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Water and Sanitation in Developing Countries: Internet Based Computing Model for effective Delivery of Services.

by

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Declarations

I, Ndirangu Kibata, (Registration Number 9509579) hereby declare that this thesis titled *Water and Sanitation in Developing Countries: Internet Based Model for effective Delivery of Services* is the result of my own investigations and research and has nor been submitted in part or in full for degree or any other purposes in this or any other University.

Abstract

The study aimed at improving the communication continuum within the water and sanitation industry for developing countries. This was conducted by modelling various aspects of the water and sanitation industry measured against the introduction of the Internet technology in the sector.

Literature on the Internet and its deployment in other sectors of the economy was reviewed with a view to determining as to whether the use of the Internet in water and sanitation is desirable. A survey was conducted to determine the type of information the water and sanitation industry would like availed on the Internet. A survey was then conducted to determine the extent to which the information desired by the industry was available on the Internet.

Having established the need to introduce an Internet based information dissemination and retrieval regime, a multi-criterion optimisation model was developed to compare the performance of traditional methods of information dissemination and retrieval against Internet based methods. The model thus developed was then applied to select pilot projects used in the research to determine the disposition of actors in water and sanitation towards Internet based information system. Further, the pilot projects were monitored in order to document best practices in so far as their operations were concerned.

The study then focused on the diffusion of the Internet technology into the water and sanitation. The diffusion was modelled using models developed in the classical theories of technology diffusion. The models were then tailored for use in water and sanitation and modelled the diffusion of Internet technology into the sector. The model then optimised on the rate of diffusion of the technology.

The study concludes that whereas a firm basis for widespread use of the Internet in water and sanitation has been laid, effective use of the technology has not taken off. The study suggests ways in which this can be improved.

The research produces 3 products. These are an algorithm for gauging water and sanitation information flow over the Internet, a documentation of best practices in the use of the Internet in the water and sanitation information continuum, and a model for technology diffusion in the water and sanitation sector.

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ARPANET	Advanced Research Project Foundation Network
CTRI	Cumulative technological replacement index
DO	Dissolved Oxygen
EARN	European Advanced Research Network
FU	Fractional Utility
HAI	Horizontal Availability Index
HTML	Hyper Text Mark-up Language
IAWQ	International Association for Water Quality
IRC	International Reference Centre for Water and Sanitation
ISDN	Integrated Subscriber Dial Network
ISP	Internet Service Provider.
ITN	International Training Network for water and sanitation.
MCOM	Multi-Objective Optimisation Model
NCWSTI	National Community Water and Sanitation Training Institute (For South Africa)
NSFNET	National Science Foundation Network
NGO	Non Governmental Organisation
RDP	Reconstruction and Development Programme
SRI	Shadow Rating Index. An Index used to rate the quality of information contained in a particular water and sanitation Internet site.
TCP / IP	Transmission Control Protocol / Internet Protocol.
UFR	Usage Frequency Rating

List of Abbreviations

UI	Utility Index
URL	Uniform Resource Locator. This is actually refers to an Internet address on the World Wide Web.
WatSan	An acronym for water and sanitation
WEDC	Water Engineering, Development Centre
WENDY	Water and Environmental Sanitation for Developing Country Needs.
WES	Water and Environmental Sanitation (Services)
WISA CWSSD	Water Institute of Southern Africa – Community Water Supply and Sanitation Division.
WSSCC	Water Supply and Sanitation Collaborative Council

Glossary

Circuit switching	How the plain old telephone system (POTS) works: The phone company establishes a dedicated circuit across its lines from caller to callee.
Computer Protocol	A language set to certain standard which computers use when executing certain functions as well as communicating with each other.
Cookie(s)	A small text file embedded in the file of a user's computer on accessing a particular Internet site. This file helps build up the user profile for use in the analysis of the site access.
Grey Literature	Collection of field reports, usually collected by development workers, detailing field observations. Grey literature is not usually verified using rigorous scientific methodologies but forms a good basis for conducting research and compilation of field manuals.
Hit	A term used to refer to an individual access to a particular Internet site.
Hyperlink(ing)	A way of linking related ideas using highlighted text (the hyperlink) to call up the document that logically follows the active one
Horizontal availability (of information)	A measure of the quantity of information available over the Internet on water and sanitation.
Internet Miners	Professionals who search the Internet for specialised information and sell to their clients.
IP	Internet Protocol, the IP in TCP/IP. The set of rules and standards that govern how packets of data are sent and received over the Internet
Java Scripting	A light form of programming that is used within web pages to execute specific instructions over the Internet. The scripting language is similar to Java programming language but tends to be more accommodating in terms of syntax. It is also more portable than the actual program in order to enable execution over the Internet. Other scripting languages such as Vbscripting, PERL, etc also exist but Java Scripting is by far

	the most popular.
Mission-Critical tasks	Tasks undertaken in the operations of an organisation's core business. Generally, they draw their legitimacy from the organisation's mission statement.
Packet switching	How most data networks work. Data is divided into packets, with the destination computer's network address appended to each. Hardware along the network examines these addresses and forwards the packets accordingly.
Peering Agreement	An agreement between Internet service providers with the same capacity to exchange Internet traffic at the same level to facilitate seamless connection between their respective networks.
Q-Test	Technique developed in the research for testing the quantity of information available on the Internet on a particular topic.
Routers	Computers on a network that direct data to the intended destination. They are typically located at the end of one network and connect to the next network. This is the hardware that ties the Internet together, by forwarding packets from one network to another.
Search Engines	Computer programs that conduct search over the Internet for particular information. Usually owned and operated by large Internet companies which use their sites for advertising and referral services.
Shadow Rating	A technique for gauging the quality of information on a water and sanitation Internet site using indirect measures.
Switches	Same as routers but designed for higher capacity of traffic.
T1	High Speed Internet data carrier lines. Usually made from fibre optics and transmitting data at speeds of up to 10 MB/s. Other classes in this line are T2, T3 and T3.
Technology Diffusion	This refers to the rate at which organisations in the given economic

	sector adopt a new or innovative technology and subsequently, the extent to which the organisations use the technology.
Technology Diffusion Trajectory	When a new or innovative technology is initially introduced in an organisation, its capabilities are largely untested. At that point, several combinations of the technology mix (old and new) exist. Through experience, the organisation settles at the optimum mix when the transition is over. The preferred technology mix is what is referred to as the technology diffusion trajectory.
Teledensity	Number of main telephone lines per 100 inhabitants of a country.
Underserved (in water and sanitation)	A reference to poor people in developing countries who do not have access to reasonable water and sanitation services both in urban and rural areas.
Vertical availability (of information)	A measure of the quality of information available over the Internet on water and sanitation.

Chapter 1: Introduction

Clean water supply and adequate sanitation are a prerequisite to a reasonable standard of living for a given populace. However, in majority of developing countries, access to clean water and adequate sanitation is not guaranteed to a large proportion of the inhabitants. Several reasons have been advanced ranging from lack of funds to a low priority given to the services by the policy-makers. To compound the problem, costs in provision of water and sanitation services in developing countries have been rising while the quality of available water is falling (Seregeldin, 1995). This thesis asserts that it is possible to improve on water and sanitation coverage through the input of information technology into the sector. Intensive use of information technology has been proven to increase productivity and lower costs in the business and financial sector (Tapscott, 1997). However, incorporation of the technology in provision of water and sanitation services in developing countries has not been as extensive (Talero and Gaudette, 1996). This thesis is a result of a research into the use of information technology aimed at increasing coverage through ensuing lower cost as well as increased productivity in water and sanitation.

Information technology consists of several categories, all of which have different purposes in a given process. The particular aspect of Information technology that the research dealt with is the use of the Internet.

The Internet makes available 3 channels through which delivery of services in water and sanitation can be enhanced. These are: -

- efficient and timely transfer of appropriate and *state of the art* technology in water and sanitation,
- lower costs as a result of effective means of communication through the sector,
- better management of water and sanitation delivery mechanism through enhanced communication within the organisation.

Whereas the research focused mainly on the first delivery channel given above (transfer of appropriate and *state of the art* technology), it was difficult to distinguish the between the channels. It was not deemed necessary to draw a rigid line between the channels for the purposes of the research either.

1.1. Background to the Thesis

It has been established that in water and sanitation, it takes an average of 10 years for a new technology, however applicable, to gain universal acceptance (Hanna *et al*, 1995). Various reasons have been advanced for this lag. However, difficulties in communication of the technology (technology transfer) stand out as the overriding reasons for this lag (Drucker (a), 1994). The implication of this technology lag has been continued usage of technology that is more expensive than what is available at a given time. Developing Countries thus stood a chance of saving costs in water and sanitation if they implemented appropriate or state of the art technology. However, in order for these savings to be realised, the lag between a technology and its universal acceptance had to be reduced.

Various ways of reducing this technology lag were sought. In the meantime, developments in electronic networking through the Internet opened up new possibilities for the communication of technology in the water and sanitation sector. However, information on water and sanitation particularly on developing countries on the Internet was (and still is) scattered and hard to find. In the project, the International Association on Water Quality (IAWQ) and the Water Research Commission of South Africa agreed in 1995, to support the Pollution Research Group (PRG) at the University of Natal, Durban in creating an information gateway, in the form of a home page on the Internet. This was provisionally known as WENDY and later changed to INTERWATER. The IRC International Water and Sanitation Centre, together with the United Nations Centre for Human Settlements (Habitat), the Environmental Health Project (EHP) of USAID, and the Water, Engineering and Development Centre (WEDC) at Loughborough University were invited to become members of an International Steering Committee to guide this development. Following a demonstration of a prototype information gateway for the sector at the Third Global Forum of the Water Supply and Sanitation Collaborative Council, held in Barbados in November 1995, the Council approved the inclusion of the Internet initiative in its programme of activities for 1996 - 97. The council further authorised the steering committee to function as a council task force on the subject, under the co-ordination of IRC.

Following discussion among Task Force members, it was decided to change the name of the initiative to INTERWATER in order to establish more clearly its connection with the water sector for users of the Internet.

A pilot web site was established and tested for its potential use in providing technical information on water and sanitation in developing countries was evaluated and reported in work by Kibata (1996) and Dindar (1997).

1.1.1 The Water and Sanitation Information Continuum

Water and sanitation is generally associated with the *underserved* of the developing communities. Associated with it is the accompanying practice, where the levels of service to those communities are usually the lowest available. The RDP policy on water and sanitation is one such example as is the subsequent government policy on water and sanitation (ANC, 1994 and Department of Water Affairs, 1994). Assuming that the level of service is proportional to the capital outlay necessary to address the backlog in the services, question arises as to why despite the low capital requirement, backlogs in water and sanitation services continue to increase throughout developing countries. A partial answer to this question is simply the sheer numbers of people without access to adequate water and sanitation services. **Table 1.1** gives the backlog of the services in water and sanitation in developing countries.

Table 1.1: Estimated number of people without access to adequate water and sanitation services in developing countries, 1994 (Seregeldin, 1995)

Service	Number of *unserved* people
Water	830 Million
Sanitation	1200 Million

The number of people without the services represents 52 % of the rural population and 25 % of the urban population in developing countries. Coupled with the high number of the underserved population in developing countries, a high population growth outstrips the marginal gains in coverage achieved through various efforts.

Seemingly, it is paradoxical to consider Information technology in a sector where bottom end of technology is necessary in order to achieve useful results. However, this study asserts that there is a scope for application of Information technology in the sector and more so the Internet. The big numbers involved require an integrated management at national and international level with efficient co-ordination in order to consolidate any gains in the coverage. Information Technology has been successfully applied in integrated management

of resources in other sectors and there is no reason why the same should not apply to water and sanitation.

The study will review the emerging paradigm in computing that is being successfully implemented in other sectors.

1.1.2 Previous work on the Internet, water and sanitation in developing countries

In his work, Kibata (1996) concluded that

- understanding the role of clean water supply and improved sanitation in country's sustainable development is important if the policy planners are to put necessary emphasis on the sector. However, this role tends to be ambiguous and little understood. Thus the study identified this as an area, which in which a full-scale site containing technical information on water and sanitation sectors of developing countries could play a part by bridging this information gap.

- despite the role played by appropriate technologies in provision of clean water supply and adequate sanitation, there is a lower level research in the sector due to perception that appropriate technology is inferior by engineers. The site was thought to have a potential to simulate research and development in the sector through enhanced information provision. Examples of the appropriate technologies were given as slow sand filtration, sub surface dams, ferro-cement tank, ventilated improved pit latrines, gravity flow water projects, rainwater harvesting, constructed wetlands for water quality improvement, waste stabilisation ponds and septic tanks.

- there exists effective, appropriate solutions to technical problems encountered by engineers in developing countries within the developing countries.

- greater access to the Internet in developing countries is a pre-requisite to an effective use of the Internet in water and sanitation sectors of developing countries for technology transfer and exchange.

Kibata (1996) hence recommended that

- in order to increase access to the information held by the web site to sector professional in developing countries, it was necessary to present the web site in

popular languages, creation of awareness of its presence in print and electronic media and to increase access to the Internet in developing countries for engineers involved in water and sanitation sectors of developing countries.

- priority be given to inclusion on the site of information on appropriate technology. This may have an effect of stimulating research in this direction, which is beneficial to communities in developing countries.

- a listserver that is specific to water and sanitation in developing countries be established to exchange technical views and information among engineers.

- establishment of a parallel project to improve access to the Internet in developing countries.

- standardisation of technical information held by partner organisation in order to ensure logical and effective flow of information among the engineers.

- Previous work done on Internet, water and sanitation in developing countries for rural areas

In his work, Dindar (1996) concluded that: -

- rural water and sanitation forms an integral part in the overall development of the country. Therefore it is necessary that comprehensive policies and strategies for the delivery of these services be drawn up at the highest level of government. The lack of political will at these levels of government has often hindered the efforts of donor organisations and non-governmental organisations.

- in delivery of water and sanitation services to isolated rural communities in developing countries, particular attention has to be paid to the use of technologies which are cost effective, sustainable and designed for the local rural conditions, i.e. appropriate technologies. Although these technologies may be outdated, they will be more successful in the delivery of services than modern technology. Often designers and engineers planning rural water supply schemes are not aware of these technologies since they do not form part of mainstream tertiary education. Thus there is a need to transfer this information to the relevant authorities and planners. The

dissemination of this information can be facilitated through the established information network on the Internet.

- formal and informal communication between sector professionals in water and sanitation sectors of developing countries is very important. These processes can be conducted efficiently and cost effectively through the use of Internet tools such as e-mail, listservers, discussion groups and world wide web. These tools can also be used for the distribution of reports, newsletters and software at a fraction of the cost of distributing printed material.

Dindar hence recommended that:

- since little research is dedicated to rural water supply and sanitation, research institutions need to develop specialised courses that will provide adequate training to individuals involved in water supply and sanitation. This will encourage research in the sector. In addition to this, research institutions in association with experienced sector professionals should conduct intensive training courses and workshops for individuals involved in the sector that may not have the necessary skills.

- organisations and sector professionals should be encouraged to collect store, and disseminate data electronically. The aim should be to gradually move away from printed data / information dissemination to electronic data/information dissemination. This data can then be made available world wide through the Internet at a reduced cost.

- the hardware and software used by the web site and its partner organisations should be standardised in order to maximise the speed and format in which data is disseminated. Although this has partly been achieved through the Internet, it should also be implemented in the types of databases and indexing systems used to catalogue large libraries of information. Standard hardware and software will also prevent the problem of a breakdown in communication due to the inability of certain computers to communicate with others.

- the language base of the web site should be increased to include French, Spanish, Portuguese, Arabic and Chinese. The responsibility of maintaining the web site in the various languages should be given to organisations/individuals proficient in these

languages. This will also enhance the globalisation of the web site rather than confining it as an Anglophone countries' activity.

- the information available through the web site and its partner organisations should be indexed in a standard format. This will simplify the task of searching and finding information that will attract rather than discourage individuals from using the web site repeatedly.

From the recommendations of these 2 studies, further work was deemed necessary in order to consolidate the use of the Internet in water and sanitation, hence the current study.

1.1.3 Water and Sanitation in Developing Countries

Investing in water supply and sanitation is considered beneficial to a country's populace. Definite correlation between improved sanitation and water supply on one hand and reduction in infant mortality has been found (Blum and Feachem, 1983). Other studies suggest reduced morbidity from a host of water related diseases with improved water supply and sanitation (LaFond, 1986). It is has also been found that improper sanitation leads to excreta disposal that lacks in privacy with attendant loss in human dignity and especially so in case of women (Okun and Ernst, 1987). The problem of lack of water and sanitation in developing countries has been put in context by LaFond (1993) who reports that women and children in developing countries spend over 10 million man-years in fetching water, usually from polluted sources,. Efforts to reverse various negative effects due to lack of sanitation and clean water are generally hampered by the reasons outlined in **Section 1.0**.

It is in view of this background that the research leading to this thesis was formulated.

1.1.4 Paradigm Shift in Water and Sanitation for Developing Countries since the Water and Sanitation Decade.

Prior to 1980, water supply and sanitation for developing countries were well understood in so far as technical issues were concerned. By mid 80`s, increased investment in water and sanitation had not produced commensurate rise in health benefits. Moreover, the percentage rise in coverage was outstripped by the population growth. This lead to a rethinking of the water and sanitation strategies for developing countries.

The rethinking of the water and sanitation strategy for developing countries lead to recognition of the role-played by a range of issues hitherto not considered in water and

sanitation for developing countries. Among those issues were socio-anthropological issues, environmental issues, community education and management as well as increased emphasis on sustainable sanitation. The import of this recognition was the greater visibility of the role played by effective communication in bringing about sustainable water and sanitation in developing countries.

Introduction of the Internet has helped improve communication in the field of research as well as business and commerce sector. Coupled with the improvement, a significant drop in communications costs has been afforded through the use of the Internet. This research will help identify as to whether scope exists for extending these benefits noticed elsewhere to the field of water and sanitation in developing countries.

