services, and how that has an impact on supply and demand.

Infrastructures and reliability

In analogy with other infrastructures success depends not only on operational performance, but can be evaluated and classified from several perspectives, such as in (Israel, 1992):

- Maintenance & condition of infrastructure
- Demand & supply performance
- Competitive markets – financial performance
- Degree of government intervention
- Operational – operational performance

One key element in any of these perspectives for enhancing efficiency and effectiveness of infrastructure is through an increased focus on **reliability** of services. Where the first aim of any (information) infrastructure is to enhance access to (information) services, one would find that access alone is not enough. If effective demand is lacking or other services are desired, consumption will be less than expected. For users and beneficiaries, reliability means that a service has a high probability of being available at an affordable cost, and in the quantity, quality, and at the time required. This concept of reliability directly links provision of infrastructure to a specific use, and providers to users. Substantial changes in reliability will induce changes in users' behaviour, and thus suppliers face however a variety in demands for reliability. Users demand different levels of reliability depending on their particular usage activity, and adopt reliability-enhancing strategies when the levels provided do not meet their needs. The reliability, capacity, and cost of infrastructure services at any point depend on the management and maintenance practices of infrastructure suppliers and the dynamic response of all users to infrastructure unreliability.(Israel, 1992) describes:

Industries producing goods for trade depend on infrastructure as an input. The reliability, capacity, and cost of infrastructure services at any point depend on the management and maintenance practices of infrastructure suppliers and the dynamic response of all users to infrastructure unreliability. Users demand different levels of reliability depending on their particular usage activity, and adopt reliability-enhancing strategies when the levels provided do not meet their needs. The extent to which users adopt such strategies can be used as information to infrastructure providers when selecting optimal investment decisions to improve either the reliability or capacity of infrastructure systems.

Globally the public sector is under increasing stress to reduce their budgets and scale down their activities, which could be outsourced and privatized. Part of these activities includes infrastructural works. One of the major reasons why many infrastructures in developing countries are not functioning from an public sector point of view is because they have lost value due to the lack of maintenance. The same would be true for systematic data collections and a SDI. SDI being in the realm of public interests, this maintenance is often expected from the public sector. Yet, even in countries where data are being upgraded, for example through donor incentives or systematic Land Information Systems projects (example Nepal), often one sees a systematic bias in favor of new construction and design at the expense of maintenance of available records. Most of the value of the SDI is derived from its capability of maintenance. Part of the problem is the failure to include beneficiaries in the (information) system design, top-down or donor driven approaches that emphasize complex ICT solutions. Problem is obviously a focus on short-term technical rationality rather than long-term process of institutional development. In that sense, developments in SDIs follow a similar pattern as most other development projects.

Impact on SDI's

Applying the above perspectives to SDIs, one could find that:

- Maintenance depends on the ability and capacity to keep the information up to date; the actuality and the completeness of the databases would be performance indicators.
- Demand has until recently mainly depended on the land market, but is increasingly depending on the information market. Supply may not always be in par with this development.
- There has always been little or no competition on the geospatial data infrastructure market. With increasing privatisation worldwide, things are on the move.
- The responsibility of geospatial data infrastructure has been mainly in the realm of public administration so far in most developing countries.
- With increasing demands, operational performance requirements have increased.

In more detail, one could describe these by a number of quality parameters, such as:

	Influence on efficiency and effectiveness of SDI can be measured by indicators on
1) Maintenance and condition of SDI:	• Data volume / population • Actuality of data / information; • Frequency of update • Utilization of technology
2) Demand & supply performance	• Number of land transactions per day • Effective use of information (enhancing users' production processes output and outcome) • Ability / capacity to change / improve • Flexibility in processes • Ability to change processes

	• Inclusion / relation with customers • Data formats (whether these are sharable…) • Access to technology • Dependence on ICT • Ability / capacity of communication among stakeholders
3) Competitive markets – financial performance	• Availability of accurate (management) accounting information on production and provision process • Accounting procedures • Ability / capacity to manage cost (not only ex post, but also ex ante) • Ability / capacity of communication with external organizations / institutions • Ability / capacity to oversee and manage the whole SDI
4) Degree of government intervention	• Degree of transparency of production and provision • Transparency and clarity in responsibilities • Degree of informality • Adherence to rules, transparency • Structure of organizations (uniformity vs. pluriformity)
5) Operational – operational performance	• The SDI's capability of providing aggregated information • Connectivity / ability to share/exchange with other data(bases) • Degree to which geospatial data production integrated with other data production processes • No .of interactions with other infrastructures i.e. statistics, civil registration, education, health, etc. • Ability to manage processes as a whole • Ability / capacity to manage staff time / human resources • Relative number of operational staff vs. managerial staff • Availability of TQM procedures

Reliability and cost

Bringing this further to the cost and cost efficiency questions, one could argue that the cost of infrastructures would than also include the cost of the reliability-enhancing strategies. It relates the cost of providers to that of users if certain strategies from either side are implemented. It also shows that it is not enough to look only at the (static) user needs, but that one needs to

take into account the users' (dynamic) behaviour, or dynamic reaction to certain static or dynamic situations. In absolute terms one could summarize this as follows:

