SYSTEMS THINKING: AN APPROACH TOWARDS THE DEVELOPMENT OF SPATIAL DATA INFRASTRUCTURES: THE CASE OF ZIMBABWE

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ABSTRACT

The development of sustainable spatial data infrastructures (SDI) in the developing world is a multi-dimensional, complex task. Many projects are initiated in an environment of political, economic and social uncertainty. Technically sound SDI projects have been developed in developing countries but usually under the facilitation of foreign consultants. In some instances, they have had some measure of success but often they have had minimal impact. This is primarily due to the institutional, political and human dimensions of spatial data management being overlooked.

A holistic approach is required that encapsulates the technical, institutional, social and political dimensions of SDI development. Soft systems theory, in particular soft systems thinking, provides a conceptual basis for such an approach. The context of the discussion is SDI development in Zimbabwe, an example of a developing country that is experiencing substantial uncertainty.

INTRODUCTION

An approach to SDI development in countries that experience substantial, social, political and economic volatility is desirable. Comprehensive, accurate spatial information provides the basis for much development and commercial activity. The South African experience has shown that spatial information forms a foundation for many of the strategies that underpin social, political and economic reform. Largely as a consequence of the manner in which a contentious land redistribution program is being implemented, Zimbabwe is currently experiencing much social and political uncertainty and the economy is fragile. In this paper we explore the context of SDI initiatives taking place in Zimbabwe.

In general, SDI development depends on cultural needs, social evolution, economic reality and national ambitions. The macro-environment (e.g. social, political, economic, technological and legal) and market demand will shape the most appropriate SDI (FIG Commission 3, 2000). In contrast to stable, developed world situations, methods that are suitable for addressing easily definable problems that can be solved by a number of small, clearly defined projects are unlikely to achieve a desired result in volatile situations that are typical of many developing countries. In developed countries, many of the macro-

environmental factors are stable and change in them tends to be incremental. In contrast, many developing countries experience volatility in at least one of these factors. In these cases, a systemic approach that takes into account change, volatility and uncertainty is proposed.

This paper commences with a brief description of Zimbabwe followed by an overview of SDI development. The specific case of SDI development in Zimbabwe is then discussed. This is followed by a brief description of what spatial data infrastructures are. The specific problems that have hindered SDI development in Zimbabwe are then outlined. Premises for an alternative approach are given. Systems thinking is discussed as a theoretical model that can be used to conceptualise an uncertain situation. This discussion is extended to assess how systems thinking can be used to improve the development of Spatial Data Infrastructures. The discussion ends with some recommendations for further research into this subject.

ZIMBABWE

Zimbabwe covers a total area is 390,580 square kilometres with an estimated population of 12 million people. After being colonised in the late 19th century, Zimbabwe gained its independence from British colonial rule in 1980. Zanu (PF) became the ruling party after the first general elections in 1980 and it has remained in power to date.