1.1.5 Communication as an issue in Water and Sanitation for Developing Countries.

The United Nations called for the water decade between 1980 and 1990 following the realisation that water and sanitation coverage in developing g countries was low. At the start of the decade, conventional water supply strategies backed by capital injection would lead to higher coverage. However, by the middle of the decade, it became apparent that water supply to developing communities was more complex and went beyond technical issues. The importance of non-technical issues was appreciated. Among others, the non-technical use that came to fore be public / community participation, hygiene education, water and sanitation advocacy and gender issues among others. The role of appropriate technologies in water supply also began to be appreciated.

Central to the emerging issues in water and sanitation for developing countries was the role of effective communication.

1.1.6 Communication as a Cost in Delivery of Services in Water and Sanitation for Developing Countries.

The approximate cost in provision of water and sanitation services varies from project to project. The components also vary with the various methods of estimation used. This is because some of the costs are based on either contingency valuation or even perception. One such valuation given by The Mvula Trust (1998) is presented in **Table 1.2**

Table 1.2: Percentage components of the overall costs of provision of services in water and sanitation sectors of developing countries.

	Sanitation Projects	Water Supply Projects	Integrated sanitation and water projects
Planning and feasibility	2 - 5	3 - 6	2 - 6
Advocacy and behavioural change campaigns.	1 - 2	0 - 1	2 - 4
Hygiene Education	2 - 4	2 - 4	2 - 5
Design and consultancy	3 - 7	3 - 7	3 - 8
Construction	50 - 70	60 – 70	60 - 70
Training and capacity building.	1 - 5	1 - 3	1 - 7
Administration	1 - 4	1 - 4	1 - 4
Operations and maintenance	9 - 12	9 - 12	8 - 9

Evidence from elsewhere (Narayan, 1995) suggests that there is an overall increase in project success rate with: -

- higher level of integration between water and sanitation projects, and
- greater investment in advocacy, hygiene promotion and training that is the case with traditional water and sanitation projects.

Communication is the built in component of all the phases that make up an effective implementation of water and sanitation project. Whereas direct measurement of the contribution of effective communication to the total cost / value of the component of the project is difficult, quantitative methods developed by Sherman (1993) suggest that up to 25 % of project cost can be attributed to communication.

1.1.7 Internet and the Emergence of the Information Economy

Talero and Gaudette (1996) believe that a new kind of economy, the information economy, is emerging. This new economy has global feature with trade and investment being conducted on a networked basis and with knowledge. A corresponding new society is emerging. Among other features of this society, it is friendlier to the environment. Stevens and Defenderfer (1996) have similarly reported the emergence of this society, describing an Internet community that has features of communities in the traditional sense of the word the only difference is the physical contact between members of the community. Talero and Gaudette (1996) see a need brought about by these changes to for developing countries to adjust in order to harness this emerging information revolution. This thesis argues that one such way that the developing countries can place themselves in a position to take advantage of the emerging information economy is to apply the information technology to the water supply and sanitation sectors of developing countries.

Talero and Gaudette further argue that the information revolution has created an opportunity to solve the problems of poverty, inequality and environmental degradation in developing countries. One way in which environmental degradation can be solved in developing countries is paying closer attention to water and sanitation hence improving on the water quality of these countries. Talero and Gaudette as have suggested ways in which the opportunity presented by the information revolution could be realised:

- widespread and equitable access to communication and information services through accelerate deployment of national information infrastructure and effective integration into international communication and information network.

- systematic improvements in functioning and competitiveness of key economic sectors through strategic information policies and systems,

- new ways to use information technology to help solve the problems of human and economic development.

This research will model a new way of solving the old problems of inadequate water supply and sanitation as per the suggestions by Talero and Gaudette (1996) reported above.

1.2. Statement of Problem

Effective provision of water and sanitation services in developing countries involves funding of the various elements of water and sanitation; technical and non-technical. Effective communication plays a central role in successful implementation of water and sanitation projects. It has been suggested that the existing communication continuum in the water and sanitation sectors of developing countries can be improved by incorporating advances in information technology, principally the Internet (Kibata, 1996). However, this has not been the case. Thus, the problem being solved through the research is the fact that advances in information technology (mainly the Internet), together with the attendant benefits, have not been reflected in water and sanitation.

1.3. Overall research hypothesis

The research is centred on a hypothesis that the Internet can be a useful tool in provision of water and sanitation services in developing countries. This hypothesis further states that this usefulness can be achieved through development of organisations (and individuals) involved in water and sanitation that are responsive to the use of the Internet for information dissemination and retrieval.

1.4. Research Objectives

In view of the foregoing discussion, a research is formulated. The overall research goal is to improve on delivery of services in the water and sanitation sectors of developing countries taking cognisance of the recent paradigm shifts that have place in mode of water supply and sanitation in developing countries as well as developments in the Information Technology. Principally, the recent developments and evolution of the Internet give rise to an opportunity for improvement on the efficiency on delivery of services in water and sanitation sectors of developing countries.

Thus, the research objectives are: -

- to develop a model for Internet based communication in the water and sanitation sectors of developing countries,
- to investigate and determine whether the Internet is a useful tool for retrieval and dissemination of Information in water and sanitation sectors of developing countries.

- to identify the information needs of water and sanitation sectors of developing countries and develop strategies of improvement of delivery of these services through enhanced communication based on the Internet.

- to develop a management regime for an Internet based information networks for water and sanitation so as to avail information efficiently and in a manner useful to Engineers.

- to compare the inherent perceptions of the role players in water and sanitation on the various sources of information pertinent to their operations, including the Internet.

- to investigate the rate of diffusion of the Internet technology into the water and sanitation sector and develop an appropriate model to optimise the rate of diffusion.

- Scope of the Research

Taking cognisance of time and financial constraints, the scope of the research was set as: -

- the literature survey was limited to defining the context of the problem as well as reviewing the scientific methods used in the investigations.

- five pilot projects were established to investigate best practices in operation of sites containing information on water and sanitation. The five projects were also used in the well as comparative study

- technology diffusion model was only tested for South Africa and the results extrapolated for other developing countries.

- information needs survey was heavily skewered towards the South Africa due to the ease and convenience of gathering data from South African organisations.

- although the Internet has several potential applications in an organisation, investigations were conducted on the information function of the Internet alone. Reference was only made to the other functions for brevity in most cases.

1.5. Organisation of the thesis

Chapter 1 gives a background to the thesis as wells as the motivation for the research in view of the unique nature of the research.

Chapter 2 defines the context of the problem through a partial review of the existing knowledge of

- water and sanitation,
- electronic communication in general and the Internet in particular, and
- the various scientific methods used in the research.

Chapter 3 presents a survey of the information needs of the role players in water and sanitation. These needs are modelled in subsequent chapter in fulfilling the objectives of the research.

Chapter 4 examines case studies of the pilot projects established and operated during the research period. Attention is paid to evolution of best practices necessary in order to realise the expectations of the users and provider of information on water and sanitation as examined in **Chapter 3**.

Chapter 5 models the inherent perceptions of the users and providers of information on water and sanitation with regards to information source. In the modelling, the chapter studies the human element in effecting change that introduces the use of the Internet and the accompanying benefits in water and sanitation organisations.

Chapter 6 takes the concept of the use of information technology in water and sanitation further and models the rate of technology diffusion into the sector. The modelling in this chapter is based on the findings from the foregoing chapters that infusion of the Internet technology into the sector is desirable.

Chapter 7 tests the model for technology diffusion developed in **Chapter 6** using data collected during the research period.

Chapter 8 is a consolidation of results from all the chapters with an integrated analysis.

Chapter 9 discusses the results, concludes and makes relevant recommendations from the results.

Chapter 2: Information Technology, Water and Sanitation in developing Countries: Literature Review

The partial literature search presented here is an attempt to identify the existing gap in knowledge that this thesis seeks to fill. Internet as a form of communication has been around since 1960 (Smith, 1995). However, application of the Internet in solving problems in general and concerned with provision of clean water and adequate sanitation is not as developed (Buckley and Kibata, 1996; Salwen, 1996). General application of the Internet in desktop and network computing only gained momentum after 1995 with the Introduction of Java scripting.

Recent developments in electronic networking through the Internet open up new possibilities for the exchange of information between professionals in the water and sanitation sectors of developing countries. Salwen (1996) sees in the Internet a promise for simplifying and speeding up research, networking, and technology transfer.

2.1. The Internet

Internet has been described as a network of computers and computer networks connected through a common language known as *protocol* (Buckley 1996; Smith, 1994). Internet applications are many are well documented elsewhere (Buckley *et al*, 1996; Buckley and Hurt, 1996; Kibata, 1996).

2.1.1 History

Whereas electronic communication began in the 19th century, communication over digital electronic networks is a much newer phenomenon (IBM Canada, 1998 (b)). It originated in the late 1960s through a project funded by the Defence Department's Advanced Research Projects Agency. The purpose was to link federally sponsored research facilities in a network to permit sharing of computer resources and data. The ARPANET, as it was known, was initially intended to serve no more than 1,000 individuals, most of them computer specialists. Without changing its basic purpose, the system expanded rapidly and by 1977 the first international links, involving two additional networks, were established in what was now called the ARPA Internet. Only a small number of university computer departments were part of the system, however. So, in the early 1980s, the National Science Foundation began to fund efforts to build regional university networks and eventually to create a backbone network for supercomputer centres called NSFNET, which, in turn, offered access to the

university-based networks. European Countries later established a similar research network called EARN. By the late 1980s, the US Defence Department decided to shut down the ARPANET and its sites moved over to NSFNET.

Meanwhile, commercial networks had also begun to develop in the early 1980s. Consumer connections to the Internet were offered by organisations such as American On-Line, CompuServ and Prodigy. In South Africa, companies such as Internet Africa and Internet Solution also established a commercial presence by providing Internet services.

In the early 1990s, the National Science Foundation decided to permit commercial networks to connect with the NSFNET. By then, the Internet protocol called TCP/IP, which allowed computers to *speak* to other computers on the Internet, had already been agreed upon. With the development of the concept of the World Wide Web by a researcher at the CERN physics lab in Geneva, Switzerland and, after that, the creation of Web browsers and a language permitting *hyperlinking* among Web sites, the Internet began to emerge in its present form. The result was a rapid shift towards the commercial use of the Internet and toward substitution of the World Wide Web for other facilities such as file transfer protocols by individuals seeking information and entertainment. By the mid-1990s, the NSF had turned over many of its Internet management functions to private organisations. These include provision of Internet backbone transmission facilities and the assignment of classifications and individual identities to groups with Internet access (Wilson, 1995).

Most academic institutions now obtain access to the NSFNET or Internet from commercial providers, either from Internet Network Service Providers, or NSPs, or from Internet Service Providers, or ISPs. NSPs interconnect with one another under what is known as a *Peering Agreement* and are the major sources of network connectivity. NSPs may sell access to large enterprise-based users, directly to consumers or to resellers, including ISPs. A local example of an NSP is UNINET that provides Internet services to the academic and public research sector in South Africa (Buckley and Kibata, 1996).

When individual consumers obtain Internet service, they typically gain access through an ISP, which is reselling access from an NSP. That gives them access to materials not just on the ISP's own network but also on the NSPs network which interconnects to every other network on the Internet. Services such as use of the World Wide Web, e-mail, newsgroups, etc., are purchased through a provider, often as part of the basic access arrangement. These services require special software, most of which is routinely obtained by consumers from the

provider or can be purchased at low cost from a vendor or downloaded from the Internet itself.

The Internet has emerged as a global network linking many independently maintained computer networks. It has become the principal method of interconnection for thousands of corporate Intranets and for millions of individuals using various operating systems and communications software. Top executives use it on the job for a variety of tasks and stock clerks, sales personnel and factory workers. It is changing how students learn how health care systems operate and how government information and services are delivered (IBM Canada (a), 1998).

The development and stunning growth of the World Wide Web, the deployment of Web browsers, and the introduction of Hyper Text Markup language (HTML, which allows hyper-linking between web pages) has already created new network businesses such as Web-based advertising, e-commerce, and the delivery of information and entertainment services. In 1997 the Internet recorded more than 60 million users around the world much of the information technology industry orienting itself toward it. Thus, governments all over the world have begun to take an interest in what is transmitted over the Internet and who is responsible for it. Because it developed as a government-backed service that mainly served the scientific community, the Internet has generally escaped most of the regulations, and controls that apply in many countries to broadcasters, telecommunications service providers, and publishers. Whether it should continue in this unregulated status is the subject of growing debate (IBM Canada (b), 1997).

2.1.2 How the Internet Works

The Internet is a collection of many, diverse networks that are linked together through the use of a common computer language or protocol (Cerf, 1996). Transmissions among these networks are routed in such a way as to ensure that they will transmit even if one or more routes is blocked. That was part of the original design of the ARPANET, intended to make it both efficient and robust. All transmissions across the Internet are organised as *digital packets* (fractional messages) each with its own address and routing instructions. This approach, called *packet switching*, allows digital communications to take advantage of the full resources of the network, finding the quickest and the most economic path available at a particular moment. Packets are transmitted in a common format, the Transmission Control Protocol / Internet Protocol (TCP/IP), which enables the hardware and software of the

originating system to communicate with hardware and software of other systems en route and at the eventual destination. At each intersection with a new connecting network, individual packets encounter specialised computers called *routers* or *gateways*. Routers act, in effect, as traffic police, examining the destination of every packet and directing each by the least congested pathway to its destination. A pathway will normally involve passing through many networks and routers. On each occasion, the destination is once more checked and an onward path selected. Packets forming a complete message will usually travel quite different pathways to their common destination, a computer, referred to as a host. The packets are then reassembled according to self-contained instructions into the starting order. Should any part of the message be lost, the originating system is notified so the message can be resent. Neither the person sending the message nor the person receiving it has any reason to know that it travelled in pieces enroute. At the time it was introduced, *packet-switching* differed markedly from the way in which telephone and telex messages as well as TV signals and cable TV were transmitted and, continue to be transmitted. These other forms of communication normally involve establishing and maintaining a single pathway from start to finish. The fixed pathway approach, called *circuit-switched routing* in the telephone industry, has a degree of manageability and predictability for national governments seeking to regulate transmissions occurring within their geographic borders. In contrast, digital packets making up a single Internet transmission may be routed in an unpredictable way through many different countries, and the next message from the same source to the same destination may follow an entirely different set of routes. This routing process poses a security challenge and is discussed in more details later.

While the Internet's transmission technique may seem baffling, it makes the Internet both reliable and efficient (IBM Canada (a), 1998). Reliability emanates from the fact that in case of an outage at any point, the *packet switching technology* will cause traffic to automatically re-route around it (i.e., it is self healing). The efficiency emanates from the fact that traffic is always routed to the least congested pathway, minimising the need for standby capacity to handle heavy traffic. The use of fairly simple computers as routers instead of more complex and costly switches makes the Internet's costs significantly lower than for comparable circuit-switched networks. These characteristics of reliability and efficiency have been key reasons why the Internet has grown. Second, converting all computer language to a cross-platform computer language, TCP/IP, means that incompatibility of different computer hardware and software systems is no obstacle to joining the Internet. Network operators need only determine whether they wish to connect and then do it after obtaining the necessary access.

At present (Jan / Feb 1998), more than 120,000 networks are connected to each other under the TCP/IP protocol, up from 50,000 in 1995 (IBM Canada (b), 1998). The sum total of these networks and everything that moves across them is the Internet, as we know it. The organic nature of the Internet makes it fundamentally different from other networks. Public switched telephone networks are a collection of relatively large networks that interconnect on carefully defined terms. Cable TV satellite networks are independent networks, accepting content at one point and distributing it to many end points. Unlike these other networks, the Internet is not owned or operated by anyone. Each participating network owns its own facilities, and the Internet owns nothing.

2.2. Previous work done on Internet, Water and Sanitation in Developing Countries

Kibata (1996) and Dindar (1997) did the pioneering work on the use of the Internet in the water and sanitation sectors of developing countries. The 2 studies had concluded that scope exists for adapting the emerging Internet technology to for use in the water and sanitation sectors of developing countries. This section briefly reviews the findings of those 2 studies.

2.2.1 Urban Areas

In his work, Kibata (1996) concluded that

- understanding the role of clean water supply and improved sanitation in country's sustainable development is important if the policy planners are to put necessary emphasis on the sector. However, this role tends to be ambiguous and little understood. Thus the study identified this as an area, which in which a full-scale site containing technical information on water and sanitation sectors of developing countries could play a part by bridging this information gap.

- despite the role played by appropriate technologies in provision of clean water supply and adequate sanitation, there is a lower level research in the sector due to perception that appropriate technology is *inferior by* engineers. The site was thought to have a potential to simulate research and development in the sector through enhanced information provision. Examples of the appropriate technologies were given as slow sand filtration, sub surface dams, ferro-cement tank, ventilated improved pit latrines, gravity flow water projects, rainwater harvesting, constructed wetlands for water quality improvement, waste stabilisation ponds and septic tanks.

- there exists effective, appropriate solutions to technical problems encountered by engineers in developing countries within the developing countries.

- greater access to the Internet in developing countries is a prerequisite to an effective use of the Internet in water and sanitation sectors of developing countries for technology transfer and exchange.

Kibata (1996) hence recommended that

- in order to increase access to the information held by the web site to sector professional in developing countries, it was necessary to present the web site in popular languages, creation of awareness of its presence in print and electronic media and to increase access to the Internet in developing countries for engineers involved in water and sanitation sectors of developing countries.

- priority be given to inclusion on the site of information on appropriate technology. This may have an effect of stimulating research in this direction, which is beneficial to communities in developing countries.

- a listserver that is specific to water and sanitation in developing countries be established to exchange technical views and information among engineers.

- establishment of a parallel project to improve access to the Internet in developing countries.

- standardisation of technical information held by partner organisation in order to ensure logical and effective flow of information among the engineers.

2.2.2 Rural Areas

In his work, Dindar (1997) concluded that: -

- rural water and sanitation forms an integral part in the overall development of the country. Therefore it is necessary that comprehensive policies and strategies for the delivery of these services be drawn up at the highest level of government. The lack of political will at these levels of government has often hindered the efforts of donor organisations and non-governmental organisations.

