The importance of information system design improvisation in meeting the needs of an emerging democracy in South Africa, a case study of a national waste information system

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Abstract

Designing a successful national waste information system (WIS) for an emerging democracy in South Africa requires that the system be relevant, efficient, effective and above all sustainable. To do this, the needs of government and stakeholders and the opportunities and constraints which face government and industry, need to be understood. The design methodology needs to consider these needs, opportunities and constraints to ensure that the risk of system failure, whether total or partial is reduced. The identified needs, opportunities and constraints are further explored and an approach to reduce the design-actuality gap proposed.

1. Introduction

South Africa emerged as a democratic society in 1994, following the abolishment of apartheid. The past ten years have seen both a significant growth in environmental policy within the country, as well as a positive change in the approach towards environmental management. The South African Department of Environmental Affairs and Tourism (DEAT) published a White Paper on Integrated Pollution and Waste Management (IP&WM) in 2000 (DEAT, 2000) which outlined "*government's new thinking in relation to pollution and waste management*". The policy (goal 6) identified the need to develop and maintain databases and information management systems, to monitor and collect information on pollution, chemical hazards, toxic releases, transportation of hazardous materials and waste generation. The intent being to support the implementation of pollution and waste reduction measures, effective integrated pollution and waste management, and the constitutional rights of all South Africans through access to information (Act 108 of 1996, Act 2 of 2000).

In 1999, the development and implementation of a waste information system (WIS) was costed at R21 million ($3.6 million) (development and investment costs), with an annual operating cost of R57 million ($9.7 million) (DEAT, 1999). The staff requirements to implement the WIS were given as ~370-850 persons solely within government. No figures were given as to the staff requirements within the companies responsible for providing the data, but with an estimated 200 000 data providers to the WIS (DEAT, 1999), the capacity required within the waste industry, and the associated cost, is daunting.

A prototype system was developed and piloted in 1999, but was never implemented. Implementation lay dormant for five years (1999-2004). Possible reasons include the high turnover of government officials following the development of the policy or the lack of ownership of the policy by government due to the heavily consultant driven approach adopted by the donor funded project.

A donor funded project was again initiated in 2004 (DEAT, 2004) to develop and implement a sustainable, national WIS for South Africa, a system capable of routinely collecting accurate data on waste,

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across three spheres of government and from various waste industry role-players. This in light of government's previous, unsuccessful, attempt to develop and implement a sustainable WIS.

2. System sustainability

Information system failure is not unique to South Africa. Nor is it unique to other developing countries or even to developed countries. In fact developed countries show up to a 50-85% partial or total failure rate of information systems (Heeks, 2002). Developing countries do however show a comparatively higher failure rate than that experienced by developed countries (Heeks, 2002; Peterson, 1998) due to a lack of appropriate technical and human infrastructure (Heeks, 2002; Moussa & Schware, 1992), limited management capacity and commitment (Peterson, 1998), high government staff turnover (Moussa & Schware, 1992), an unsupportive public sector culture (Mursu et al., 2000; Peterson, 1998), post development withdrawal of donor funds (Heeks, 2002), and adoption of often overly complex (Peterson, 1998) or unsuitable industrialised country information systems (Heeks, 2002; Odedra, 1993). According to Peterson (1998:38), "*Information systems fail or underperform more often than they succeed in the public sector in Africa"* primarily because *"they outstrip the capacity of government staff to manage. The management task is formidable.*"

Heeks (2002:104) proposes that these system failures are as a result of a "*mismatch between local actuality (where we are now) and system design (where the design wants to get us)*", what he terms as the '*design-actuality gap*' (Heeks, 2002) or the '*design-reality gap*' (Heeks, 2005). The greater the gap between the proposed system design and reality, the greater the change required to close the gap, the greater the risk of failure of the information system (Heeks, 2002) and the greater the potential for conflict between users and stakeholders (Warne, 2003).

According to Peterson (1998:38), "*The objective of systems development is the creation of a useful and sustainable information system.*" With the previous failure to implement a WIS in South Africa, system sustainability [(2)] was a critical aspect to consider in the design and development – an aspect which needed to be considered not at the end of the project, but importantly during design and development.

3. Identifying the design-reality gap (needs, constraints and opportunities)

The development of a sustainable WIS required a framework or system design which had the support and buy-in of both government and key stakeholders. The preparation of such a system design therefore required an understanding of the current 'philosophy' of government and stakeholders with respect to the WIS, the needs of government with respect to waste information, and the issues which stood in the way of successfully developing and implementing a sustainable waste information system in a developing country such as South Africa. The design process needed to clearly understand both the "*local actuality (where we are now) and system design (where the design wants to get us)*" (Heeks, 2002:104), so as to identify critical gaps which could potentially undermine system sustainability.