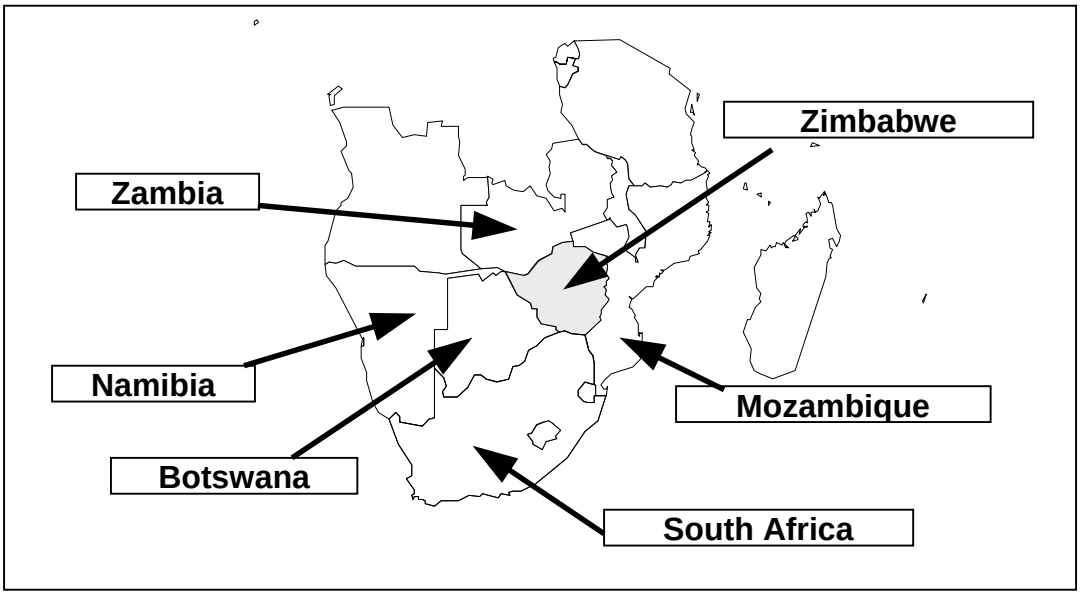

Figure 1: Map showing the location of Zimbabwe

Many of the problems facing Zimbabwe today are a legacy of segregative laws during the colonial era and the subsequent socio-economic crisis in the new Zimbabwe. In recent years, the cost of living has escalated; shortages of basic commodities such as paraffin and

fuel have increased; foreign exchange is increasingly in short supply; and socio-political unrest has increased.

The land issue is one of the most contentious issues in Zimbabwe at the moment. Colonial imbalances left the majority of the black population without fertile agricultural land. The government embarked on a land redistribution program to provide land to the previously disadvantaged populace. This program though has met with a lot of controversy due to the compulsory land acquisition exercise.

Zimbabwe is typical of an uncertain, volatile situation. This is likely to continue in the near future. Returning to stability constitutes a major challenge. A factor that will be critical to the success of many strategies to effect social and political stability, economic recovery and land reform is an infrastructure of accurate, accessible, integrated spatial information.

SPATIAL DATA INFRASTRUCTURES

The concept of any infrastructure, SDIs included, is that certain services cannot be provided to users as and when needed. Rather, these services are best provided as a foundation and fabric of all other activities of the society or community [Bathurst Declaration 1999]. An SDI is conceived to be an umbrella of policies, standards, and procedures that encourage data sharing among organizations. The goals of an SDI are to promote efficient production, management and use of geospatial data, while minimizing investments in duplicative data sets [Tosta 1997].

The SDI should not be seen as a large collection of data sets held in one computer system. It is also not owned or is under the control of one organisation. The SDI will comprise the entirety of many individual geographical data sets collected and held separately by different organisations.

COMPONENTS OF AN SDI

Drawing on Douglas (1997) and ANZLIC (1996), a spatial data infrastructure can be conceptualised as a model that comprises four core components – partnerships within an institutional framework, technical standards, core datasets with their associated metadata and a clearinghouse. The relationship between these components is portrayed in figure 2 below and a brief explanation of these components follows.

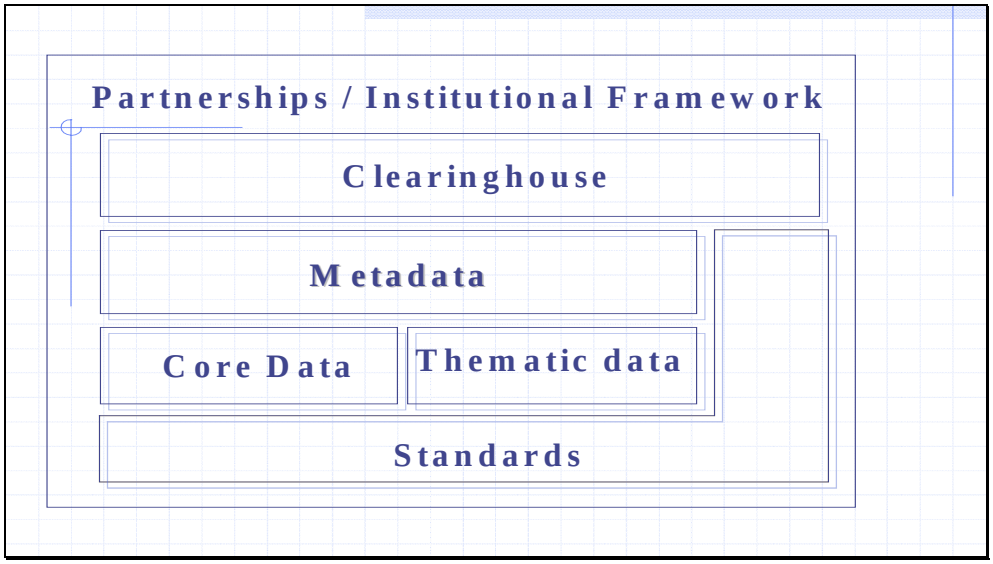

Figure 2: Components of an SDI [Modified from Douglas 1997]