- in delivery of water and sanitation services to isolated rural communities in developing countries, particular attention has to be paid to the use of technologies which are cost effective, sustainable and designed for the local rural conditions, i.e. appropriate technologies. Although these technologies may be outdated, they will be more successful in the delivery of services than modern technology. Often designers and engineers planning rural water supply schemes are not aware of these technologies since they do not form part of mainstream tertiary education. Thus there is a need to transfer this information to the relevant authorities and planners. The dissemination of this information can be facilitated through the established information network on the Internet.

- formal and informal communication between sector professionals in water and sanitation sectors of developing countries is very important. These processes can be conducted efficiently and cost effectively through the use of Internet tools such as e-mail, listservers, discussion groups and world wide web. These tools can also be used for the distribution of reports, newsletters and software at a fraction of the cost of distributing printed material.

Dindar hence recommended that:

- little research is dedicated to rural water supply and sanitation, research institutions need to develop specialised courses that will provide adequate training to individuals involved in water supply and sanitation. This will encourage research in the sector. In addition to this, research institutions in association with experienced sector professionals should conduct intensive training courses and workshops for individuals involved in the sector who may not have the necessary skills.

- organisations and sector professionals should be encouraged to collect store, and disseminate data electronically. The aim should be to gradually move away from printed data/information dissemination to electronic data/information dissemination. This data can then be made available world wide through the Internet at a reduced cost.

- the hardware and software used by the web site and its partner organisations should be standardised in order to maximise the speed and format in which data is disseminated. Although this has partly been achieved through the Internet, it should

also be implemented in the types of databases and indexing systems used to catalogue large libraries of information. Standard hardware and software will also prevent the problem of a breakdown in communication due to the inability of certain computers to communicate with others.

- the language base of the web site should be increased to include French, Spanish, Portuguese, Arabic and Chinese. The responsibility of maintaining the web site in the various languages should be given to organisations/individuals proficient in these languages. This will also enhance the globalisation of the web site rather than confining it as a European / Anglophone countries' activity.

- the information available through the web site and its partner organisations should be indexed in a standard format. This will simplify the task of searching and finding information, which will attract rather than discourage individuals from using the web site repeatedly.

2.3. Emergence of the Information Economy

Talero and Gaudette (1996) believe that a new kind of economy, the information economy, is emerging. This new economy has global feature with trade and investment being conducted on a networked basis and with knowledge. A corresponding new society is emerging. Among other features of this society, it is friendlier to the environment. The emergence of this society has similarly been reported by Stevens (1996) who describes an *Internet community* that has features of communities in the traditional sense of the word the only difference is the physical contact between members of the community. Talero and Gaudette (1996) see a need brought about by these changes to for developing countries to adjust in order to harness this emerging information revolution. This research argues that one such way that the developing countries can place themselves in a position to take advantage of the emerging information economy is to apply the information technology to the water supply and sanitation sectors of developing countries.

Talero and Gaudette further argue that the information revolution has created an opportunity to solve the problems of poverty, inequality and environmental degradation in developing countries. One way in which environmental degradation can be solved in developing countries is paying closer attention to water and sanitation hence improving on the water quality of these countries. Talero and Gaudette have suggested ways in which the opportunity presented by the information revolution could be realised as:

- wide-spread and equitable access to communication and information services through accelerate deployment of national information infrastructure and effective integration into international communication and information network.

- systematic improvements in functioning and competitiveness of key economic sectors through strategic information policies and systems, and

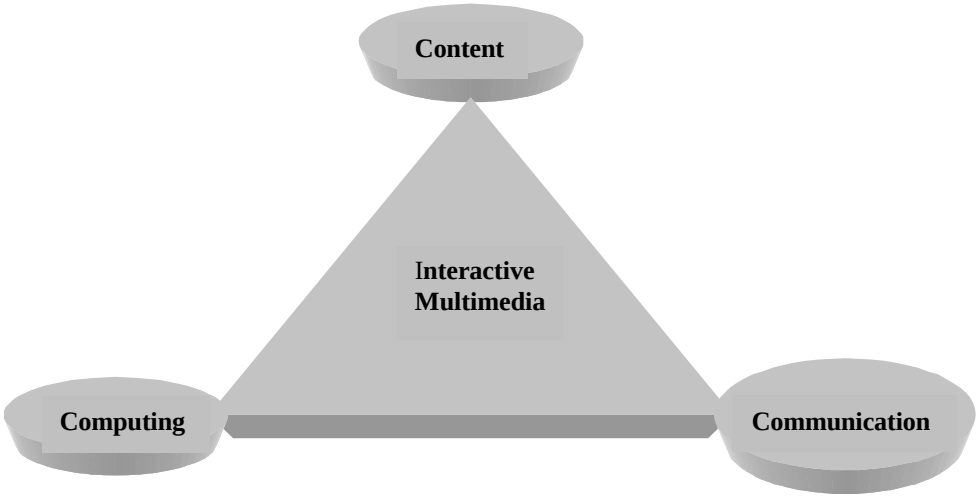

Figure 2.1: Convergence of technology and content in the new Paradigm

- new ways to use information technology to help solve the problems of human and economic development.

This research attempts to explore a new way of solving the old problems of inadequate water supply and sanitation as per the suggestions by Talero and Gaudette (1996) reported above.

Richardson (1997) suggests an approach to be adopted in exploiting the potential opportunities brought about by the Internet. This approach has been labelled as a *communication for development approach*. This will be discussed in greater details in **Chapter 3**. The other feature of the emerging paradigm is what Tapscott (1996) refers to as convergence of the computing and communication industries and their respective content, and in the process, giving rise to an interactive media. **Figure 2.1** illustrates this convergence as seen by Tapscott (1996). In essence, the traditional media of computing and that of computing are converging together with that in content (such as TV and newspapers) to form an interactive media. It is becoming increasingly more difficult to tell different organisations in Computing, communication and content apart.

2.3.1 Emergence of Information Economy and Implications for the Developing Countries.

Talero and Gaudette (1996) define the following as the essential components of the Information economy: -

- the global information infrastructure,
- networked intelligence. This refers to the network of computers and computer networks, and
- networked Internet communities.

Knight and Boostrom (1995) see the development of computer networking in Africa and other parts of developing world a unique opportunity to make a major contribution to the Africa's current and future development. This type of development will simultaneously advance objectives of sustainable development, capacity building, decentralisation in decision-making, and private sector development. However, if the developing countries do not seize the opportunity fast, they stand to be marginalised further from the world's economic mainstream.

Sadowsky (1996) had also arrived at similar conclusions. He sees rapid expansion of the Internet as holding substantial promise for developing countries, which can benefit greatly from the Internet's information and communication delivery capabilities.

The various opportunities available with increase in electronic networking and particularly the use of the use of Internet in developing countries as seen by Knight and Boostrom (1995) are:

- **delivery co-ordination**; electronic networking's unique ability to transfer data or to provide simultaneous access to data instantaneously to a wide dispersed group of people provides a tool for improvement of co-ordination of organisations involved in delivery of services in developing countries. Such organisations could be donor communities, executing agencies (NGOs, governments and UN bodies), research institutes, or individuals.
- **client consultation**; with funding organisations typically based in the west and the client based in a developing country, constraints in communication due to poor

communication infrastructure in developing countries could be a hindrance to an efficient delivery. The improved access to the Internet in developing countries promises to solve problems of this kind.

- **capacity building**; various organisations in the west such as the world bank hold a wealth of technical information that would create the necessary capacity of the personnel involved in development works in developing countries. Since computer networks allow fast transfer of big quantities of information, personnel training coupled with the requisite technology transfer can be affected.

- **decentralisation**; Francey (1990) quotes Okun and Ernst (1987) as having described typical decision hierarchy in developing countries involving three structures, these being the central government responsible for term planning among others, regional structure responsible for development of project and local structure responsible for operation and maintenance of the project. This hierarchy is described in greater details later. The decision making process in such circumstances can be cumbersome especially under the circumstances where communication is not at its best. The use of electronic networking can potentially reduce this difficulty.

- **private sector development**: the globalisation of the world economy and the explosion of the information technology has transformed the nature of the private sector. Improved access to electronic networks in developing countries makes it possible to conduct commerce electronically. This will have an effect of stimulating the private sector in developing countries leading to a private sector led growth of these economies.

Where does the water and sanitation sector of the developing countries fit in the opportunities available as a result of increase in electronic networking in these countries? The research attempts to answer this question.

Nyirenda *et al* (1995) contends that lack of access to information has several impacts on the state of the environment, and especially the ability to manage natural resources. In recognition of this, the Government of Malawi developed local environmental information centres to cater for information needs of researchers, scientists, decision-maker at levels, development workers, and rural communities. In recognition of this, the Malawian government is taking steps to

- promote sharing of resources through national networking in order to strengthen institutions in environmental programmes,
- develop links with international environmental information systems such as INFOTERRA, GEM, GRID, e.t.c,
- consolidate, analyse, repackage and publish data and information from computer networks regarding a variety of parameters indicative of environmental trends in Malawi, and
- improve on communication patterns with communities and various organisations in order to explore ways of promoting sustainability and self reliance of projects.

The project from Malawi cited by Nyirenda *et al* (1995) is a typical example of Internet led Intervention to a traditional problem of development taking advantage of the rise of the information economy and the accompanying paradigm shift in computing.

2.3.1.1. Features of the Emerging Information Economy

Talero and Gaudette (1996) assert that the information revolution will not soon be slowed by technological limits. Fundamental limits are still remote, and many constraints believed to be fundamental in the past have been breached. The knowledge to successfully apply information technology is however still limited. The limits of this knowledge are readily apparent in the many failures and deficiencies of information systems at all level. Improvement is occurring, but slowly. This problem is, if anything, worse in developing countries.

2.3.1.2. Emergence of Global Information Infrastructure

Various factors have been attributed to the phenomenal growth of the Internet. Cerf (1997) summarises these reasons as:

- a fertile mixture of high risk ideas and stable research funding,
- visionary leadership,
- extraordinary grassroots co-operation, and
- vigorous entrepreneurship.

These factors have combined to produce a global infrastructure that piggybacks on the Internet. Cerf (1997) estimated the industry associated with the Internet to be worth about US $ 35 billion and growing at an annual rate of between 35 % and 50 %.

Sadowski (1997) asserts the physical communication infrastructure is crucial in creation of effective electronic networking. It is imperative that local and international links are present and reliable. It is equally important for the equipment to be easy to obtain, repair and maintain. This physical infrastructure includes computers and related peripherals.

Talero and Gaudette (1996) assert that it will not be easy for developing countries to build their national information infrastructures. However, these infrastructures are essential for achieving sustainable economic development in the networked world. Talero and Gaudette (1996) further posit that information technology holds the promise of generating the economic efficiencies required attracting the investments, which are the engine of growth around the world. At the same time, information technology can also provide the means to reach, mobilise and empower citizens and to reduce income as well as information disparities through adoption of a *pro-poor* agenda that will integrate rural and urban poor communities into economic life.

IBM Canada (a) (1998) contends that the global information infrastructure will not be possible without *interoperability*. Technically, *interoperability* means the ability to use any information appliance to plug into any part of the global information Infrastructure and access any database or communicate through any network in any other part of the infrastructure. It allows diverse systems made by different vendors to communicate with each other, thereby making communication easier for users. User interest in having *interoperability* is already driving industry to respond aggressively to these needs. Market forces will cause interoperability to occur more rapidly than would the standards process or governmental intervention.

IBM Canada (a) (1998), however cautions that standards, where appropriate, also play a useful role in furthering the goal of *interoperability*. The industry led voluntary standards development process is the best way to achieve the interoperability required for the Information Society. Key elements of this process include open interfaces whose technical specifications are open to other manufacturers and service providers, and proprietary rights, which enable the licensing of technology on reasonable terms

and conditions. The *Internet protocol* used by computers and computer networks in communication is a typical example of the interoperability of the components that comprise the global information infrastructure.

IBM Canada (c) (1998) see the essential components of the global information infrastructure as a close integration of communications networks, computers (including both hardware and software), information and services, and users.

The first building block comprises interconnected and interoperable **communications networks**. These networks must incorporate agreed upon international technical standards that will facilitate putting the network together and enable the pieces to work in harmony.

High-performance **computers** resident on the communications networks are central to the ability of the global information infrastructure to provide intelligent switching and enhanced network services. Powerful, personal computers and workstations mask the complexity of the underlying system and enable individual users to tap into the global information infrastructure easily. Development of the system is also dependent on software, including operating systems and application packages. New software techniques, including impenetrable data-security features, reusable, object-oriented programming and intelligent agents will greatly facilitate global information infrastructure use.

A wealth of **information and services** already exists on the global information infrastructure and continues to expand (IBM Canada (c), 1998). For example, public and private databases and digital libraries that include material in text, video, image, and audio formats are proliferating, as are information services and network directories that assist users in locating, synthesising, and updating information. It is thus incumbent upon the players in the water and sanitation sector to avail services and information on the global information infrastructure in order to ensure the sector's integration into the infrastructure.

It is **people** who will ultimately use the global information infrastructure, create its content, and service and maintain it (IBM Canada (c)), 1998). However, it carries with it requirements for appropriate education and training that will materially affect what skills are taught and how the teaching is conducted all over the world. The utility of the global information infrastructure will depend on the abilities of the role players to take

advantage of the rich and varied resources available through the system. People with a high level of technical education must staff the organisations that create, package, communicate and sell information through the global information infrastructure. Thus, the networks themselves will require trained engineers as well as expert technicians for service and support.

2.3.2 Emergence of the Information Economy: Opportunities

Sadowski (1997) asserts that correlation between information, communication, and economic growth is well known. This makes the usefulness of electronic networks evident. Electronic networking is a powerful, inexpensive way of communicating and exchanging information. Sadowki (1997) further reports on a latent demand for national and international collaboration that is being realised by electronic networking services that have been noticed in the developed countries. According to Sadowski (1997), this latent demand is caused by such inconveniences such as need to secure large budgets and approval for travel, need to continuously retype long letters transmitted by fax or mail or disruptions caused by delay in mail. The collaboration borne of the electronic networks has led to greater productivity, which comes out of the resultant synergy. Further, the collaboration has led to inter-linking of resources.

Sadowsky (1997) further reports that electronic networking is now crucial to the scientific research and development efforts. This networking is reported by Sadowski (1997) to be yielding tangible economic benefits including sustainable growth in gross national products of some countries. Sadowski further explains that increase in electronic networking will help improve the lives of developing communities through improved effectiveness of development agencies.

2.3.2.1. New Ways of solving old problems

The information revolution has created new ways of doing business in developed countries (Drucker, 1994).

Talero and Gaudette (1996) assert that new economic rules distinguish an information economy from an industrial one. This is because information can be replicated at negligible costs and overcome time and distance constraints. In essence information ranks among other factors of production such as entrepreneurship, land, labour, capital, and energy.

Taking cognisance of the power of information, Drucker (1994) suggests that developing countries must shift from basing their industrial development from comparative labour advantage to application of knowledge. This can only come about with enhancement of information technology in developing countries. The value of knowledge is demonstrated quantitatively by Sherman (1993) who makes calculation showing that knowledge added 25 % to the value of Ford Mustang, 1993 model.

In order for developing countries to take advantage of this power that information is, Allaire *et al* (1994) prescribes an overhaul in the information infrastructure of these developing countries. Such an overhaul will include structures that will enhance the use of the Internet.

The Information revolution that is taking place creates opportunity for solving problems of poverty, inequality, and environmental degradation with potential to achieve unprecedented gains in economic and human development (Talero and Gaudette, 1996).

The role of the governments in tapping a nation's information wealth as seen by Talero and Gaudette (1996) is:

- improving their own efficiency so as to remove distortions in the economies brought about by governments' inefficiencies,
- regulating the information industry,
- catalysing infrastructure projects through government spending,
- increasing in training expenditure, and
- jump-starting the private sector.

A question arises as to where and how the water and sanitation sectors of developing countries can take advantage of the improving information technology so as to improve on the delivery of services.

In Chile, Food and Agricultural Organisation’s (FAO’s) Communication for Development in Latin America Project is pioneering a participatory approach to the development of Internet information and communication networks among the farmer organisations of small-scale producers. This system provides farmer organisations with

data on crops, international crop status and market timing, prices, markets (regional, national, international), weather, technical and training information, and information about the various organisations that support their work. The users have full access to the Internet to find other information relevant to their lives and communities (e.g. health, social service, education, etc.), and they can use electronic mail to communicate with other farm organisations in Chile, as well as all the people using the global Internet world-wide. The most important aspect of this initiative is its specific attention to local information needs assessments, and assisting farm organisation personnel with developing the skills necessary to analyse and disseminate information that is locally relevant. This methodology emerged from previous development communication experiences using small format video, print media, and rural radio. Water and sanitation is a basic need for most rural communities living in developing countries. This example from Chile thus serves as an indicator of an option available in developing communities in solving water and sanitation challenges.

Richardson (1997) further argues that community organisations need instant information on global market prices, negotiation techniques and strategies, analyses of product potentials in various markets, new production and marketing techniques, new transportation systems, and global trade rules. Information that can reduce the costs of transactions and improve prices received at markets (or open new markets) is highly valued. These organisations can and do act as communication conduits or intermediaries, facilitating the flow of information between local people and the rest of the world. The global Internet is one tool that can enhance this flow of information. It is an inexpensive way to communicate and access global information. Well-organised local user groups and farmer organisations can easily manage local Internet services. Information and analyses can be tailored to local, regional and national knowledge and communication needs and realities. When combined with national and global market information systems, and with the ability to communicate quickly with potential buyers and brokers, local Internet systems become valuable strategic planning and decision-making tools. Community information centres and farmers' organisations can also gather information from the Internet and disseminate it via local radio stations, newspapers and other local information sharing networks and tools. For example, daily market prices and agricultural news can be posted at co-operatives, local stores, transportation hubs, agricultural supply outlets and social gathering points. Simple newsletters can be developed using Internet information and distributed to members of

farmer organisations. When integrated with other media tools, the Internet can be a powerful information resource and research tool.