In order to quantify these needs, constraints and opportunities a participative approach involving all end users (government and the waste industry), community based organisations (CBOs), non-governmental organisation (NGOs) and specialist consultants was adopted. The 'gap' between reality and design could be identified in terms of the constraints which stood in the way of successful system development and implementation, and the opportunities could be identified as those aspects where little gap existed and on which the system design could be founded.

[2] Sustainability is seen as being the "*the ability of a programme or project to continue, and to continue being effective, over the medium to long-term*" (UNAIDS, 2005).

3.1 Understanding the needs

Moussa and Schware (1992) in a study of information systems in Africa found that for 29% of systems, the intent or purpose of the information system was unclear, and for 27%, the systems were not relevant to the organisational objectives. These problems relate to the lack of a clear understanding of the needs of the relevant stakeholders. A problem recognised as being one of the top three reasons for information system failure (Schmidt et al., 2001; Axtell et al., 1997 in Fisher, 2003).

Two parallel processes were adopted for assessing the needs of stakeholders, (i) workshops were held in selected provinces and (ii) a postal questionnaire was sent out to all 284 local authorities.

The top needs of government with respect to the national WIS, as identified from this participative process (Godfrey, 2006), were to (i) inform waste management *planning*, (ii) support *compliance/enforcement* by government, (iii) support public *access to information*, (iv) inform *decision-making*, (v) inform *policy development*, (vi) inform *new development* initiatives, (vii) support *human resource & operations management*, (viii) inform *budgeting/billing/financial management* of waste operations.

The needs analysis recognised that an improvement in the management of waste was required, and that to do this a change in the way government and industry addresses waste was necessary. This change could be facilitated through the successful implementation of a national WIS.

3.2 Understanding the constraints

With these needs in mind, the constraints to successfully developing and implementing a WIS in South Africa were explored through workshops with selected provincial and local governments. In terms of Heeks' design-reality gap model (Heeks, 2002; Heeks, 2005), a constraint is seen as a gap between the current state or '*reality*' and the desired state or '*design*'. Understanding the constraints therefore assists in identifying critical gaps which may undermine successful system implementation.

The key constraints to development and implementation of a WIS within government and industry were identified as a (i) *lack of high-level political and management support* within government to develop and/or implement the WIS; (ii) *poor communication* between the three spheres of government and between government and industry; (iii) *lack of resources* (human, financial and technological) within government to develop, implement and sustain the WIS; (iv) *lack of experienced or knowledgeable staff* within government, as it relates to the WIS; (v) current *lack of data* to populate the WIS and uncertainty as to the accuracy and reliability of existing data.

3.3 Identifying the opportunities

Opportunities are recognised as those aspects which are currently aligned with the desired state or objective of the WIS and which would provide a foundation for the development and implementation of the WIS, i.e. areas where little or no gap exists between design and reality. Such opportunities include (i) institutional restructuring in DEAT in response to an expressed need for a WIS, thereby creating a staffed sub-directorate at national government responsible for overseeing the WIS; (ii) sufficient time, with a project duration of 3 years to allow for systematic design, development, testing, redesign and final implementation; (iii) financial resources at national government to support the design, development, testing and initial implementation, and (iv) impending legislative reform, to support legal enforcement.

4. Reducing the design-reality gap

The design-reality model (Heeks, 2002) proposes that by reducing the design-reality gap, the risk of system failure will be reduced. The design-reality gap may be reduced by either changing the system design (*design improvisation*) or changing actuality (*actuality improvisation*) (Heeks, 2002). This paper focuses

on how one can reduce the design-reality gap for the WIS, through design improvisation, by addressing four key identified constraints or 'gaps':

- Information constraints
- Technology constraints
- Capacity constraints
- Financial constraints

Although each issue is discussed separately, the following sections will show the inter-relatedness of these four constraints and the influence that each one has on the other during system design improvisation.

4.1 Information constraints

Government and industry in South Africa are currently collecting very little data on waste and where data is collected, the accuracy and completeness of this data is questionable. The implications of the national policy on pollution and waste (DEAT, 2000), would be the need to collect detailed data, from a large number of role players (estimated at 200 000 companies), on a wide array of pollution and waste issues. To be able to collect all of this data would require complex and sophisticated information systems, many highly skilled staff in government and industry and significant financial resources in order to be sustainable.