INSTITUTIONAL FRAMEWORK/ PARTNERSHIPS

Within the formal institutional framework, policy and administrative arrangements for building, maintaining, accessing and applying the standards and datasets are formulated. This can seldom be achieved by one agency. It is a result of partnerships that are formed by participating institutions. These partnerships may be formally constituted, in which case there are likely to be documented policies and institutional arrangements. They also occur informally, often by means of personal networks, and policies and arrangements are likely to be implicit and flexible rather than formally constituted. According to Douglas (1997), the institutional framework comprises several key elements:

- LEADERSHIP: It is imperative that an institutional structure be identified to lead the development of a national spatial data infrastructure.
- FUNDING: For the SDI initiative to succeed, a funding mechanism should be established. The ideal situation would be to have the government fund this initiative.
- CUSTODIANSHIP: A custodian of a fundamental dataset is an agency having the responsibility to ensure that a fundamental dataset is collected and maintained under conditions and in a format that conforms to standards and policies established for the national spatial data infrastructure.
- DATA DISTRIBUTION: Distribution involves institutional issues of establishing directories and policies to make the data affordable. This includes policies relating to distribution mechanisms, pricing, copyright and privacy.
- EDUCATION AND TRAINING: More often than not, in designing and developing the infrastructure, it may be determined that there is a shortage of appropriately educated and trained people and that this is an impediment to successful implementation of the infrastructure.

TECHNICAL STANDARDS

A national spatial data framework requires standards in each of the following areas: reference systems, data models, data dictionaries, data quality, data transfer, and metadata. (Douglas, 1997)

FUNDAMENTAL DATASETS

A fundamental dataset (core data, thematic data and associated metadata) is a dataset for which more than one agency requires consistent coverage in order to achieve their objectives (Douglas, 1997).

THE SDI CLEARINGHOUSE

The clearinghouse is the means by which the Fundamental Datasets are made accessible to the community, in accordance with policies determined within the Institutional Framework, and to the Technical Standards agreed (Douglas, 1997).

THE ZIMBABWEAN SDI INITIATIVE

Given below is the status of the SDI initiative in Zimbabwe. The summary comes from a study that was jointly carried out by the University of Zimbabwe and the Midlands State University (Mavima, 2000).

(i) There is no formal SDI in Zimbabwe. No institutional arrangements have been put in place to facilitate the development of a formal SDI. However, laws and administrative regulations have been established to give exclusive mandates to government departments [Ezigbalike *et al*, 2000]. However, most of these departments lack the capacity to satisfy the needs of the expanding user community.

(ii) Some thematic data sets are available from agencies such as the Forestry Commission, the Department of Natural Resources, the Department of Agricultural and Extension Services (AGRITEX), the Environment and Remote Sensing Institute (ERSI) and the Central Statistics Office (which provides socio-economic data). Each of these data sets is produced in an arbitrary standard, which makes it very difficult to combine data sets from different agencies.

(iii) Efforts are underway to create digital databases through conversion of existing maps into digital format. Some of the organisations involved are the Surveyor General's Department, Forestry Commission, Natural Resources, National Parks, Ministry of Health. However, it is still difficult for potential users to establish the data sets that exist and if these can satisfy their requirements.

(iv) The Surveyor General's Department is currently developing an Integrated GIS database that is being funded by a Swedish agency. The system could be technically sound but it lacks a vision of becoming a component of a larger nationally co-ordinated system. Several other agencies are following the same approach leading to a proliferation of incompatible GIS's.