2.3.2.2. Summary of Generic Opportunities brought about by the Internet.

IBM Canada (1998) summarises the following as the actual and potential sector benefits that have been made possible throughout the use of the Internet.

Electronic Commerce: As more commercial and industrial transactions are nationally and internationally linked, electronic commerce networks are emerging. These networks allow a wide variety of transactions to take place. With Electronic Commerce, productivity of business transactions within and across nations will be improved. International trade will become more active with transactions and communications made easier.

New and diverse business opportunities will also emerge. There will be new possibilities of reaching customers, presenting goods and services, and ordering and delivering them. New ways of conducting business and economic activities will be developed. For example, new business activities will include multimedia telecommuting, world-wide research networks, global sourcing and procurement, large-scale development and sharing of databases, new training and education capabilities, and many alliances or networks of companies.

Environment: The benefits of the global information infrastructure for the global environment will be seen in its contribution to areas such as environmental monitoring and the development of more effective approaches to ecosystem management that will lead to sustainable development practices. Global environmental monitoring is critical for analysing environmental issues and advancing prediction and early warning capability. The fundamental limitation is that the current infrastructure that gathers, exchanges, and analyses environmental data and information in a fragmented manner and does not allow the kinds of capabilities envisioned for a multidisciplinary and global view of the environment. The Global information infrastructure will address this weakness by supporting the global process of environmental observation, analysis, and information dissemination in a co-ordinated manner.

The global information infrastructure is making and will continue to make a significant contribution to ecosystem management and sustainable development through the

analysis of an array of information. These data are derived from globally distributed observation systems as well as historical environmental observations and analyses that are contained in disparate and geographically distributed databases and libraries. To provide the best possible decision support, access to both real-time and historical data and information is required. Advanced modelling and predictive tools, data visualisation capabilities and high-speed multimedia networks will be needed. The global information infrastructure will make these available.

Manufacturing: Manufacturing has become a complex set of processes, involving exchanges of information and data on product development between companies and across international borders. Product specifications, fabrication instructions, inventory data and customer feedback are also exchanged. Global information infrastructure applications will assist manufacturers in coping with these complexities. Application areas will be diverse, ranging from global and cross-firm collaboration in R&D activities and production design to automated production and after-sale services. The network applications will allow efficient and effective integration of manufacturing processes horizontally and vertically.

Health Care: Currently, there are Internet applications being used to help address the challenges of improving health care access and quality while reducing medical costs. For example, community health care information networks can allow physicians, hospitals, patients and others access to critical health information. Desktop videoconference applications allow patients to consult with physicians and specialists at regional and national centres. This application allows access to health care resources that would otherwise be economically or physically impossible in instances, for example, where a patient cannot travel long distances to receive treatment.

Transportation: Internet applications for transportation are increasingly seen as a key to helping alleviate the problems of poor transport. These applications will be able to

- enhance the performance of existing transportation infrastructures,
- improve transportation safety, and
- alleviate demand pressure for physical transportation of people and goods by presenting alternative means of communications. For example, Intelligent Transportation Systems linked to the information infrastructure will include

systems to help manage traffic, traveller information, fleet management and onboard electronic navigation.

Overlaying the existing transportation infrastructure with a complementary information infrastructure will dramatically improve transportation service, cost, safety, and efficiency, while lessening adverse environmental impacts.

Government Services: Governments around the world are Increasingly turning to information processing and networking technologies to solve the dilemma of growing budget deficits, increasing demand for services, and proliferating data that must be collected and processed. As the world becomes more interdependent economically and socially, the information and data governments handle also become international from customs information and international trade and financial statistics, to communication to embassy staff and international information services. The Internet will advance government efforts to cope with these challenges not only by supporting cost effective decision making, but also by improving administrative productivity. Internet technologies present effective tools for faster, in-depth analysis, while decreasing the cost of collecting, processing and delivering information. It will enable governments to reduce or eliminate duplication of data in different forms and locations, thereby reducing costs, increasing efficiency and minimising privacy concerns. Also, by using the Internet, small municipalities will be able to link up with each other to take advantage of bulk purchasing discounts offered by vendors.

Home Entertainment and Services: New products and services will enhance the quality of life by improving the way people shop, play and learn. The major players in the development of this emerging market include companies, which will provide programming and information or content, computer and software companies, telecommunications firms, and cable providers. Increasingly, technological advances such as the ability to translate all audio and video communications into digital format are blurring the lines between the computer and communications industries. New methods of storing and compressing the digitised data are allowing data to be sent through phone and cable lines. At the same time, advances in fibre-optic wiring are providing a virtually limitless transmission pipeline. These advances combined with advances in distribution systems and the proliferation of Low Earth Orbiting Satellite (LEOS) networks are bringing home entertainment and services to even the most remote parts of the globe.

Education and Lifelong Learning: Information technology is beginning to revolutionise education around the world, changing the ways in which teachers instruct and students learn. Applications involving extensive networks have been developed to enhance learning for students at all levels. New learning programs are based on software with specially equipped computers that can provide hands-on learning emphasising exploration, problem-solving, and creativity.

2.3.2.3. Jumpstarting the Opportunities.

Richardson (1997) reports that current evidence suggests that in order to achieve sustainability and success, Internet projects for rural development (including water and sanitation projects) must begin with the real needs of the local community of users. To this extent, the research addresses the needs of the communities in developing countries who do not have access to clean water or adequate sanitation. Richardson (1997), further suggests that addressing the real needs of the community requires an approach that catalyses local participation, supports information and communication needs assessment, build awareness of potential Internet uses, helps build communities of users and builds locally managed, and ultimately, self supporting communication and information networks. It also requires attention to capacity building and institutional strengthening for intermediary agencies that serve the population (e.g. NGOs like say The Mvula Trust). At the policy level it requires dialogue with national telecommunication agencies to help transform and liberalise monopolistic telecommunication service environments, which are major impediments to the spread of Internet services in developing countries.

Richardson (1997) asserts that like participatory video process, the Internet may help in meeting peoples' information and communication objectives. This will be in order to attain their development goals and objectives, but it must be integrated within human contexts and seen as a communication process tool and not simply a static information technology or unidirectional broadcast medium. Otherwise, Internet tools will be relegated to the junk heaps of inappropriate development technologies or dismissed because of previous failures to make the medium locally relevant and useful. For example, information outputs derived from highly technical water quality models can be made available to communities through the Internet and in a fully comprehensible manner. If this is not the case, then there is failure to fully leverage the large

infrastructure investments involved, and to assist people in making appropriate decisions based on such valuable information.

2.3.2.4. Towards Grass-Root Electronic Networking

In order for the opportunities afforded by the Internet and other form of electronic networking to be afforded and extended to the water and sanitation sector in developing countries, grass-root networking has to take off. Grass-root in this context refers to professionals working in water and sanitation sector within the communities such social workers and community organisers.

One way in which the communities that are under served with water and sanitation services will be able to exploit this opportunity is by taking advantage of the enhanced information flow on water and sanitation thereby affecting a more effective delivery of services (Kibata, 1996, Dindar 1997).

Richardson (1997) suggests that local community oriented Internet services are also valuable when placed in the service of rural development organisations, which act as local communication conduits or intermediaries. Along with improving community's knowledge of issues surrounding provision of water and sanitation services, they can also:

- develop locally appropriate applications and creative services,
- provide knowledge about successful development strategies,
- enable efficient regional, national and global organisational,
- provide improved access to a variety of information, training, research and educational resources (including distance education services) that are typically unavailable in rural and remote areas due to the costs associated with accessing printed materials and books,
- enable rural young people to learn about computers and to have access to the technologies and information available to their urban peers,
- provide access to critical technical information for water and sanitation professionals such as community workers, sociologists, anthropologist, technicians

and engineers, thereby providing further encouragement for these professionals to continue practising in rural and remote communities,

- enable local NGOs to gain a global presence and make better contact with potential donors and supporters through on-line publication of resources and information, and through the use of electronic mail, and

- sensitise urban policy makers to the realities and needs of rural populations.

These measures are thought to be viable first steps towards the establishment of grass-root electronic networking. Steven and Defenderfer (1996) have similarly reached the same conclusions.

2.3.3 Emergence of the Information Economy: The Challenges

The opportunities brought about by the Internet are wrought with challenges that need to be overcome before full use could be made of these challenges. Some of the challenges that were evident during the research are documented in **Chapter 4**. Whereas information technology holds high promise for developing countries, both in economic and human terms, the promise can only be realised if the developing countries take the steps necessary to provide a public policy environment that will attract world-class companies. These companies will of necessity be capable of delivering locally at competitive costs the technologies, products, services and content that is the backbone of the *Global Information Society* (IBM Canada (a), 1998).

2.3.3.1. Universal Internet Access

Efficient telecommunication system is a prerequisite to development of a vibrant Internet (Erberg, 1994). While access to a telephone is taken for granted in the industrialised world, a telephone is still a luxury, if at all available to ordinary people, in most developing countries. Thus, in the beginning of 1993, high-income economies with 15% of the world's population had 71% of the world's telephone lines (ITU, 1994). The disparity between rich and poor countries in terms of *teledensity* (number of main telephone lines per 100 inhabitants) has hardly changed in the last decade. Erberg (1994) argues that the gap is growing, at least in terms of quality and access to advanced services.

In most developing countries the majority of the populations live in rural areas. Yet, *teledensity* in rural areas in these countries is about 10 times less than in urban areas. Typically, more than 75% of rural localities have no access at all to even basic telephone service (World Bank (a), 1992).

IBM Canada (a), (1998) asserts that developing country governments interested in extending the benefits of the Information Society as widely as possible must abandon regulatory policies that may have been suitable in an era of monopoly-provided voice telephone service but which are inappropriate to the new era. Telecommunications and Information technologies are converging, and many different industries are offering new products and new services in direct competition with one another without regard to previous lines of demarcation. IBM Canada (a) (1998) gives an example of China, where cellular phones and pagers are the fastest growing segments of telecommunications services. For everyone to benefit from these products and services, world-class competitors must be free to provide customers all over the world with the best and most affordable information technology and communications products and services, and governments must grant them these competitive freedom.

Erberg (1994) believes that for those persons left unserved by competition, governments must be prepared to fund programs that facilitate universal access while preserving the competitive market, which serves most citizens. One approach to ensuring access is to locate networked personal computers in public places such as post offices, schools and community centres. There, computers can be used for a variety of purposes, including education, job training, e-mail, receiving governmental information and communicating with government offices.

2.3.3.2. Information Redundancy

Information on water and sanitation over the Internet is scattered and difficult to find (Buckley and Kibata, 1996). Several reasons are attributable to this apparent lack of information. The overriding reason for this apparent lack of substantive information is the fact that the art of placing information on the Internet is still evolving. It is to be expected that with time, technology that will organise information on the Internet in a logical order will evolve.

The *search engines* on the Internet have been an attempt at improving on the dissemination of the information on the Internet. However, this has not always been

successful (Salwen, 1996). The result has been that organisation holding useful information on water and sanitation are hesitant to put it up on the Internet since they are not convinced as to the true value of putting up the Information on the Internet given the apparent confusion on the Internet (Kibata, 1996).

2.3.3.3. Information Poverty

Kibata (1996) defined *information poverty* as lack of access to information necessary for development in developing countries due to the absence of the communication infrastructure. Reuters (1995) reported that the gap between the north and the south is being escalated by the rise of this phenomenon of *information poverty*. While the Internet and other forms of electronic networking are opening up opportunities in the North and helping transform the economies from industrial to information, the converse is not true for developing countries. Instead, the developing countries continue to be mired in ignorance borne of lack of access to this information.

Sadowski (1997) argues that, *information poverty* in developing countries is one of the more significant and insidious obstacles to effective exploitation of information processing and other types of technology. Lack of adequate information regarding developments in other countries and other environments is often not noticed, and in absence of new information, old techniques and procedures are continued without conscious knowledge of alternatives. In addition, even though developing countries may not be hurt by information poverty in an absolute sense by lack of information, they are negatively affected by any relative measure. Herein lies the challenge for developing countries to overcome the lack of established communication infrastructure and avoid falling into the vicious circle brought about by *information poverty*.

2.3.3.4. The Rise of Linguistic and Cultural *Imperialism*

Most of the content over the Internet is predominantly conducted in English (Salwen, 1996). This is because the original works over the Internet was developed in the USA (This statement was true at the time submission in June 1999, However, this is no longer the case). As of June 1997, about 78 % of the traffic generated over the Internet had its origin in the USA (Internet Society, 1997). This traffic was almost entirely in English. Furthermore, the dominance of ASCII character in the Internet, especially on the World Wide Web, has encouraged use of languages that use the English alphabets. This has an effect of the rise of the phenomena being referred to as *linguistic*

imperialism. The continued dominance of the English language over the Internet threatens development of other languages especially in the future when the Internet becomes an everyday feature of people's lives. IBM Canada (a) asserts that the fact that the English language is heavily relied on the Internet raises concern on the part of many developing countries that do not speak English and desire to preserve their linguistic heritage.

However, Sadowski (1997) believes that expansion of the Internet should lead to greater development of other languages in the long run. To this end, a standard to be known as UNICODE is being adapted for use in the Internet to help foster universal inclusion of all character in different languages within the architecture of the Internet. With its introduction, it will be possible to browse through web page written in say Chinese or Arabic characters.

The culture of the Internet reflects its roots in the North American research community; having pioneered the use of the Internet (Sadowski, 1997). What might be considered to be elements of freedom of expression in the Western culture could be potentially offensive to other cultures. This is the phenomenon referred to as *cultural imperialism.*

2.3.3.5. Security Risks and Universal suspicion of the Internet

Cerf (1997) reports that the Internet will not evolve if users are not confident about the privacy of their information and transactions on the networks. It is essential that sensitive, personal and proprietary information be protected and made available only in accordance with internationally accepted guidelines. Equally important, individuals, companies and other organisations will not take advantage of the global system unless they are assured of the security and integrity of their information and transactions. This has been one of the greatest challenges to face the development of the Internet. Data security involves the protection of information from unauthorised or accidental modification, destruction and disclosure. Unless individuals, businesses and other organisations are confident of secure communications through the Internet, they will not use it. Thus, before organisations involved in the dissemination of information on water and sanitation are ready to disseminate their information on the Internet, they need assurances on the privacy of their information (Buckley and Kibata, 1996).

IBM Canada (a) reports that for developing countries, a networked environment will serve not only as the vehicle for delivery of content and services but also as a platform which developing countries can utilise to enter global business, including software development and Trans-border data processing. Intellectual property protection is a prerequisite for networking. Without it, the platform will be built more slowly if at all. Without it, less content will be created, and those who do create it will be reluctant to send it over the network. The same applies to substantive information on water and sanitation. As the world shifts towards a more global market and a more open competitive system, private investment will naturally flow to those countries with attractive business climates, and companies will likewise prefer to do business in those countries. Poor intellectual property protection, or an environment that promotes software piracy or results in weak enforcement of intellectual property laws, will seriously impede the ambitions of any country seeking to participate in the Global Information Society (IBM Canada (a) (1997). It is thus imperative for the Internet community to work out a system of intellectual property protection in order to encourage organisations to avail substantive information over the Internet.

2.3.3.6. Lack of *Political Will* and Government Control of telecommunication sector in Developing Countries

Sadowski (1997) reports that a clear correlation between free flow of information (as occasioned by the Internet) and democratisation. Access to information affects political democratisation efforts at local and international level. In developing countries where much of the media is controlled by the state, and individual access to networks limited, a challenge is to decentralise the networks and the requisite infrastructure in order to ensure benefits of Internet access filter to a country's populace. However, governments in developing countries are suspicious of such efforts because this is perceived to lead to a loss of control over national resources and infrastructure. This loss to the governments in question represents loss of both political and economic control. (Zambrano and Daudpota, 1995).

In respect to evolution of the Internet in developing countries, Sadowski asserts that the key factors in a country's rate of absorption and utilisation of computing and networking technology include both internal and external ones. Internal factors include existing physical and human resources infrastructure of the country, the rate of development as well as the rate of growth. External factors include willingness of

supplier to do business in the country and availability and amount of International assistance directed towards the transfer of such technology.

There is a strong correlation between such telecommunication improvements in developing countries and national telecommunication policies that help liberalise telecommunication services (Richardson, 1997). For example, growth of Internet usage in the rural Zambia is possible because of a telecommunication regulatory environment that enables private sector initiatives and competitive service. Relatively restrictive regulatory environments in Zimbabwe, in contrast, have so far prevented the release of portable telephony, despite significant demand. Richardson reports that in Uganda and Ghana, countries in which Internet use is increasing exponentially, have adopted liberalised telecommunication policies. The Egyptian government's decision to support private sector Internet service provision is resulting in an explosion of Internet services and parallel growth in Internet subscribers. Countries, which have poor Internet access, also tend to be countries with monopolistic national telecommunication policies and little or no service competition in the telecommunication sector (Richardson, 1997).

It may be noted that South Africa ranks highly in respect to the political commitment towards development of electronic networking (Kibata, 1997). However, full and effective advantage of the opportunities brought about by the Internet cannot be utilised when the potential sources of information on water and sanitation are still restrained in their development.

2.3.3.7. Speed of Access and Attendant Costs

The poor telecommunication infrastructure in developing countries poses a challenge to growth and development of the Internet in these countries (Sadowski, 1997). One of the most common complaints among water and sanitation NGOs using the Internet is that users in the developed countries do not appreciate the difficulty of accessing Internet services in the developing countries. The speed of information retrieval in Africa is much slower than in say, the WaterAid head office in London. Although Internet access is expanding in developing countries, users do not have access to the same range of high-speed telecommunication lines and phone lines that are available in the North. Internet *bandwidth* (a function of the size and speed of telecommunication lines) is generally less in developing countries than it is in the North. Low bandwidth

translates into longer transmission times, and for many users in developing countries, increased costs (Richardson, 1997).