Cost of implementing reliability enhancing strategies by users / agents	Low	High
Cost of maintaining reliability of SDI by provider(s) / principles		
Low	Highly efficient and effective SDI	Efficient yet not effective SDI
High	Effective yet not efficient SDI	Highly inefficient and ineffective SDI

The extreme cases of no infrastructure, or a completely perfect functioning infrastructure, are somehow excluded in this table. One could argue that in cases where no real infrastructure is available, the cost of maintaining reliability by a provider is zero, thereby leaving users to spend either zero – if they would not need any – or any amount depending on their needs. In the latter case the user would become however provider / principal themselves. The other case, being a perfect functioning infrastructure, would not necessitate any extra cost for increase or maintenance of reliability, or any reliability enhancing strategies. This is a highly unlikely scenario.

Yet, refinement could be in the question whether cost is (too) high or low. These absolute terms assume only one item of spending, whereas in practice users would always address the question in relation to other spending items. It would thus be better to include a sense of relativity, for example through the issue of "affordability". Affordable in this context would mean both possible and acceptable (although one could also make a more refined distinction, where one would include the option "acceptable" and "not acceptable"). Users can afford cost if it doesn't exceed a certain percentage of their overall spending, or if somehow the cost may lead to a certain benefit. Providers, either government of non-government funded, will define affordable in terms of budget or budget constraints, or cost recovery potential. If a certain requirement implies considerable cost, exceeding the budget or cost recovery potential, providers may be forced to deny any investment to comply with such requirement. The issue of "affordability" also incorporates the dynamics of a situation. What may be affordable now, may not necessarily be affordable in the future.

Cost of implementing reliability enhancing strategies by users/agents	Affordable to users	Not affordable to users
Cost of maintaining reliability of SDI by provider(s) / principals		
Affordable to providers	1	2
Not affordable to providers	3	4

Case	Explanation

1	Here one would expect a situation where there exist proper strategies and flexibility by providers to react to changes in demand and the market. The market is differentiated, such that users in general rely on the SDI for particular common properties, and will define each their own additional items to enhance the reliability of a market that they themselves are interested in. Examples of these include the situation in the Netherlands. The Dutch Cadastre has enhanced the use of their services by the use and therefore extra spending of ICT. Notaries as users have not waited until all possibilities of ICT dissemination were available, but have also invested in on-line ICT possibilities, both in relation to accessing cadastral databases, but also in relation to computer-based generation of contracts.
2	This situation reflects a non-functioning market, where users do not have sufficient means of enhancing their positions, or users are not really interested and do not see any benefit in improvements of the services provided by the provider. Providers on the other hand seem to have unlimited – or unchecked - access to funds, for example through additional annual budget allocations. Examples of this can be found in mostly government controlled SDI's, having no transparent accounting, no impact assessment values, and no clear market oriented information provision policies. At the same time, there are few feasible or allowable incentives of private providers.
3	This situation reflects mostly government agencies not having sufficient funds or appropriate accounting procedures to determine how much to re-engineer or (re-) invest in the SDI facilities they are providing. Users provide extra funds or spend extra cost to make sure they get what they want, either in the form or facilitation money, or by establishing redundant, duplicating institutions.
4	For this case nothing seems to work properly. Enhancing reliability would probably take several decades or centuries if the current strategies were continued. At the same time, users do not seem to have sufficient resources to enhance their benefits. One can say that there is no properly functioning information infrastructure, and very likely this would also be the case for other infrastructures. Structural changes would be needed at either side, before any enhancing strategies could be formulated, because the system is not reliable at all. In this case, it is not a question of too few or too many funds or resources available, but more a total mismatch between formal regulations and acts and implementation in reality. Investments in either production efficiency improvement or straight commercialisation are literally wasted.