(v) The Surveyor General's project is an example of a donor-funded project where consultants come from abroad and prescribe systems that have worked in their environments but have no impact on the intended beneficiaries in the developing world. The stakeholders in this instance are only passive observers. They therefore do not feel the ownership of the projects.
(vi) A disturbing trend has been the general decline of funding for SDI related projects by the Government. This can be attributed to the failure by the responsible authorities to recognize the economic and developmental benefits of a good land infrastructure.
(vii) The other major problem facing Zimbabwe is the lack of prominent SDI champions at high government levels. It therefore remains a challenge to see how this initiative can seriously get off the ground.
(viii) Financial resources are scarce and investments in spatial data projects are long term rather than immediate. Politicians would rather commit the scarce resources to short term projects that will yield results in time to affect their electoral fortunes.
(ix) The economic downturn, the controversial land redistribution program and the volatile political situation only add to the intensity of uncertainty in the country.
(x) An interim SDI committee was set-up to oversee the kicking off of an SDI programme in Zimbabwe. This committee is made up of volunteers who do not have resources at their disposal; it therefore follows that it will be very difficult for this committee to carry out any meaningful work. The composition of this committee is mainly from the GIS technocrats and they are unlikely to make meaningful inroads when they try to sell their ideas to the politicians.

The above indicates that it will be extremely difficult for the development of an SDI to be seen as an important national activity that is high on the list of national priorities. An integrated approach to SDI development will be difficult to achieve. Strategies to effect an SDI will have to take into account a fragmented institutional structure where partnerships are likely to be informal. Moreover, partnerships are likely to form and dissolve frequently as, because of their informal nature, they are likely to be dependent on certain people being committed to SDI projects and their remaining in relevant positions in key institutions.

What is needed is a way of thinking about such a situation, analysing it and responding to it. System thinking in general and soft systems thinking in particular, provides an empirically based theoretical foundation for this (Barry and Fourie 2001). This does not mean that the conventional technical methods are outdated; it only means that some adaptation or extension is required [Roling N, 1996].

SYSTEMS THINKING

Mankind has succeeded over time in conquering the physical world and in developing scientific knowledge by adopting an analytical approach to understand problems (Kofman *et al*, 1993). This approach involves reducing a problem to its components, studying each part and then drawing conclusions about the whole. This mechanical way of solving problems has become inefficient in solving today's problems. Most issues nowadays are interrelated and new approaches are required to handle such situations. Kofman *et al* (1993) contend that, in order to understand the source and the solutions to modern problems,

systems thinking should be adopted, this is a way of thinking where the dominance of the whole is acknowledged.

A system, as defined in the NCGIA core curriculum is a group of connected entities and activities that interact for a common purpose (NCGIA, 1990). Spatial Data Infrastructures can be classified as systems where the components outlined in Figure 2 have complex relationships that should interact to ensure more efficient production, management, and use of geospatial data.

SYSTEMS THINKING IN THE DEVELOPMENT OF SPATIAL DATA INFRASTRUCTURES

This section looks at how SDI development can benefit from the systems thinking approach. A Spatial Data Infrastructures, as outlined above, can be classified as a system whose components have complex relationships that should interact to ensure more efficient production, management, and use of geospatial data. Systems thinking provides a framework for exploring and understanding SDI development during uncertain situations. It provides an environment and a methodology for drawing the different actors into the process and performing interventions. It does not prescribe a method or technique, as this should be devised according to each situation [Barry and Fourie 2001].

Systems thinking acknowledges the primacy of the whole. SDI development in Zimbabwe suffers from the difficulty of bringing the stakeholders together to discuss the way forward. An approach that looks at the whole will receive recognition because it endeavours to put everyone on board.

Zimbabwe is currently faced with a lot of social, political and economic uncertainty. Systems thinking provides a framework for looking at these uncertainties in the search for an SDI development strategy.

SDI development cannot be modelled using conventional reductionist scientific approaches. This however does not mean that the conventional scientific methods are obsolete; it only means that some adaptation or extension is required. SDI development will therefore need to be investigated so that a framework is developed that considers the socio-technical nature of the SDI.

Strategies to address such a situation should take into account that intervention may create more turmoil than exists at a particular time [Barry and Fourie 2001]. However, inaction, a "do nothing" strategy is also inappropriate as an infrastructure of spatial data is critical for development once the situation stabilises. Systems thinking provides a framework and methodology for a holistic conceptualisation of the intended SDI and for developing strategies based on leveraging activities in areas which are most likely to yield desirable results.