One remedy for the *bandwidth* problem, suggested by Richardson (1997) and one that has a relatively minor cost, is to *mirror* information on regionally located servers that could be managed by local Internet Service Providers. The service providers could gain some much-needed revenue, and local users would have dramatically improved retrieval speeds, which would encourage use and analysis of the information that is available to them from development agencies.

It may also be noted that in 1997, the *packet switching technology* on which the concept of the Internet is built on has improved significantly to enable global use of *proxy servers* that are distributed evenly over the Internet. These servers nowadays enable *caching* of information on a computer close to the users hence improving on transmission speeds (Cerf, 1997).

2.4. Water Supply and Sanitation and the Emerging Information Economy.

Water and sanitation in developing countries experiences 3 fundamental problems that militate to reduce the overall coverage. Seregeldin (1995) gives the problems as

- increasing costs of delivery of services in the water and sanitation sector,
- increasing demand for water and sanitation services, and
- decreasing quality of the available water resources.

These problems have persisted to plague the water and sanitation sector despite a decade of capital injection into the sector (LaFond, 1993). In an attempt to solve these problems, a paradigm shift in provision of services was suggested. The new paradigm emphasises closer integration between the various elements of water and sanitation services and the role player. This in turn creates a demand for an efficient communication continuum in water and sanitation.

2.4.1 Costs of Providing Water and Sanitation Services are Rising

Seregeldin (1995) predicts a shift in approach to the economics of water supply and sanitation in developing countries in the nineties through to 21st century. Principally, this is due to the increasing role of the private sector participation in the water and sanitation sectors of developing countries. The other reason due to the shift is recognition on the part of

communities in developing countries that they have an economic role to play in provision of these services. With this in mind, the communities are becoming more assertive particularly in technology choice and hence a change in financing patterns.

Private sector participation in water supply and sanitation seems to offer a solution to the growing costs of provision of services that are coupled with increased competition for scarce resources in developing countries (Idelovitch and Ringskog, 1995). **Table 2.1** illustrates the trend in cost of provision of water supply in some cities of developing countries. Although the data is derived from urban environment, the trend can be expected to be the same for rural areas.

Table 2.1: Cost of water supply indices for selected cities in developing countries for the years 1992 and 2012 (World Bank, 1992).

	1992	2012	current/future indices
Algiers (Algeria)	0.19	0.49	2.58
Amman (Jordan)	0.35	1.33	3.80
Bangalore (India)	0.10	0.20	2.00
Dhaka (Bangladesh)	0.10	0.32	3.20
Hyderabad (Pakistan)	0.14	0.63	4.50
Lima (Peru)	0.25	0.58	2.32
Mexico City (Mexico)	0.51	0.83	1.62
Shenyang (China)	0.04	0.13	3.25

Several reasons exist for the projected increases in the cost of provision of water supply in developing countries. Among them, World Bank (1994) cites institutional weaknesses manifested in financial inefficiencies and irresponsibility. Thus there is an increasing trend to shift the water and sanitation sector management to the private sector.

Idelovitch and Ringskog (1995) have identified various risks and opportunities in private sector participation in water supply and sanitation in developing countries. Primary risk

though is the risk that the services will not be affordable to the communities. On the other hand, experience in developed countries and some developing countries has shown that delegation of water and sanitation services to the private sector can result in some benefits such as stable management, higher efficiency and improved access to private capital. Other externalities such as improved health and environmental well being are some other spin offs that may come about.

Financing and economic profiles of the water and sanitation sectors in developing countries can thus be said to be at crossroads. Seregeldin (1995) has also reached the same conclusion. If the transition is carefully managed higher coverage in water and sanitation in developing countries can result with attendant benefits of improved health and environmental well-being. Exchange of experience would thus be important in management of the transition hence the importance of the research.

2.4.2 Water Quality is Deteriorating

Seregeldin (1995) asserts that while water quality in developed countries has been improving, that in developing countries deteriorated in the 20 years between 1960 and 1990. This is due to sewered and unsewered discharge into the ground and surface water resources in developing countries. The implication of the deteriorating water quality is increased cost involved in treating the water and lower quality of health for those using untreated water. **Table 2.2** by Seregeldin (1995) shows the average dissolved oxygen levels as indicators of water quality in developing countries between 1980 and 1990.

Table 2.2: Average dissolved oxygen levels in rivers in developing countries and industrial countries between 1980 and 1990 (Seregeldin, 1995)

	Low income	Middle income	High income
1980	7.3	7.0	10.0
1990	6.0	7.0	10.8

Dissolved Oxygen (DO) is in mg/l. Depending on temperature, DO levels of above 6.4 mg/l are acceptable while below 5.2 mg/l are not acceptable.

Iwugo (1995) is of the opinion that all forms of land based pollution in developing countries are on the increase because there no well established technological, economic, and legislative

control to monitor pollution are not being implemented. On the other hand, Howard (1995) believes that water pollution was not a priority until recently in developing countries. However, this is changing with the realisation that water resources are limited and need to be managed more judiciously.

Other available literature (Iwugo, 1995; The World bank, 1992), agree that there is a need to prevent pollution to the water resources in developing countries as a first step in a more effective provision of water and sanitation. Further, there is a need to take measures to clean up the damage that has been caused by the pollution.

The water quality information held by various developing countries can be useful in formulation of strategies to deal with the deteriorating water quality. A possible forum for this information interchange would be an established and vibrant water quality information exchange network based on the Internet.

2.4.3 Demand for Water and Sanitation Services is increasing

Water supply and sanitation takes place in a real world of scarce funds, competing priorities, human resource and other institutional limitations. All this is within the framework of social and political systems that both shape and determines the success of water supply and sanitation programmes. These limitations affect the extent to which a country can realistically address its needs in the sector (Water and Sanitation for Health Project, 1993). Population growth presents an example on how facility development can be out stripped even after many years of investment in water and sanitation. **Table 2.3** indicates urban population that was *unserved* with water and sanitation at the beginning and the end of the water decade. **Table 2.4** compares the coverage gain with population growth in developing countries over the same period. Coverage gain refers to the difference between the population served at the beginning and the end of the decade.

Serageldin (1995) suggests that The International Water Supply and Sanitation Decade has had mixed results in provision of clean water and adequate sanitation as shown in **Table 2.3.** From **Tables 2.3** and **2.4**, it can be discerned that 1 800 million people were provided with access to water of reasonable quality over the period. The number of urban dwellers with access to clean water increased by 80 % during this period. At the same time, the number with adequate sanitation facility increased by about 50 % (World Bank, 1992). However, despite these improvements, 1000 million people still lack access to an adequate supply of water and 1 700 million do not have adequate sanitation facilities (Seregeldin, 1995).

Table 2.3: Urban population *unserved* with water and/or sanitation at the beginning and the end of the water decade (1980 - 1990) in developing countries, in millions (Water and Sanitation for Health Project, 1993).

	1990	1980
Water	235	204
Sanitation	374	345

Seregeldin further argues that while the aim of the International Drinking Water and Sanitation Decade was to provide water of reasonable quality and adequate sanitation, an emerging agenda that emphasises environmentally sustainable development has come to the fore. This concern extends to the quality of both surface and ground water. This has been in line with the thinking that the quality of an environment and in this case the aquatic environment is a global concern. However, cities in developing countries continue to have a low level of sewage treatment. This is the case in middle-income countries as well. For example, Buenos Aires treats only 2% of its sewage. This is amplified by the fact that while environmental quality in industrial countries improved over the period 1980 to 1990, it declined in low income countries over the same period (World Bank, 1992). This fact is illustrated in **Table 2.4**.

Table 2.5: Overall growth in urban population compared with coverage gains in water and sanitation at the beginning and the end of the water decade (1980 - 1990) in developing countries in millions (WASH, 1993).

	Water coverage	Sanitation coverage
coverage	427	425
population growth	393	396
net gain	31	29

2.4.4 The New Paradigm in Provision of Water and Sanitation Services

Cross (1997) summarises the following as the principles of the new paradigm that has come to be known as *Dublin Principle* for provision of water and sanitation services.

- holistic approach in the management of the ecology in the provision of water and sanitation services,
- institutional management to be participatory at the lowest appropriate level, in most cases the community. The role players should be actively involved in the formulation of the policies that affect the way in which water and sanitation services are provided to them,
- water is *the instrument* of the new paradigm and ought to be managed as an economic resource,
- financing of water and sanitation should be a fundamental consideration, and
- provision of water and sanitation services should be demand driven.

The new paradigm is further amplified by Murray (1997), who after conducting a research on rural water supply schemes in South Africa, identifies the following as key factors that influence the sustainability of a domestic rural water supply scheme: -

- the community, as opposed to an outside agent, identifies their needs,
- the community shows a willingness to resolve internal conflicts,
- the community supports the project,
- the community shows a willingness to pay for operation and maintenance,
- the community shows that the operation and maintenance of the scheme is affordable,
- the community shows a willingness to operate and maintain the scheme,
- the community understands the implications of long term operation and maintenance, especially the financial implications, and

- the community is willing to choose suitable people to manage the development process and the operation and maintenance of the scheme.

It is widely believed that people's participation in decision-making and local ownership results in effective and sustainable rural water and sanitation systems. However, quantitative evidence supporting this claim has been lacking. Narayan (1995) carried out an in-depth survey of 121 completed rural water supply projects in developing countries around the world and arrived at similar conclusions.

Central to the new paradigm is the role of communication (Kibata, 1997). This is because incorporation of the various players in the management of water and sanitation services requires a higher level of co-ordination than has hitherto been the case. This co-ordination can only be achieved through a vibrant information exchange network such as the one suggested through the Internet.

The integration of the various elements of water and sanitation in the new paradigm further underscores the need for closer co-ordination. This can be best achieved through use of an efficient communication framework (Kibata, 1997).

2.4.5 Importance of Communication in Water and Sanitation: Review of Selected Issues in Water and Sanitation Sector.

Buckley and Kibata (1996) assert that while the information on water and sanitation in developing on the Internet is available in insignificant quantities, and the little there is scattered and difficult to come by. They thus proposed a solution to this problem through the use of an Internet based *information clearing house* known as INTERWATER combined with institution of proper management regime so as to effect efficient and effective technology transfer and exchange between civil engineers in developing countries.

Buckley *et al* (1996) demonstrated that use of the INTERWATER site could be made of to transfer technology in water and sanitation sectors of developing countries. This was conducted using engineering specifications of various designs of ventilated improved pit latrine (VIPLs). Although the models used by Buckley *et al* (1996) involved rather simple technology, the research suggested that it was possible to transfer technology in bulk if proper documentation of the technology was carried out.

Kibata (1996) concluded that the Internet generally and the INTERWATER site in particular have a potential for technical use in water and sanitation sectors of developing countries.

Dindar (1996) arrived at similar conclusions. Further presentations from Sadowski (1996), Richardson (1997) and IBM Canada (a) (1998), suggest that wider issues affecting the use of the Internet need to take cognisance of the wider issues such as individual character of the of the organisation providing the information on water and sanitation.

This section highlights the importance of communication in selected sector issues and draws the possibility of Internet led intervention in improving on the communication hence the delivery of services.

2.4.5.1. Advocacy and Community Participation in Water and Sanitation Projects.

Gorre-Dale *et al* (1994) define advocacy as the act of lobbying political, religious and economic leaders for support or pleading a cause. Common techniques involve providing information, persuading people there is a problem, which they can solve, indicating possible actions and supporting those in power to take them. Again, central to the issue of advocacy is effective communication.

The Water Supply and Sanitation Collaborative Council has identified advocacy, social mobilisation and programme communication as important elements for improved water and environmental sanitation programmes (Ring and Reader-Wilstein, 1993). Advocacy, or raising awareness about sector issues, is important in obtaining the commitment of decision-makers at all levels to improve water and sanitation programming. The general goal of advocacy is political commitment to human development, and the specific objective of advocacy is increased priority for water and sanitation. Most advocacy activities concentrate on three themes, i.e.

- improved programming through communication, mobilisation and participation (IPC),
- environmental sanitation, and
- people and the water crisis.

Awareness creation on key water supply and sanitation issues is needed at local, national and global levels. Gorre-Dale *et al* (1994), agree that there is broad agreement on the aims of a communication strategy in support of sector goals, and forms an integral part of achieving

those goals. In that framework, the overall objectives of the communication strategy for water and sanitation are:

- recognition: a broad understanding of the importance and benefits of water and sanitation to the economic, social and physical health of communities,
- efficiency: optimising available human and financial resources, through greater co-ordination,
- effectiveness: full application of the lessons learned during the decade, and
- participation: maximising co-operation and support, both human and financial.

Gorre-Dale *et al* (1994) assert that communication as practised in advocacy in water and sanitation helps to design better sustainable projects. It helps to mobilise people for development action, and to promote co-ordination and linkages. Communication spreads knowledge about successful experiences. It points people to sources of information and advice, education and learning, and planning and decision making. Communication helps to organise and manage systems for exchanging information between rural or urban people, or between technicians, or from planners to grassroots and back from grassroots to planners. Consequently, communication improves the reach and impact of training and extension.

The Internet has the potential to play a leading role in advocacy by acting either as a source of information to be disseminated or merely acting as a tool for communication (Dindar, 1997, Kibata 1996).

2.4.5.2. Institutional arrangements and their effect on Water Supply and Sanitation in Developing Countries.

Institutional arrangements in developing countries in water supply and sanitation can roughly be broken down to those rural and urban areas. Typically, provision of water and sanitation in urban areas involves bulk supply which remains in hands of government institutions or institutions closely linked to the government (Francey, 1990). On the other hand, institutional arrangements in the rural areas of developing countries as described by Okun and Ernst (1987) usually consist of three levels i.e. national, regional and local. National level is responsible for long term national planning, standard setting, obtaining and distributing financial resources, procurement of imported equipment and parts, hiring foreign consulting services, co-ordinating

training efforts and providing support and advice to regional agencies. At the local level, the community organisations (water and sanitation committees, local water authorities, etc.) are responsible for management, operation and maintenance of their local systems. The middle level structure develops the national guidelines for application to the particular areas of their operations. The delineation of these areas tends to run along administrative boundaries rather than catchment boundaries. This form of delineation tends to impact severely on water supply and sanitation (Francey, 1990). For example, pollution control from communities living on the same catchment but different administrative areas would be difficult to enforce.

The role played by the institutional arrangement in success or failure of delivery of services in water and sanitation sectors has tended to vary from country to country and within the country (World Health Organisation, 1986). Leonard (1987) concludes that institutional development, as with all development is a slow process with no instant solution. However, although cost of proper institutional development is high, it is attainable with proper planning and good timing. Edwards (1988) contends that proper institutional development presents an avenue for an efficient delivery of services in developing countries.

With regards to sanitation, Iwugo (1995) lists the following as the minimum institutional requirements with regard to a system's ability to deliver on environmental sanitation and environmental pollution control: -

- strengthened environmental legislation and standards in developing countries.
- the need for adequate sustainable infrastructure (regular water supply, vigorous town planning and urban renewal and laboratory facilities)
- appropriately trained and motivated technical staff.
- co-ordination of duties and responsibilities between different national agencies and organisations.
- Co-ordination of aid and assistance between different international development agencies and,

- vigorous research and development including field trials of appropriate water pollution control systems.

Perhaps it is in the field of institutional arrangements more than anywhere else that a sound information exchange system can help in improving.

2.4.5.3. Urban Sanitation

Mejia (1996) contends that whereas *hard* aspects of urban sanitation are well understood and documented, the *soft* aspects are not as well understood. Moreover, the interaction between the two is even less understood. Elsewhere, Pinidiya and Minnatullah (1994) have identified the lack of knowledge of interaction of the two aspects of urban sanitation as causes of failure of urban sanitation projects. Based on studies of urban sanitation projects in Sri Lanka, Pinidiya and Minnatullah (1994) identified the following as causes of failure of urban sanitation projects in developing countries: -

- lack of a demand responsive approach in problem identification and planning. This in turn influences project performance, technology choice, ownership and overall system sustainability.

- lack of cost recovery mechanism,

- appropriateness of technology is important in the success of the project. In the study carried out in Sri Lanka,, Pinidiya and Minnatullah (1994) found that some Ventilated Improve Pit Latrines had been erroneously designed (had sealed bottoms) and soon overflowed causing the communities to abandon using them.

- poor planning for operation and maintenance,

- lack of public awareness campaigns and hygiene education programme contributed to the low demand of the sanitation services, proper operation and maintenance and ultimately proper use of the facilities.

The last point highlights the importance of public awareness campaign in promotion of urban sanitation. The basis for the use of the Internet in supporting public awareness campaigns has been set in **Section 2.3.2.4** on grass-root networking.

2.4.5.4. Hygiene Education, Health and Epidemiological Issues

Hygiene education has been defined by Green *et al* (1980) as reported by Boot (1995) as any combination of learning opportunities designed to facilitate voluntary adaptation of behaviour that will improve or maintain health. Hygiene education is commonly used to consolidate the gains made through improved water and sanitation services. The definition by Green *et al* (1980) thus implies that,

- hygiene education is not teaching but learning,
- hygiene education is planned, with clear objectives to reach,
- hygiene education helps people to make decisions for themselves and to acquire confidence and skills to put these decisions into practice.

Health and hygiene education promotes beneficial changes in health behaviour by providing health information through all available channels (Gorre-Dale *et al*, 1994). Boot (1995) contends that there is general consensus that hygiene education is essential for achieving health and socio-economic benefits from water and sanitation programmes. However, the conceptual framework, factual knowledge and material input needed are lacking in developing countries. Water and Sanitation for Health Projects (1993) assert that hygiene education is the key in bringing about behavioural change, thus in realising system sustainability and achieving health benefits from water supply and sanitation improvements.

Water and Sanitation for Health Projects (1993) suggest that in most societies, women are the most important people to educate in hygiene. They control the household activities, are most concerned with the health of the family, and are the primary source of information on domestic matters of the family.

Water and Sanitation for Health Projects (1993) further asserts that changing hygiene behaviour depends on how appropriate the educator and the material are for a particular audience. Hygiene education material should be based on careful studies of the target audience's attitudes, beliefs, practices, and past experience with water and sanitation. Water and Sanitation for Health Projects (1993) suggest that the hygiene education material should be based on the available funds, production material, and equipment. Traditional communication media is given as a probable tool for hygiene education.