With financial and human resources identified as a key constraint, the feasibility of being able to collect all of the envisaged data, let alone verify, process and disseminate the data, is unlikely. A phased or iterative approach to the development of the national WIS would however allow for the system to grow together with the capacity of government and industry, fundamental to the systems sustainable implementation in South Africa.

A phased approach, both in terms of the detail of the required data as well as the providers of data was adopted. Detail of data is expanded upon with time, from e.g. indicating the type of waste simply as hazardous in phase 1, to identifying the specific pollutants (hazardous category) in phase 4. Data providers are expanded upon by focussing on end-of-pipe facilities (landfills, treatment, reprocessors) in phase 1 and phasing in generators in phase 4. Thresholds are also used to phase in data providers, e.g. by requesting data from only medium and large general waste landfill sites in phase 1, data on 84% of the waste stream can be obtained from only 27% of the landfill sites (DWAF Baseline Data, 1998). Phase 1 requires a more limited volume of data for the system, which, in turn, reduces the human resource and associated financial burden on government and industry, but still provides sufficient data to government for effective planning. The framework provides sufficient detail on the first four phases of implementation to allow flexibility for local authorities and provinces to choose to implement the WIS more comprehensively, where resources are available to them.

4.2 Technology constraints

To support government in the collection, verification and dissemination of data, the WIS must be: accessible to all stakeholders; reliable in terms of completeness and accuracy; and reasonably fast. Use of a web-based WIS made the most sense, since it would allow for data providers to directly submit data on-line to government. It would also provide all three spheres of government with access to data stored within the WIS, thereby promoting the sharing and dissemination of data. Statistics however show that only 9.9% of the South Africa population (~ 4.8 million users) have access to the Internet. In relation to the rest of Africa, South Africa has shown slower growth in Internet usage over the past five years (99.2% over the period 2000-2005) (Table 1), but is at the level of Internet growth experienced globally (169.5%) (Table 2).

The statistics provided some degree of assurance that South Africa would continue to experience Internet user growth and connectivity, with more municipalities and companies being connected to the Internet. As such a web-based approach was adopted, however the system design would also need to provide for

the capturing of data by those companies with no access to the Internet. A web-based approach however opened up a number of security and user access issues. The system needed to be developed to ensure that data could not be altered or deleted once verified and that data providers and users had restrictions on access to certain data.

Table 1. Internet Usage Statistics for South Africa and Africa (Internet World Stats, 2005)

AFRICA	Population (2005 Est.)	Internet Users Dec/2000	Internet Users, Nov/2005	% Population (Penetration)	(%) Users in Africa	User Growth 2000-2005
South Africa	48,051,581	2,400,000	4,780,000	9.9 %	20.0 %	99.2 %
TOTAL AFRICA	896,721,874	4,514,400	23,917,500	2.7 %	100.0 %	429.8 %

Table 2. Comparison of South Africa and World Internet Statistics (Internet World Stats, 2005)

World Regions	Population (2005 Est.)	Population % of World	Internet Usage, Nov/2005	% Population (Penetration)	Usage % of World	Usage Growth 2000-2005
South Africa	48,051,581	0.75 %	4,780,000	9.9 %	0.49 %	99.2 %
WORLD TOTAL	6,420,102,722	100.0 %	972,828,001	15.2 %	100.0 %	169.5 %

4.3 Capacity constraints

The original thinking around the national WIS (DEAT, 1999) was one of all data providers providing data to local government, who would collate and submit to provincial government who would verify and submit to national government. This approach placed a considerable work load onto local government as the principle recipient of data. While this approach made sense in terms of the constitutional mandates of local and provincial government, the question of the number of staff required versus the available capacity within local government was identified as an issue of concern.

A review of capacity assessments of local municipalities in 2003/04 (Municipal Demarcation Board, 2005), indicated that 54.2% of municipalities could not fully perform their existing waste management functions as assigned to them under the Constitution. Reasons given for non-performance included insufficient budget; insufficient staff; insufficient equipment; service not required; poor access to areas; and 'other' (Table 3), with 40.8% of all municipalities indicating non-performance due to a lack of staff.

Table 3. Percentage of local authorities which indicated non-performance of waste service delivery for 2003/04 (Municipal Demarcation Board, 2005).

Insufficient budget	Insufficient staff	Insufficient equipment	Service not required	Poor access to areas	Other
45.4%	40.8%	38.7%	13.4%	11.3%	6.7%

How could national government assign additional responsibilities through the implementation of the WIS, to a sphere of government which was already underperforming with respect to waste management and which lacked budget and staff?