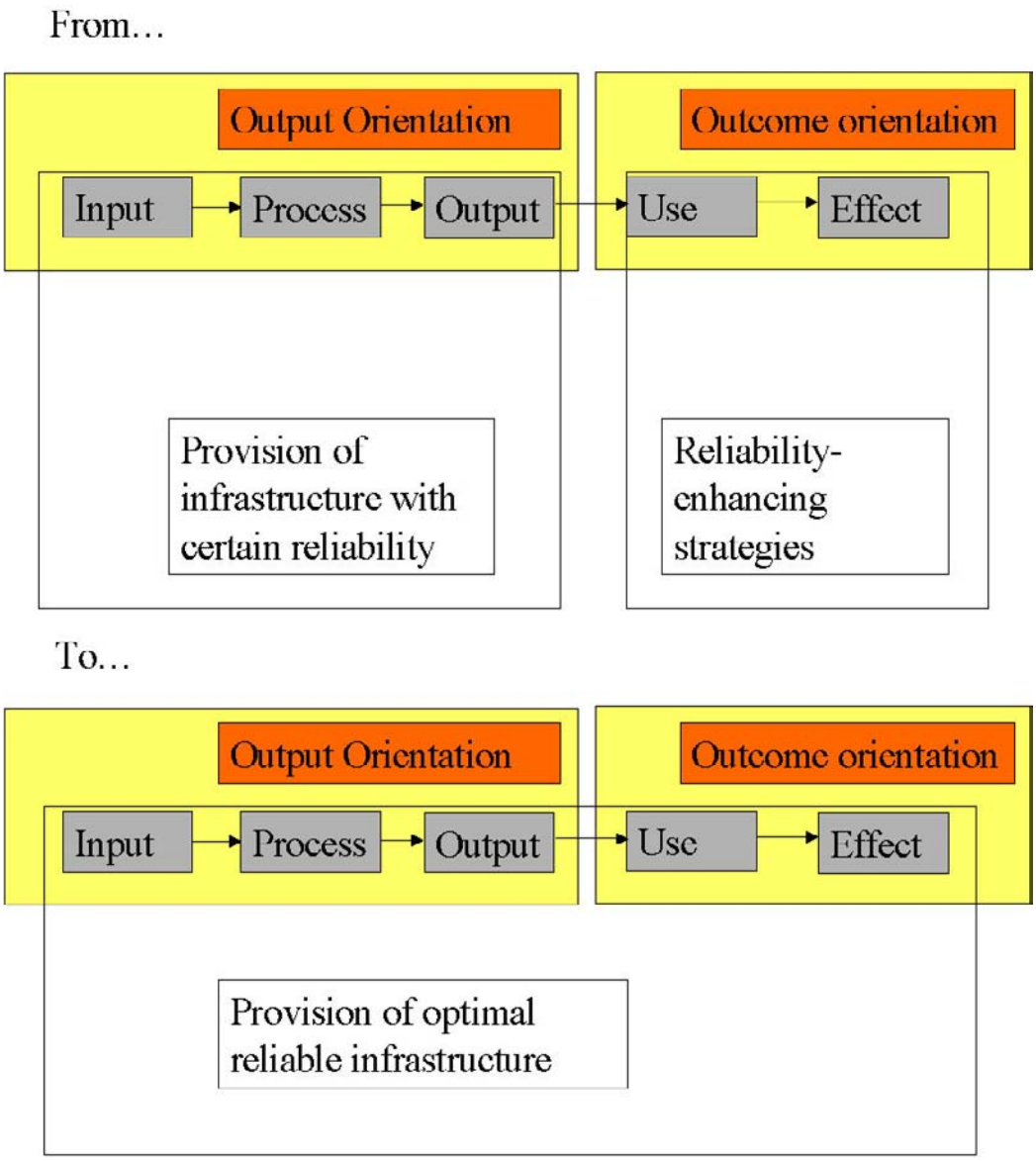
For each of these cases, one would expect to need different scenarios of efficiency and effectiveness improvement strategies.

Managing SDI's involves assessing the extent to which users adopt such reliability-enhancing strategies. These strategies by users can in particular be found when comparing business and revenue models of commercial users of spatial information with public providers of spatial information. Most of the clearinghouses organised and managed by public agencies are geared towards distribution of information rather than optimisation of use, optimisation of outcome, and optimisation of economic benefit. Privately run clearinghouses and geospatial data companies rely however on direct revenue sources and will therefore automatically seek closer contacts with users and possible uses. As a result, one can observe incorporation of real time spatial data use, forceful and diverse business models and interrelated services provision. Some of these could however be considered examples of reliability-enhancing strategies adopted by

private users, especially when information and services are provided which are in fact related to foundation data.

Management response

Given a certain situation in reliability of infrastructure services, the question is now how to respond from an SDI management point of view. The problem of reliability can be traced back to the focus of management operations on output rather than outcome. Or in other words, a focus on provision and distribution (often backed by most sophisticated technology) rather than use and benefit generation. As a result, users and potential users are not included in the management strategy and its possible effects. This inclusion could be a first step towards enhancing the reliability. In theory such a management response could be visualised by the following change in operations and activities:



SDI providers and contributors would need to respond to these strategies. Such a response would need to include management of the above 5 perspectives.

When unreliability in:	Possible reliability-enhancing strategies
1) Maintenance and condition of SDI	• Filling specific gaps in the spatial coverage of the database • Collecting specific data which are more up-to-date • Development of local, "informal" and commercial databases
2) Demand & supply performance	• Supplying information of several sequential transactions at the same time • Influencing processes
3) Competitive markets – financial performance	• Provision of aggregated data at commercial cost • Provision of similar services by private sector • Development of insurance services
4) Degree of government intervention	• Development of local informal databases • Enhance relation with private sector – surveyors for example – to increase relevant output
5) Operational – operational performance	• Adopting interoperable, commercial standards for various sorts of data instead of "formal" standards • Providing extra incentives to speed up information access and retrieval processes

Conclusions

This article reviewed the concepts of reliability of infrastructure services, which is a measure for many physical infrastructures in the discussions on reform. If public geospatial information providers would consider their output in terms of reliability, than a link can be made with the extent to which users need additional reliability in order to achieve acceptable or affordable outcome. This link cold be the basis for the formulation of reliability-enhancing strategies.

References

Israel, A., 1992. Issues for infrastructure management in the 1990s. 171, World Bank