Marieke (1995) concludes that the compounding problem on hygiene promotion is lack of understanding as to the necessity for hygiene education, a problem that even pervades technical workers such as engineers in water and sanitation. Marieke (1994) thus suggests more audio-visual tools to increase the capacity for imparting knowledge to people.

IBM Canada (1998a) draws comparison between traditional medium of communication such as radio and TV. The similarity therefore, suggests potential for use of the Internet where traditional media has been used at lower costs. This reasoning is used as a basis of the research.

2.5. Internet, Water and Sanitation in Developing Countries; Opportunity for improved Delivery of Services through Technology Transfer.

This section of the literature reviews some selected areas in water and sanitation, which could benefit developing countries as a result of, enhanced communication induced by the Internet. It is by no means exhaustive but only seeks to expose areas, in the opinion of the researcher, in which Internet led intervention could assist in improving the delivery of services in the water and sanitation sector.

Opportunity exists for enhanced technology transfer of appropriate technology in the water and sanitation sector. The potential for the transfer was demonstrated by Buckley *et al* (1996) (see **section 2.4.5**). Cairncross and Feachem (1993) define appropriate technology with regard to water and sanitation in developing countries as the technology that fits the circumstances. The technology must be appropriate in term of cost so that it may be affordable; it must be appropriate in terms of performance so that it does the job required and must be appropriately simple so for ease in operation and maintenance. Thus, one can look at appropriate sanitation technology as a technology that when applied, brings about efficient and safe disposal of excreta in an inexpensive way, and one that is easy to operate and maintain under the prevailing conditions.

2.5.1 Waste stabilisation ponds

Most of the developing countries fall within the tropics. The country thus renders itself to wastewater treatment through the use of waste stabilisation ponds. Cairncross and Feachem (1993) contend that some wastewater treatment systems used are not suitable for hot climates. Trickling filters, for example, often become a nuisance due to flies and odours in hot

climates. Moreover, they involve moving parts, which can break down and are difficult to replace given the resource constraints in developing countries.

Mara (1977) suggests alternatives in use of waste stabilisation ponds, aerated lagoons, and oxidation ditches. Waste stabilisation ponds system consists of anaerobic ponds, facultative ponds and maturation ponds. Anaerobic ponds are used as a pre-treatment for strong wastes. Cairncross and Feachem report and average BOD removal of about 60 % in anaerobic ponds with at least 2.5 days retention time and 70% removal for more than 5 days retention time. It is in facultative ponds where most of the treatment takes place. They are usually the largest ponds in the system.

The maturation ponds are responsible for final effluent polishing. Mara and Silva (1979) report up to 95% removal of faecal coliforms from maturation ponds in Brazil. Despite the various applicability of the pond system in developing countries, various problems in research and development about whose solution can be enhanced through information exchange. Such problems would include odour emission from anaerobic ponds, large space requirements for facultative ponds and susceptibility by the ponds to shock loading.

2.5.2 Ventilated Improved Pit Latrines

Ventilated improved pit latrines (VIPL) is a technology that has its origins developing countries having been originally developed in Zimbabwe (Marks, 1993). This technology provides a model on which technology transfer on the Internet can be based. It has received wide recognition and it is recommended as an alternative form of sanitation (UNDP, 1983).

Design and construction as well as operational characteristics of the VIPL are well documented elsewhere (Cairncross and Feachem, 1993; Marks, 1993; Morgan, 1977; Morgan and Mara, 1982). However, despite the known advantages of the VIPL, it has not been possible to provide communities in developing countries with this very simple form of sanitation. Whereas a host of financial / economic, technical and sociological factors may be responsible for this poor performance, lack of information on the workings of the VIPL has been identified as one of the reasons (Cairncross and Feachem, 1993). For instance, when the authors visited some community sanitation projects in Zambia in January 1996, the construction of the so called VIPL was being conducted using outdated manuals and ended up being ineffective and expensive and hence beyond the means of the communities. This is an example of an area in which a properly managed Internet based information network can intervene for the benefit of the communities in developing countries.

2.5.3 Gravity Flow Water Projects / Spring Protection

Surface water quality in developing countries tends to be poor. There is a further health risk in that drinking water in rural areas tends to be untreated (Mara *et al*, 1977). Springs thus offer a good alternative source of drinking water due to the relatively high quality of the raw water. Springs that are located on top of hills are easy to reticulate the water using gravity.

Spring protection considerably enhances the final quality of the water. The attraction with the spring protection technology is the simplicity and cost effectiveness. In a survey by Feachem (1980), total coliforms in protected springs were found to be generally low but reduced further with protection. **Table 2.5** shows the result of survey from different countries.

Table 2.5: Reported average concentrations of *Escherichia Coli* per 100 ml of water sample in springs in Africa (Feachem, 1980).

Country	Protected	Unprotected
Kenya	-	0
Lesotho	200	900
Tanzania	15	20
Uganda	20	2000

It can thus be seen that the range of coliform control is different for different springs and different countries. It is not clear whether this difference is attributable to the technology or to other factors. This is an area where information exchange can play a part in understanding these mechanisms better leading to more efficient designs. It may be noted that spring protection is a viable alternative in water supply in the mountainous regions of South Africa in the Eastern Cape, Kwa-Zulu Natal and Western Cape. However, these resources have not been exploited despite the increasing need for clean water in South Africa. It is suspected that lack of information on the means of tapping these water resources is responsible for the under-utilisation.

2.5.4 Rain water harvesting

Rainwater like spring water also provides good quality drinking water at low collection and treatment cost. According to Cairncross and Feachem (1993), the biggest cost associated with rainwater harvesting is the storage due to intermittent nature of rainfall. The storage takes form of storage tanks and subsurface dams.

Ndege (1992) identifies various areas that need co-ordinated research in rainwater harvesting. These are harvesting and storage technologies, rainfall patterns, materials and sociological issues associated with rainwater harvesting. Ndege (1992) also calls for proper documentation of rainwater harvesting techniques and practices. It is with this regard that the research can make a significant contribution.

2.6. Summary of the literature search

The literature search presented here reveals 3 salient points of the research topic at hand. These are:

- advances in information technology and particularly the advent of widespread use of the Internet is changing ways in which people have traditionally conducted their work in varying sectors of the society ranging from education to government. The changes have in most instances resulted in more efficient and less expensive ways of doing things,

- service delivery in water and sanitation for developing countries is influenced by several factors, some of which are unique to developing countries. These factors have contributed to failure by traditional interventions in bringing about improved service delivery, and

- there is scope for Internet led intervention in bringing about improved service delivery in water and sanitation in developing countries.

Having established that scope does indeed exist, the remainder of the research report outlines the field work conducted to establish the nature of intervention required by players in water and sanitation, and modelling the results accordingly in order to establish the mechanism by which the Internet led intervention can be deployed in order to achieve the desired results of improving of the service delivery.

Chapter 3: The Promotion of the Internet as a Source of Information on Water and Sanitation: Field and Case Studies

The field and case studies presented in this chapter formed the first part of the Internet usage stimulation. This was carried out through a series of pilot projects aimed at promoting the use of the Internet in water and sanitation sector. Then was necessary before any substantive modelling could be conducted. It was decided to adopt a strategy whereby promotion of the Internet usage would be carried out with the role players. The role players would then impart the Internet usage culture to the larger community in the sector. Eventually, it was hoped that a reasonable population of users would be achieved in order to carry out the various aspects of the modelling process. This chapter reports on these activities. Included are: -

- advocacy and Internet support for the Mvula Trust,
- advocacy and Internet support for NETWAS,
- advocacy for Internet usage at various water and sanitation forums.
- transfer of responsibilities for maintenance of INTERWATER to the International Reference Centre for Water and Sanitation (IRC) at the Hague.
- advocacy and Internet support for the National Community Water and Sanitation Training Institute.
- lobbying organisations and individuals through the Community Water Supply and Sanitation (CWSS) division of the Water Institute of Southern Africa (WISA), KwaZulu Natal Branch.
- participation in 2 conferences covering various aspects of water and sanitation.

3.1. Support to the National Community Water and Sanitation Training Institute (NCWSTI).

The NCWSTI is an ITN training network in South Africa as is NETWAS (see **Section 3.3)**, in Kenya. Increased collaboration between these two organisations and especially through the Internet has the potential to ensure that South African information on water and sanitation was

disseminated to an international audience. In turn, South Africans would be able to access information on water and sanitation from international sources cost effectively.

Results from the meeting indicated that there is scope for achieving the research objective by increased collaboration with the institute.

3.1.1 Background

The Institute came into being in October 1996, through a directive by the minister for Water Affairs and Forestry in the white paper on Community Water and Sanitation policy of 1994. It is a non-profit non-governmental institution and has been established under the framework of the UNDP / World Bank International Training Networks for Water and Waste Management (ITN). It is the fifth ITN centre in Africa with the other being NETWAS in Nairobi, Kenya, CREPA in Ouagadougou in Burkina Faso, TREND in Accra, Ghana, and Institute of Water and Sanitation Development at the University of Zimbabwe in Harare, Zimbabwe.

The mission of the institute is *to build capacity in community water and sanitation sector in collaboration with other key players by empowerment of people through the development of competencies in an efficient and cost effective manner. It is a centre for training trainers*.

Its aims and objectives are: -

- developing and promoting appropriate training and capacity building for community based development in water supply and sanitation on a national basis,
- developing curricula, modules and material on a national basis to work towards standardisation and accreditation of water supply and sanitation courses ranging from community capacity building to technical and engineering aspects,
- supporting policy development to ensure an integrated development approach, improved methodologies, and effective planning for targeted training and capacity building programmes for water and sanitation sector,
- promoting and supporting training of trainers from implementing and training institutions and,
- providing support to enhance training capacity of governmental and non-governmental bodies,

- networking and linking with national and international training organisations and offering information support services based on research and data collection,

- undertaking action centred research and piloting of curricula through holding workshops both at the centre and out in the field.

Currently, the institution has 7 full time employees and a core of up to 50 professionals throughout the country from which they are able to draw upon as resource persons. The institute is based at the University of the North, Sovenga Campus outside Pietersburg, South Africa.

3.1.2 State of the Internet and its Usage within NCWSTI

The institute had 2 computers that had dial-up accounts with a commercial Internet provider. The institute was operating 2 separate accounts. There was no LAN or other form of network present within the NCWSTI. NCWSTI is well equipped in terms of other computer hardware.

The Institute did not have a presence on the WWW as at the beginning of the research period, hence there was no information available about the NCWSTI or from the NCWSTI on the Internet as of that time.

The institute's staffs use the WWW extensively in their research mainly in literature search.

3.1.3 NCWSTI and the Research Objectives.

The support accorded to the NCWSTI can be seen within the context of the project objectives as follow: -

- NCWSTI falls within the category loosely defined as policy makers, organisations involved in planning, designing, financing implementation and operation of water and sanitation services, and

- NCWSTI has several useful international links that with time can avail their cumulative information on water and sanitation to South African organisations and vice versa.

3.1.4 Potential Areas of Internet led Intervention

Following discussions with the Executive Director, NCWSTI the following were identified as possible areas of Internet led intervention: -

- assistance by the NCWSTI in transfer of information on water and sanitation from other ITN centres in Africa and the world to South Africa and vice versa.

- being in constant touch with organisations involved in water and sanitation on the ground, NCWSTI is strategically placed to inculcate a policy and paradigm shift with those organisations that emphasis increased Internet usage within the organisations.

- the *training of trainers* role played by the Institute has the potential to inculcate a culture of Internet usage by the community leaders and the grassroots levels with the attendant advantages of increased Internet usage,

- possible assistance in quality control in so far as proposed training standards by the institute are concerned e.g. Internet based proficiency tests and exams.

- creation and consequent use of *Intranets* for the core professional involved in various NCWSTI training, development, research and consultancy services.

3.1.5 Proposed Intervention Measures

In view of the possible gains identified in the potential areas of Internet based intervention, actions were proposed to

- assist in setting up a pilot NCWSTI site on the CCWR computer.

- help produce conference material over the Internet for the coming ITN conference entitled standard setting, quality control and co-ordination for training in the water and sanitation sector

- present a paper / poster and demonstration on the water and sanitation resources available on the Internet during the above conference.

- deliver a seminar/training course to some NCWSTI members of staff to impart basic web authoring skills to the NCWSTI staff,

- develop the web searching skills for more efficient search and retrieval of information on water and sanitation form the Internet,

- develop a vision to be adopted and followed by the NCWSTI for Internet strategy,

- advocate for increased use of the Internet between NCWSTI and its resource persons with a view to improving on the general Internet by the people on the grassroots level involved in water supply and sanitation, and

- investigate the cost implications of getting and giving publications.

3.1.6 Proposed and Implemented Intervention Measures

The project team initially spent 2 days on the premises of the NCWSTI. The following activities were conducted:

- seven members of the NCWSTI of staff were given training on the rudiments of the Internet.

- two members of the NCWSTI staff were trained on advanced web authoring skills.

- an initial NCWSTI home page was developed and uploaded on to the Internet.

In a follow-up meeting, NCWSTI documents were published on to Internet on a *mass production* basis with a view to providing substantive information on water and sanitation over the Internet. It was proposed that NCWSTI join INTERWATER as a partner. At the reporting time, this recommendation was yet to be effected.

It was argued in the previous report that imparting of Internet and web authoring skills to NCWSTI would form an important first step towards the introduction of grass-root computing beyond the project period. The follow-up meeting could thus be seen as a first concrete step towards the promotion of Internet computing in the water and sanitation sector.

3.2. Support to the Mvula trust

The Mvula Trust being a leading NGO in Water Supply and Sanitation in South Africa presented a logical start in a programme of advocacy of Internet usage in water and sanitation sector in South Africa. The project team was been involved with promoting Internet usage at the Mvula Trust with a view to making available the information held by the Trust to other role players in the sector.

3.2.1 Background

Previously, the following steps had been taken in advocating for increased usage of the Internet at the Mvula Trust and in particular the establishment of a WWW page: -

- in October 1995, the Executive Director, Mvula Trust attended the 3 rd Global Forum on Water and Sanitation in Barbados. At this time, the parallel IAWQ project on water and sanitation and Internet was in its formative stages and its objectives were presented to the plenary session where it was adopted as part of a mandated task of the Water Supply and Sanitation Collaborative Council. The delegates, including the Mvula Trust Executive Director, committed themselves to increased usage of the Internet within their organisations.

- the project team made a visit to Mvula Trust in March 1996 during which it was agreed in principle that Mvula Trust will set up a WWW page on the Internet.

- a follow-up visit was made to the Trust offices in April 1996 and Mvula Trust computer operations staff were given a basic course in web authoring.

- In June 1996, the project team was requested to help draw up a letter of motivation for establishment of a WWW site for the Mvula Trust. The letter was to be used in motivating for the necessary funds from the board of trustees.

- A pilot page for the Mvula Trust was established in March 1997 on a commercial site.

Thus, the purpose of the last review meeting with the Mvula Trust in May 1997 was to assess progress made and investigate on a need for any further assistance.

The Mvula Trust's WWW page has been established on a commercial Internet site. The current hard disk space limit is 10 MB, which cost R 750 per month. Further, it costs R 250 make any alterations to the pages. The Trust feels that these charges are excessive and unsustainable. This is especially so because the Mvula Trust staff is still honing their web authoring skills hence the need to modify the HTML documents on the server from time to time. In view of this, a less expensive Internet provider was being sought.

The project team was informed that the Trust sees the Internet as a tool for supplementing their current operations. Area in which they desired to expand to included electronic based dissemination of their newsletters.

At the time of writing, Mvula Trust was co-ordinating a programme on the NGO forum that is funded by the European Union. Soon, the project will have an official launch and a parallel launch on the Internet was thought to be desirable.

3.2.2 Proposed Solutions

It was proposed to do the following to address the challenges and opportunities identified in **Section 4.2.1** as follows: -

- download all the existing pages from the commercial site and set up a parallel site based at the CCWR. Further changes can then be made on the information on the site without incurring further expenses.

- work with the members of staff from the Trust to improve on their web authoring and Internet site management skills.

- the Mvula Trust will then make a decision as to whether to discontinue the present commercial site or have 2 parallel sites or to maintain the commercial site only.

- conduct an analysis of the usage of information contained in the site. This was to be conducted through a *hit and linkage analysis*.

Having addressed these problems and opportunities, it was hoped that a culture of Internet usage would have been inculcated into the Mvula Trust as an organisation.

3.3. Internet Support for NETWAS

NETWAS is one of the organisations through which the project team would like to forge stronger link with South African organisations with a view to making information on South African water and sanitation available globally and vice versa. NETWAS is a mature water and sanitation NGO based in Kenya but new to the use of Internet. Interaction with this organisation, it was hoped, would provide guidance to the information requirements of mature water and sanitation NGOs.

3.3.1 The Organisation

NETWAS is an indigenous Kenyan NGO and is a member of the ITN (International Training Networks) training centres. The other centres are CREPA in Ouagadougou in Burkina Faso, TREND in Accra, Ghana, Institute of Water and Sanitation Development at the University of Zimbabwe in Harare, Zimbabwe and the latest one is the National Community Water and Sanitation Training Institute, based at the University of the North, Sovenga near Pietersburg, South Africa. Whereas the NETWAS's principal area of focus is training in the water supply and sanitation sector, it also has 2 other areas of focus i.e.

- focus on networking and information services. This service is given in cognisance of the fact that collaboration in water and sanitation is becoming recognised as an important component of enhancing sustainable sector management. In this regard, NETWAS is a member of several networks and has a well stocked documentation centre available for use by other role players in the sector. The documentation centre holds about 2 000 books, trade literature, catalogues, directories newsletters and slides.

- focus on research, advocacy, advisory and consultancy services. Through its research arm, NETWAS offers researched consultancy and advisory services to the sector institutions.

The Centre offers specialised training in the water and sanitation sector to other NGOs, government ministries, development projects and donors.