Meeting the original demands of the WIS (DEAT, 1999), meant either (i) increasing the number of government positions required to manage the WIS (an additional 370-850 positions), or (ii) designing the

WIS to be less reliant on a large number of government officials, particularly at local government where the bulk of the load was seen to fall. Since the problem with capacity is not so much about creating positions, but rather in filling positions and retaining staff, it was not considered sustainable to develop a WIS which relied on a large number of skilled staff. As such, design improvisation needed to consider how to (i) change the roles and responsibilities of the spheres of government in alignment with human resource constraints, or (ii) reduce the dependency of the WIS on scarce resources through improved technology. This was achieved by changing the roles and responsibilities of local government in the system design, by moving the bulk of the administrative activity away from the 284 local authorities to the nine provinces, thereby concentrating staff and activities at provincial government level. This in conjunction with a reduction in the data load (Section 4.1) would result in fewer staff requirements particularly for phase 1 of system implementation.

4.4 Financial constraints

Development and implementation of a WIS requiring an operational budget of R57 million per annum (DEAT, 1999), raises concerns as to the socio-economic feasibility of such a system in a developing country such as South Africa.

South Africa, a lower-middle income country, has an unemployment rate of 26.5% (Statistics South Africa, 2005), with 23.8% of South Africans living on less than $2 a day (at 1993 international prices). (World Bank, 2004). This level of poverty is further compounded by the fact that between 1994 and 2002 the number of South African families living in shacks doubled to reach 1.8 million (World Bank, 2004). 42.9% of households in South Africa do not have access to refuse removal and 32.2% of households do not have access to piped water (HSRC, 2006). South Africa faces many basic challenges of housing, water, sanitation, health services, security and job creation. As indicated in Section 4.3, 45.4% of all local authorities indicated that they did not have sufficient budget to be able to fully perform their existing waste management functions.

While it is recognised that a national WIS is important in supporting the improved management of waste in South Africa and thereby reducing the impacts of waste on the environment and human health, it is the opinion of the author that the development of an information system which requires an operating budget of R57 million ($9.7 million) per annum can not be justified in light of South Africa's socio-economic status and the challenges facing society. R57 million could perhaps be better served in firstly meeting the basic societal needs of the country, e.g. R57 million could build approximately 2 300 low-cost houses a year [(3)], or in supporting the improved engineering of landfill sites in South Africa, actions which would have immediate, short-term rewards.

The goal in system design was therefore to find a balance between the need for a system and the cost of development, implementation and operation. In particular to develop a system that required a lower annual operating cost. Since the bulk (R53.5 million or 94%) of the proposed annual operating cost was made up of salaries of government officials (DEAT, 1999), reducing the annual operating cost could only be achieved by reducing the number of people required to successfully operate the WIS. It was recognised that reducing the number of people involved would ultimately affect the quantity and/or quality of data which could be collected. Since the quality of data could not be compromised, the implication of reducing the number of people involved in the operation of the WIS, would be to (i) reduce the quantity of data required by government and (ii) make the system as efficient as possible so that data can be timeously entered, verified and disseminated (See section 4.1 and 4.3).

The WIS, following the above data, technology and capacity design improvisations (Sections 4.1-4.4), is expected to have an annual operating cost to government of ~ R5 million ($850 000) per annum, less

[(3)] A 23m² Reconstruction and Development Programme (RDP) house is estimated to cost approximately R25 000 to build (Department of Housing, 2005).

than 10% of the original operating budget. A budget considered more justifiable in a young democracy such as South Africa. A higher operating budget will be required as further phases are implemented, a process which will hopefully parallel economic growth in South Africa and the improvement of basic services to all South Africans.

5. Conclusions

Design improvisation has been a necessary step in the development of a national waste information system for South Africa to ensure, as far as possible, system sustainability. It has also provided a challenge in finding the balance in improvisation between the four key design components, data, technology, capacity and finances. The inter-relatedness of these four components has required a clear objective of the intent of the WIS.

Design improvisation has seen a need to reassess the roles and responsibilities of the various government departments responsible for the WIS, so as to reduce the dependency of the system on large staffing requirements and thereby costly annual operating budgets. It has also required the phased implementation of the system, and the introduction of data thresholds, so as to reduce the data requirements and thereby the associated capacity and financial resources. This phased implementation allows the system to grow together with the capacity of government and industry.

The success in designing a sustainable WIS will only however be realised in the coming 2-3 years, as the system is rolled out to all provinces.

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