RECOMMENDATIONS

On the basis of logic and current experiences, the systems approach towards the development of SDIs in situations such as that in Zimbabwe is advisable. Political, social and economic turmoil are semi-permanent characteristic features of many developing countries. It is therefore imperative that an approach is taken that incorporates shared learning, negotiation, accommodation of conflicting goals from multiple perspectives, consensual approaches to the resolution of conflicts and partnership agreements among stakeholders (Roling N, 1997). Above all, it should be realised that SDI development is an innovation and this could mean doing things differently but collectively.

We hope this paper presented a sufficiently convincing case to stimulate further discussion on SDI development in developing countries. We believe that systems thinking is a base on which SDI practitioners can unite and formulate a new mission and research agenda. Given below are some recommendations on SDI development in developing countries.

- The development of SDIs in developing countries has few precedents; it should therefore be treated as an innovation process.
- SDI development is a multidisciplinary activity that requires expertise in disciplines such as social science, systems design and development, information technology and geomatics. It is therefore imperative to develop a comprehensive human resource plan if SDI development is to be a success.
- SDI development in developed countries such as Norway, Australia and USA, just to name a few, has met with some good measure of success; but their political, social and economic settings are different from those of the developing world, it is therefore important to study what they have done and use that knowledge to help develop methodologies that are applicable to the context of developing countries.
- SDI development methodologies must acknowledge the primacy of the whole; not only technical, but social, political and economic factors in a particular jurisdiction must, of necessity be taken into consideration.
- The beneficiaries of the SDI must be actively involved in its development and implementation. These beneficiaries include users, data owners, data suppliers, government departments, the financiers and the SDI development team.
- In a case like that of Zimbabwe, where there are no prominent SDI champions in influential positions, the technocrats who have the conviction that an SDI is a bedrock for the development of the country must start SDI activities at their level and this can hopefully drive the higher policy levels. The best situation though is to have a champion at the highest possible level in government.
- We believe that systems thinking is a base on which SDI practitioners can unite and formulate a new mission and research agenda. Further areas of research may include:
    1. Comparative analysis of SDI development methodologies in selected developing and developed countries with a view to identifying patterns in SDI development.
    2. Investigating the nature and purposes of spatial data infrastructures in the developing world.
    3. Investigation of political, social and economic uncertainties faced by developing countries and their implication to SDI development.

4. Investigation of systems thinking in the formulation of strategies for SDI development in developing countries.
5. Developing a framework for SDI development in developing countries.

It is critical that any SDI development frameworks and strategies are cognisant of the uncertainties and changes that prevail in many developing countries. Moreover, the political and cultural dimensions to the problem are likely to be far stronger than in stable, developed countries. In addition, methods and measures to evaluate projects that contribute to SDI development should be designed to take into account the uncertainty and the stronger cultural and political influences in the process.

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BIOGRAPHICAL NOTES

Reuben Mavima is a PhD candidate in the Department of Geomatics, University of Cape Town. His area of research is the formulation of strategies in the development of Spatial Data Infrastructures in developing countries. He is also currently employed as a lecturer and is head of department in the department of Surveying and Geomatics at the Midlands State University in Zimbabwe. He has worked before as the Deputy Director of Mapping in the Surveyor General’s Department, Zimbabwe as well as a lecturer at the University of Zimbabwe.

Professor Mike Barry is an Associate Professor in the Department of Geomatics at the University of Cape Town. He teaches GIS, Land Law and Land Tenure Systems, Cadastral Systems and Surveying. He set up and directed the Department’s postgraduate programme in GIS in 1993, which had a strong emphasis on strategic management in addition to technical theory. His primary research interests include the design and evaluation of cadastral systems during uncertainty and social transformation, and managing the design and implementation issues in GIS. He has also published in the field of offshore engineering surveys on the basis of his practical experience, but he is no longer active in this area.

Dr. Ulrike Rivett is a Senior Lecturer in the Department of Geomatics at the University of Cape Town. Ulrike Rivett completed her Dipl.- Ing. univ in Surveying at the Technical University in Munich, Germany in 1994 and proceeded with her Masters degree in Engineering at the University of Cape Town. Ulrike's main research interest is in the areas of photogrammetry, GIS and remote sensing. She enjoys the interdisciplinary nature of her research projects and the international collaboration between educational and research institutions. Due to her PhD she was mainly focused on close-range photogrammetry, but her intentions are to investigate into the application of a remote sensing and GIS combination in the context of environmental planning issues.

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