Donors (mainly the Swiss Government) funds approximately 60 % of the centre's operations while 40 % comes from services. Donor funding is usually project specific. It has a long-term aim of becoming self-sustaining. The organisation has about 30 employees.

3.3.2 Relevance to other Developing Countries

NETWAS has been in the water supply and sanitation sector for over 10 year. Their kind of experience is one that other developing countries can borrow from in order to succeed in provision of services in water supply and sanitation sectors. When accessed through the Internet, this information is easily accessible in other developing countries. From an institutional point of view, the organisation of NETWAS as a training centre for water supply and sanitation in developing countries is also applicable in many countries. Lastly,

information dissemination as traditionally practised by NETWAS through participatory action and research was thought to be instructive for other developing countries.

3.3.3 Terms of reference

The terms of reference for the assistance that was provided were: -

- to review the existing Internet facilities at NETWAS and make recommendations as to their suitability to perform the various functions of NETWAS.
- to help source and evaluate a potential Internet provider.
- to conduct a seminar for the entire NETWAS staff in order to prepare them to use the Internet for improved conduct of their duties.
- to develop a framework for creation of a NETWAS home page on the Internet.
- to facilitate in conjunction with the senior management of NETWAS the development of a vision for the growth of Internet related services within NETWAS

3.3.4 Work done at NETWAS

The following 3 sections describe the nature of work done for NETWAS in Nairobi during the review period.

3.3.4.1. Existing Services

Currently, the centre operates a UUCP dial-up from an NGO known as Healthnet for Internet mail only. Mail is retrieved from the host in the USA every 3 hours, stored at Healthnet's servers in Nairobi, and delivered to the account holder on demand. No other Internet services exist. Healthnet has the advantage of being an NGO that provides services to institutions undertaking health work in developing countries. With every account comes an offer of a BBS (referred to as conferences) focusing on health issues in developing countries. The account has the advantage of a low subscription fee of Ksh 800 (about US $ 15) per month. In terms of mail service, this service was judged adequate for the time being.

The centre had also acquired the CorelPerfect suite for Windows 95 to ease the process of web authoring. However, none of the centre's machines was on Windows 95. The

centre will soon be upgrading its hardware as a prelude to installation of Windows 95 operating system.

There was a need to improve on the existing mail reading and TCP / IP software which was found to be tedious and ultimately wasted valuable time. However, in the medium term, it would be necessary to move to full Internet connection in order to take advantage of the full range Internet services currently available. In the short term, this was made difficult by the fact that the existing phone lines in the area were unstable although the Telecomm authorities in Kenya claimed that the lines were digital. Unless that problem is rectified, it was not be cost effective to acquire a full Internet connection.

3.3.4.2. Internet Provider in Nairobi

During the research period, there were 3 full-fledged Internet providers in Nairobi and about 20 others offering other dial-up services. The pricing structure of the full Internet services providers tended to be uniform. Thus the project team influenced the choice of the provider. The chosen provider will host the NETWAS web pages and assist in automation of the documentation centre's database in order to provide the information over the Internet to a global audience.

3.3.4.3. Internet Seminar

The objective of the seminar was to prepare the NETWAS staff to take advantage of the opportunities afforded by the Internet to enhance their performance and productivity. With this in mind, the seminar was divided into 3 sections covering the rudiments of the Internet, basics of web browsing including searching, and an introductory course to web authoring. The last course was limited to documentation staff and others with particular interest in the area. Emphasis was placed on the application of the Internet at the work place in particular and water and sanitation sector in general.

3.3.4.4. Framework for development of NETWAS home page on the Internet.

There was an immediate need to establish an Internet presence by NETWAS even at a superficial level. This would ensure that at the minimum, there was an international awareness of NETWAS as a source of information on water and sanitation. It was thus decided to use the existing hierarchy of the NETWAS hard copy brochure as a start-up

page progressing into each area of NETWAS's focus area level by level. However, this is a temporary measure awaiting development of a more comprehensive site complete with search facilities for the information held by the NETWAS documentation centre. The web site has since been established using a commercial Internet Provider in Nairobi.

3.3.4.5. A vision of NETWAS and the Internet.

For the purpose of the evolution of the vision, the project team divided a time frame for growth of the use of Internet within NETWAS into short term (within 1 year), medium term (1 - 3 years) and long term (beyond 3 years). It may be noted that these definitions of terms do not strictly conform to any standard definition. This is due to the fact that change in technology in so far as the Internet is concerned is much faster than other technologies. Thus, the vision evolved was as follows: -

- In the very short run, the project team saw the continuation of the existing UUCP dial-up services from Healthnet. An initial home page was also to be developed immediately and lodged with the preferred Internet providers. This will be logically followed by full development of the page to provide useful information.

- In the short to medium term, there will be an evaluation and monitoring of the impact of the site on the operations of NETWAS and assess how the contribution of the site to the overall operational objectives of NETWAS. It was also suggested that a workshop should be held say in 18 - 24 months time to review the process of monitoring and evaluation.

- In the medium term, an endeavour will also be made to market the information held by NETWAS over the Internet where techniques such as price discrimination would be applied appropriately, effectively enabling the information to be free or available at nominal cost to developing countries and at an economic price to the developed countries.

- In the long run, the research team saw an emergence of NETWAS as a leader in provision of information on water supply and sanitation in developing countries. To this end, it may be necessary for the NETWAS to lease a Subnet from a local Internet provider to enable all the data maintenance and management to be

performed in-house. However, this last vision was not conclusive and a recommendation was made that more deliberation be done on this point.

3.4. Participation at the 19th WEDC Conference in Durban, South Africa.

Water Engineering, Development Centre (WEDC) based in Loughborough, UK hosts a conference in either Asia or Africa on water and sanitation every year. WEDC is one of the world's leading institutions concerned with education, training, research and consultancy for the planning, provision and management of physical infrastructure for development in low- and middle-income countries.

3.4.1 Background

The 23rd WEDC was held in Durban between the 1st and 5th of September 1997 at the International conference centre (ICC). The theme of the conference was *Innovations and Partnerships*. The project team participated in the conference through an exhibition of the INTERWATER and other Internet based initiatives for water supply and sanitation in developing countries. The exhibition consisted of 2 size A0 posters and 2 computers connected to the Internet at the foyer of the main conference hall. The team was also able to participate in other conference activities such as exhibitions, presentations and technical tours. The team also offered e-mail services on request from the WEDC conference organisers.

3.4.2 INTERWATER Exhibition and Demonstration.

The exhibition was conducted with an aim to popularising the use of Internet in Water Supply and Sanitation sectors of developing countries and South Africa in particular. A previous survey by the project team had concluded that one of the greatest hindrances to use of the Internet in water and sanitation sectors of developing countries is lack of suitable site which could be used a starting point before proceeding on a substantive information search. The INTERWATER site provided a useful start to any information such over the Internet hence the decision to conduct the exhibition using the INTERWATER. A copy of the posters on exhibition is attached.

Typically, an interested person would visit the stand where they would be invited to go through the promotional material. They would then be briefed on the essence of INTERWATER and any further clarification of their interest. The person would then be taken on a live demonstration of the site. At that point majority of the people expressed an interest

in INTERWATER either as a starting point for their search of information on water and sanitation over the Internet or as an institution wishing to join as a partner. The first category of enquiries was referred to the INTERWATER URL, which was sent to them immediately by e-mail while the second group was referred to the INTERWATER task co-ordinator.

A live demonstration of the INTERWATER partner sites was also given on request. Occasionally, the visitors to the stand would be allowed to *surf* the Internet for information on water and sanitation depending on the prevailing traffic conditions.

The stand was well-received recording about 70 visitors daily (the conference had 420 registered delegates). Several of the visitors to the stand expressed a wish to have the INTERWATER to be presented at a plenary session together with other Internet based initiatives.

3.4.3 E-mail Services

The conference organisers had been previously approached with a proposal to let the project team provide e-mail services to the participating delegates. However, due to restrictions with the Internet connection, this was not possible. However, some of the conference delegates approached the conference organisers requiring to be provided with temporary e-mail addresses. Apparently, it has become a norm for conference organiser in developed countries to provide temporary e-mail addresses to participating delegates in a conference. The conference organisers in turn approached us to provide the services.

However, it must be emphasised that the research team considers e-mail being an integral part of the Internet. Thus, any application of the Internet in water and sanitation must include use of the e-mail. Thus, the project objective of promoting the use of the Internet in the water and sanitation was in a way catered for.

3.4.4 Technical tour

The project team toured Efaya water scheme as part of the conference technical tour. This water supply project had been previously used in evaluation of the potential effectiveness of the prototype Internet based Information provider that was then WENDY (see Kibata, 1996). Some of the solutions suggested from the study have since been instituted and the project is about to be handed over to the community.

3.4.5 Contacts established

Various people made enquiries on INTERWATER. It is difficult to assess the seriousness of the inquiry and the probable impact of the inquiry. The international links are particularly important in that they would serve as users of South African expertise in water and sanitation and at the same time making available their experiences. Inquiries were received from the following institutions: -

- MEWD, Zambia
- Centre for Disease Control and Prevention, USA
- Murdoch University, Australia
- International Committee of the Red Cross, Nairobi
- Development Workshop, Angola
- Lawrence Berkeley National Laboratory, California, USA
- Glover Development Engineers, South Africa
- Department of Water Affairs, South Africa.
- United Nations Development Programme, Zambia.
- Leon Foundation, South Africa.
- EuroConsult, The Netherlands

3.5. Participation at the ninth ITN Conference in Pretoria, South Africa.

The ninth ITN Africa conference was held in Pretoria in December 1997. The ITN is a network of professional organisations, established to provide qualified advice, information and training in the water and sanitation sector. The ITN is a global programme established under the aegis of the United Nations Development Programme and the World Bank Water and Sanitation Programme, with centres in Africa, Asia and associated countries in Latin America. The ITN Africa centres have developed into a network of non-profit-making organisations moving towards similar ends.

The project team displayed posters on INTERWATER. A computer with a live link to the Internet was placed at the disposal of the project and was used to raise the awareness of the participants on the various source of information on the Internet.

The conference attracted about 120 delegates, 70 % of whom were South African. About 90 % of the delegates were able view the demonstration in course of the conference and on the minimum got exposed to the sources of information on water and sanitation on the Internet

3.6. INTERWATER Project and South African Water and Sanitation Sector.

The research objectives intended that the research complement an earlier initiative funded by the International Association on Water Quality (IAWQ). This earlier project has come to be known by the name INTERWATER. Kibata (1996) had concluded that the Internet generally and the IAWQ site in particular had a potential for technical use in water and sanitation sectors of developing countries. Dindar (1996) arrived at similar conclusions.

Buckley and Kibata (1996) assert that while the information on water and sanitation in developing countries on the Internet is available in insignificant quantities, the little there is is scattered and difficult to come by. The proposed solution to this problem is the use of an *information clearing house* to be known as INTERWATER combined with institution of proper management regime so as to effect efficient and effective technology transfer and exchange between civil engineers in developing countries. Buckley *et al* (1996) demonstrated that site could be used to transfer technology in water and sanitation sectors of developing countries. This was done using engineering specifications of various designs of ventilated improved pit latrine (VIPLs). Although the models used by Buckley *et al* (1996) involved rather simple technology, this research suggests that it is possible to transfer technology in bulk if proper documentation of the technology was done and suggested management techniques instituted.

3.6.1 Why INTERWATER?

The INTERWATER project was established in order to find a solution to the problem of lack of information on the Internet on water and sanitation. The International Association on Water Quality (IAWQ) and the Water Research Commission of South Africa agreed in 1995 to support the Pollution Research Group (PRG) at the University of Natal, Durban in creating an *information gateway*, in the form of a home page on the Internet, to be provisionally known as the Water Supply and Environmental Sanitation Services Electronic Network for Developing Country Needs (WENDY).

The IRC International Water and Sanitation Centre, together with the United Nations Centre for Human Settlements (Habitat), the Environmental Health Project (EHP) of USAID, and the Water, Engineering and Development Centre (WEDC) at Loughborough University were invited to become members of an International Steering Committee to guide this development. Following a demonstration of a prototype information gateway for the sector at the Third Global Forum of the Water Supply and Sanitation Collaborative Council, held in Barbados in November 1995, the Council approved the inclusion of the Internet initiative in its programme of activities for 1996-97, and authorised the Steering Committee to function as a council task force on the subject, under the co-ordination of the International Reference Centre for water and sanitation, IRC. Following discussion among task force members, it was decided to change the name of the initiative to INTERWATER in order to establish more clearly its connection with the water sector for users of the Internet.

3.6.2 Information on Water and Sanitation available on INTERWATER.

In accordance with its overall goal, INTERWATER is concerned primarily with water supply and environmental sanitation in developing countries. It aims to guide users to sources of information, and professional contacts which are of potential relevance and value to those involved with this field, rather than itself providing substantive information on these subjects. Responsibility for providing substantive information to INTERWATER users rests mainly with the partner institutions, through the medium of their own home pages.

The principal functions of INTERWATER are:

- to provide an up-to-date, structured and user-friendly guide or pointer to sources of information on water supply and sanitation available both from partner institutions and from other sources which are accessible through the Internet,
- to provide an effective mechanism for the dissemination of information by sector institutions,
- to provide an effective channel of electronic communication between sector institutions and professionals in all parts of the world, and
- to promote and propose pilot projects designed to provide selected institutions in developing countries with the equipment, materials, training, etc., required to help

them to provide and obtain information through INTERWATER (and other channels).

Additional functions are:

- to develop and distribute protocols, guidelines, standards and manuals defining the rules, procedures and methods of operation of INTERWATER,
- to promote the use of INTERWATER through awareness raising, capacity building and training activities, and
- to promote the expansion of INTERWATER by encouraging and assisting sector institutions to become partners.

3.6.3 Organisation and Membership

INTERWATER operates under the auspices of the Water Supply and Sanitation Collaborative Council as a collaborative network of equal partner institutions guided by an International Steering Committee on which each partner will be represented. The Steering Committee constitutes of a task force of the Collaborative Council for as long as the Council continues to extend its mandate to the INTERWATER activity. The Committee formulates its own rules of procedure and those for the operation and management of the network as a whole.

Any institution wishing to become a partner in INTERWATER must:

- accept and agree to support the goals and objectives of INTERWATER,
- maintain its own home page on the Internet and agree to link this page to INTERWATER,
- be willing and able to participate in the INTERWATER International Steering Committee/Task Force, and
- agree to abide by the protocols, guidelines, standards and manuals defining the rules, procedures and methods of operation of INTERWATER.

3.6.4 Resource Requirements

In accordance with procedures laid down by the Collaborative Council, it is the responsibility of the Co-ordinator, with the support of other Task Force members, to provide the resources required to implement INTERWATER and, if necessary, to mobilise any additional resources as needed.

In order for the INTERWATER initiative to be sustainable in the long term, however, it may be necessary:

- to allow individual partners to charge for information and services provided through their own home pages, and
- to charge a subscription or membership fee to partners to cover the services of the central maintenance team and the work of the International Steering Committee.

3.7. Development WWW page for Various Key organisations in South African Water and Sanitation Sector.

The Mvula Trust and Umgeni Water are key role players in the water and sanitation sector in South Africa. The project team was involved in the establishment of the Mvula Trust web presence to the extent outlined in **Section 3.2**. On the other hand, the project team had invited Umgeni Water into the membership of the steering committee of the original IAWQ water and sanitation Internet project (then WENDY, now INTERWATER). During the proceedings of the meeting, Umgeni Water was invited as partners in the project. Establishment of a web site was a prerequisite to joining the project. At that point, it was suggested that the Umgeni Water should establish a presence on the web.

Umgeni Water's page was created in November 1996 while that of the Mvula Trust was established in April 1997. The challenges was to make the information contained in these 2 sites useful and at the same time impart a culture of using the Internet for information dissemination and retrieval to other organisations in the sector.

3.8. Lobbying at the WISA Community Water Supply and Sanitation Division of the KwaZulu Natal Branch.

The aim of the lobbying at WISA was to inculcate a culture of Internet usage by the sector professional through a professional organisation. It was hoped that the culture so acquired will

enable the sector professionals perform their duties more efficiently. The process of lobbying at the WISA was a 3-tier process: -

- the project team joined the WISA Community Water Supply and Sanitation Division (CWSSD) and thereafter helped establish the communication subcommittee of the division.

- the project team made oral presentations at CWSSD quarterly workshops. In addition, the team demonstrated the use of INTERWATER at the annual general meeting of the branch. Other water and sanitation initiatives were also covered. This went on throughout the project period.

- the project team helped establish a WISA community water supply and sanitation page on the Internet. Through this page, the division was able to place notices of meetings, minutes and other articles that were of particular interest to the members.

The CWSSD has about 200 members. It is estimated that the sessions that the project team interacted with the CWSSD, about 90 % of the members had had some form of exposure to INTERWATER in particular and the use of the Internet in water and sanitation sector in particular.

The conference resolved to set up a WWW page on the Internet, which would serve the purpose of co-ordinating the Internet activities of the various member institutions. The project team was asked to assist in the process.

3.9. Lessons Learnt in the Field Study

Various issues concerned with the promotion of the Internet as a source of information on water and sanitation has 2 faces to it i.e. the demand and the supply side. Thus promotion was built around stimulating a demand for information on water and sanitation in electronic format and encouraging holders of the information to put it up in electronic format.

3.9.1 Generic problems /Issues associated with the use of the Internet as a source of Information on Water and Sanitation.

Results of the research show that it takes time to change an organisation culture, to using the Internet as a source of information and a medium of information dissemination. This is slow and needs time to

- demonstrate,
- convince,
- budget for capital and recurring expenditure,
- acquire equipment,
- evolve strategy, and
- implement.

In order to achieve the project objectives, then the above steps need to be taken cognisance of and plan accordingly.

Further to these, generic issues/problems that arise with respect to the Internet based paradigm shift are:

- who owns the information once it is availed over the Internet
- can such information be marketed and sold.
- if the information can be marketed and sold, how? who are the prospective customers?
- funding and
- sustainability.

3.9.2 Discussion of the lessons learnt in promotion of the Internet as source on Information on Water and Sanitation

Further efforts to promote the use of the Internet, as a source of information would be desirable. From the research, various useful lessons have been learnt which would be useful in future initiatives to promote the use of the Internet a source of information on water and sanitation. The lessons have been varied and are on both the demand and supply side of the information continuum.

3.9.3 General Considerations

In order to develop the use of the Internet in water and sanitation as a source of information, the following have been identified as imperative to the success of the task

- Internet infrastructure and accesses should be improved for the majority of developing countries. These are the countries whose experiences in water and sanitation would be useful if availed on the Internet. If need be, the countries should be supported in development of policies that enhance rather than stifle the growth and development of the Internet.

- structures to introduce *grass-root electronic networking* need to be put in place through out South Africa. This would encourage development of the Internet as source of information for communities that would be direct beneficiaries of the information retrieved and disseminated from the Internet.

- a network of linked sites containing substantive information on water and sanitation needs to be established. Presence of useful information on the Internet can be used as a strong motivator in the use of the Internet. The existing INTERWATER based network can be used to jumpstart the establishment of such a network.

- South African organisations ought to be encouraged to avail the information they have on water and sanitation on the Internet. This was partially addressed in the course of the research but scope exists for more work.

3.9.4 The Lessons

Demonstration: This forms the initial part of the promotion process. It is very important because it is at this point that the client and the promoter bonds. This lesson was very important because it bears similarity with the new paradigm used in the provision of water and sanitation services where the promoters have to bond with the community. This is usually a prerequisite to a successful study of the water and sanitation problem affecting the community and subsequently, providing the solution.

Financing profile and capital expenditure: Most of the organisations that the project team undertook promotion work with wwwere *Internet ready*. This means that the necessary infrastructure to put up the information on the Internet was already in existence but for different reasons. The organisations had computers, phone lines and in some cases, some

limited form of Internet capability. However, rarely did the organisations have the right software. Usually, the software was limited to post Windows 95 word processors. However, in case of players on the demand side, usually small organisations, the costs were significantly more. This is due to the fact that the organisations started by purchasing modems on the minimum. The next step was sourcing an Internet service provider, which was not very expensive. However, it involved some major decision making steps. Thus, on it may be concluded that while the actual cost of using the Internet as a source of information were low, changing the organisation culture came at a considerably higher cost. It should also be pointed out that the costs for organisations on the supply side of the water and sanitation continuum will be significantly higher because a person needs to be trained to manage and maintain the information dissemination process. The level of training and amount of time spent will depend on the extent to which the organisation concerned intends to disseminate its information over the Internet.

Evolution of information dissemination and acquisition strategy: From **Chapter 2**, similarities were drawn between the traditional medium of communication and the Internet. The differences were also highlighted. This similarity was noticed in the advocacy phase of the research project. It came out that the organisations concerned warmed up quickly to strategies that strongly identified with the organisation operational goals and strategies. This has the advantage of ensuring continuity in the information provision in case the organisation in question decides to eventually change to electronic based information acquisition and dissemination.

Implementation and Maintenance: This phase tended to be relatively easier. The lesson learnt was that once an organisation took a high level decision to disseminate and acquire information using the Internet, the implementation moved relatively fast. The presence of the project team was limited to instances where the organisations felt that they did not have the resources to carry out the implementation. In some other instance such as with Umgeni Water, the organisation hired commercial firms to undertake the implementation. The lesson learnt here amplified the fact that in introducing a new information dissemination regime, it is important to ensure minimum level of disruption to the existing structures within the organisation.

3.9.5 The Impact of the Internet on Delivery of Services in the Water and Sanitation Sector in South Africa

It has been established that communication forms an integral part of a vibrant water and sanitation project within the context of the new paradigm in water and sanitation (see **Chapter 2**). Enhanced communication methodology translates into a more efficient delivery of services in the water and sanitation sector. It is within this context that this section seek to discuss the likely impact of the research project both in the short to medium term and in the long run.

3.9.5.1. Short and Medium Term Impacts.

Demand side: On the demand side of the information continuum, a basis has been established through the project upon which role players can piggyback on in order to obtain information from the Internet. However, two reasons will act counter to the effort. Substantive information on water and sanitation is still lacking on the Internet (see **Chapter 3**). Whereas reasons for the absences are varied, it might be discouraging for organisation to establish the necessary structures to acquire information from the Internet and still find it inadequate. The likely impact is that the organisations will use Internet for communication purposes only. This in itself is a positive impact in that lower communication costs can free up resources for use on other facet of water and sanitation. However, there is a danger that the organisations might be disillusioned and altogether give up the trying. The other likely hinder is latent resistance to change a medium level management. The research concentrated on lobbying high-level management in changing the information acquisition and dissemination strategy. Once the necessary change in high-level management had been secured, it was assumed that the processes normally followed by the management in inducing cultural change would necessarily be effective. This might not always be the case.

Supply side: On the supply side, it is expected that the quality and quantity of information will increase with the demand. In a way, this would be a sustainable manner of information on the Internet, i.e. demand driven. The lesson learnt is that in order to improve on the water and sanitation information available over the Internet, a demand will have to be simulated.

3.9.5.2. Long Term Impacts

In the long run, Internet usage in water and sanitation will be influenced by the emerging paradigm in Internet computing. The emerging paradigm around computing has been shaped up by the development of the Internet. Thus, in order to understand the new paradigm, one has to take a fresh look at the recent evolution in the use of the Internet and their level of deployment.

The new paradigm has the following features (Tapscott, 1996): -

- enhanced network computing (interchangeably referred to as distributed computing),
- a thin but intelligent client,
- networked servers as opposed to hosts, and
- universally accessible network and tightly integrated natural systems. In this respect, the Internet serves as one such network though by no means the only one. Natural systems refer adapted to working habits of the user e.g. an electronic filing system similar in operations to a filing cabinet. Central to the new paradigm is use of the Internet as the universal network.

Tapscott (1996) provides a vision of the new paradigm in computing. In this new paradigm, organisations are required to change their business model to new and more efficient ones, while technology, in this case IT / Internet provides the enabling environment. The basis of the technology is reflected in the 2 features that have contributed to the near universal acceptance and growth of the Internet, these being: -

- universal addressing system (IP assigned addresses and name resolution), and
- Universal standards for data representation in the HTML language (crosses hardware and software frontiers)

Thus, as the new paradigm develops, the organisation / business will be able to deliver more in content. For example, in water and sanitation, one can visualise a situation where new designs of a low cost sanitation technology is performed by different parties from varied locations around the world and with each of the parties making a significant contribution based on their experiences. The ease of co-ordination will be

enabled by the converging technology that will allow real-time revision of the design complete with computer simulation transmitted over the Internet. Similarly, one can think of hygiene education classes conducted over the Internet in real time using the interactive media. Such a programme would have advantage of lower costs and real time access to the most recent technology in the field.

Thus, it can be concluded that the long-term impact of Internet usage in water and sanitation would be a radical departure from the traditional way of doing things in the sector. This will not be just in information dissemination but also in operations.

3.9.6 Matrix of the Projected impact of the advocacy events for target secondary audience

The matrix son in **Table 3.1** summarises the advocacy events as conducted during the field studies and make out the possible impacts on the Internet usage. Intervention required in order to achieve desired results are suggested.

Table 3.1: Projected impact of the advocacy phase of the research

Event	Target Secondary audience	Projected impact	Intervention needed
Advocacy work at the WISA-CWSD, KZN Branch	water and sanitation professionals.	enhanced Internet usage by sector professionals	none
Internet Support for The Mvula Trust	other role players, NGOs, communities, etc	informed decision making, improved communication.	*Internet Kiosks*
Internet Support for the NCWSTI	sector professionals, policy makers, communities	informed decision making, improved communication.	*Internet Kiosks*, universal WWW access
Umgeni Water		enhanced Internet usage, better communication mechanism, improved availability of project	none

Table 3.1: Projected impact of the advocacy phase of the research

Event	Target Secondary audience	Projected impact	Intervention needed
		documentation	
NETWAS Consultancy	all information recipients.	efficient technology transfer mechanism.	

Chapter 4: Information Needs Survey for Water and Sanitation

The nature of information required by players in water and sanitation formed an important first step in modelling the behaviour of the sector with the introduction of the Internet. This chapter describes the methodologies followed in investigating the information needs of the professionals in water and sanitation. The study was designed bearing in mind that the overall objective of the research was to optimise on technology transfer in water and sanitation using the Internet.

This chapter surveys the information needs of the industry and makes a review of the Internet to determine the extent to which the information needs identified are satisfied on the Internet. The ease of access of the information was also reviewed. Previous surveys are also reviewed.

4.1. Review of Previous Information Needs Surveys

For the purposes of this study, two facets of information in water and sanitation were identified as the demand side and the supply side. The supply side refers to the source of information while the demand side refers to the user of the information. The surveys reviewed in this section are

- the supply side, and
- the demand side.

4.1.1 Information needs Survey on the Demand Side

The survey by Kibata (1996) was conducted to assess the general information needs of the industry. The survey was not focused in any way towards a particular Internet service delivery channel (see **Section 1.0** for definition of Internet services delivery channel). The results of the survey are summarised in **Table 4.1**.

Table 4.1: Information needs of various end users in water and sanitation sectors of developing countries as determined by interview.

End user	Information needs
Consulting Engineers	• design standards for projects in various countries • design methodologies adopted in various projects.

Table 4.1: Information needs of various end users in water and sanitation sectors of developing countries as determined by interview.

End user	Information needs
	• approach to feasibility studies in the water and sanitation sector.
	• effluent disposal criteria and standards in different countries
Water Authorities	• policy and institutional issues.
	• project funding sources.
	• regulatory legislation on water quality in force internationally.
	• international trends in water treatment
municipal authorities	• policy issues in urban water supply and wastewater disposal.
	• policy issues on water and sanitation in peri-urban areas and informal settlements.
engineering contractors	• information on innovations in water supply construction technology.
	• pre-qualification requirements for international tendering processes
	• details of upcoming contracts with a view to bidding
government bodies	• potential sources of funds for new projects in water and sanitation sector.
	• impact of water and sanitation projects on development
urban communities	• information on the state of their environment
	• information of conformity of their aquatic environment with international standards e.g. WHO guidelines for drinking water qualities.

Table 4.1: Information needs of various end users in water and sanitation sectors of developing countries as determined by interview.

End user	Information needs
non governmental organisations	• social implications of presence/absence of adequate water supply and sanitation.
researchers and research agencies	• developments in the field. • a bridge between the *grey* literature coming out of the field with the research that is in the mainstream scientific publications.
aid organisations	• identification of potential needs of communities in developing countries in water and sanitation sector • comparison of parallel technologies in order to assess whether they are getting the best / most out of their money. • need to secure the cheapest and the most appropriate technology for the projects may be funded by these organisations.

The survey identified the information needed by sector professionals on general basis. However, the focus in the survey was not on technology transfer. Moreover, instruments of technology transfer were not considered in the information needs survey.

The survey only interviewed single participants from each of the categories of organisations in water and sanitation, nine in all. Interviewer administered questionnaires were used. Thus, the sample selection was biased towards the needs of the organisations that were selected. Further, there were no clearly defined criteria for moderating the results from the survey to filter out distortions and other sampling errors.

4.1.2 Survey on the Supply Side

A qualitative survey carried out by IMC and Mvula Trust (1997) concluded that there exists useful information on water and sanitation on the Internet. However, the report did not point to specific source of information on water and sanitation. Further, there was no effort to identify information sources useful to a study that is focused on technology transfer. The survey contacted 40 organisations that had an established presence on the Internet.

Eleven sites were categorised as being useful a source of information for water and sanitation information. The various attributes of these sites are summarised in **Table 4.2**

Table 4.2: Attributes of the sites judged to be useful in the survey by IMC and Mvula Trust, (1997).

Site	Attributes
INTERWATER www.wsscc.org/interwater	• a possible catch link to all water related web sites. • some of the INTERWATER links not current. • no information service
International Reference Centre for Water and Sanitation (IRC) www.irc.nl	• an independent non-profit organisation based in the Hague in the Netherlands. • has a large, well-established documentation centre containing a large amount of *grey* literature on water and sanitation. • documentation centre can be accessed through the web site.
Africa Water Page (South Africa) privately maintained site www.afriwater.org	• well organised • useful for its news page, which announces events such as conferences, new publications and legislation. • a list server to which one can subscribe. • no other information service
Department of Water Affairs www.dwaf.gov.za	• government publications such as acts, bills, white papers, progress reports etc. • activities of the Department of Water Affairs and Forestry.

South African Water Information Centre www.sawic.org	• a project of the Water of the Water Research Commission. • main source of information is the WATERLIT, a database of water related publications
The World Health Organisation. www.who.ch	• brief summaries of WHO documents • documents include a few on community water supply and sanitation. • site gives details on how to order hard copies of WHO publications.
United Nations Children Education Funds (UNICEF) www.unicef.org	• information about the organisation and its activities. • reports and publications can be downloaded form the web site. • searchable through a key word search. • a number of reports on this topic on water and sanitation
United States Agency for International Development (USAID) www.usaid.gov	• site provides on-line access to USAID publications. • contains technical reports and papers from the divisions and projects around the world. • also contains USAID Evaluation Publications. Includes impact evaluations, programme assessments and lessons learned form the agency's development activities, as well as documentation of best practices of USAID development processes.
The Water, Engineering and Development Centre www.lut.ac.uk/wedc	• a self-funding organisation in the department of Civil and Building Engineering at Loughborough University in the United Kingdom.

	• site provides access to WEDC's publications database. • publications database provides summaries and bibliographic details of the publications listed. • information relating to how and where to purchase documents. • some documents can be directly downloaded from this site.
UNDP-World Bank Water and Sanitation Project www.wsp.org	• a joint program by the United Nations Development Program and the world Health Organisation. • publishes reports from its projects. • web-site provides access to the programmes' publications through a catalogue and to a database of its projects. • potentially a good information source • easily accessible through the Internet.
Environmental Health Project www.ehp.org	• a development organisation funded by USAID. • EHP publications can be downloaded from the site.

The survey concluded that there was information on the water and sanitation on the Internet was adequate for low-level information awareness. This level of information would be adequate for field workers as well as others working at that level. However, the study did not examine the usefulness of the information sources. Within the context of the research, the study did not examine whether the information on water and sanitation currently held on the Internet can be used in technology transfer. IMC and Mvula Trust (1997) suggested a series of dummy literature tests in order to assess the usefulness of information held on the Internet.

The research conducted tests to determine the compatibility of the Information on the Internet with the user needs in water and sanitation.

4.1.3 Data Collection

Data collection posed various challenges. At this point in the research, the data that needed to be collected was the type of information that Engineers in water and sanitation use in their different workplaces. For this purpose, the workplaces were broken down into 7 broad categories. These are: -

- Consulting Engineers
- Academic / Research
- Training NGOs
- Non-Training NGOs
- World Bank / UN Agencies
- Central / Regional Government
- Local Government
- Water Authorities
- Aid Agencies
- Water and Sanitation companies (operations)
- Commercial Vendors
- Others.

4.1.3.1. Data Collection for the Demand Side of the Water and Sanitation Information Continuum

Having delineated the categories of the role players in the water and sanitation, questionnaires were circulated to 360 individuals in the industry. A copy of the questionnaire is attached in Appendix 1. Some questionnaires were mailed directly to

the interviewees while others were faxed. A website (http://196.21.224.196/) was set up containing the same questionnaire. Email messages were then sent to interviewees giving the URL of the website and inviting them to respond to the questionnaire.

4.1.3.2. Information required in the Questionnaire

The objective of the survey was to record the inherent perception among the engineers working in water and sanitation about the relative importance of documents used in their day-to-day work. The respondents were asked to give a usage frequency rating of the various documents that were determined to be useful in their places of work. The phrasing of the question was, *If a source of information were made available on the Internet, to what extent would you use the under mentioned information?* A rating of 1 was given to documents that were most frequently used and 4 for the ones that were least frequently used. The documents mentioned were previous design reports, community surveys, climatic data, policy data, economic data, GIS data, legislation and policy documents, standards, bibliographic databases, and industrial trends as represented by journals, and bulletins.

These documents were thought to be representative of tools of technology transfer. A literature search was conducted to find out what constitutes articles of technology transfer. However, the search did not yield any documentation on the definition of the tools of technology transfer in water and sanitation. Thus, the questionnaire was designed to be as broad as possible in as far as the scope of tools of technology transfer were concerned. It was also suggested that in keeping the scope as wide as possible, the survey had the capacity to bring out the strength of the document as a tool for technology transfer.

4.1.3.3. Sample Size and Basis of Selection

The questionnaire was circulated to 861 individuals and organisations involved in water and sanitation. Bulk e-mail message was sent to 798 of the interviewees while the rest were contacted telephonically, face to face or by fax. They were invited to fill in the questionnaire on the web site. A printout of the questionnaire was sent to those who did not have access to the Internet. The interviewees were selected based on their work in water and sanitation. However, this was limited to those in junior, middle and senior management. The study considered the fact that those in the management were the ones likely to influence decision-making and hence paradigms shift across the

sector. Of the interviewees, 713 were based in South Africa while the rest were based outside South Africa. Whereas it would have been desirable to have a uniform spread across the developing countries, the study was conducted in South Africa and therefore, there was greater probability of establishing contacts with South African based individuals and organisations. Logistical considerations also made it difficult to improve on the geographical spread of the Interviewees.

Table 4.3 lists the documents that were identified and their associated question numbers in the questionnaire. The question number rather than the document type will be used for the purposes of identification in the rest of the chapter.

Table 4.3: Documents thought to constitute instruments of technology transfer and their associated question numbers in the questionnaire.

Document	Question number	Document	Question number
Previous Design Reports	1	GIS data	9
Community Survey - Social data	2	Legislation - Water	10
Community Survey - Economic data	3	Legislation - Environmental	11
Climatic data	4	Design Standards / Guidelines	12
Policy Documents - National Government	5	Design and Materials Specifications	13
Policy Documents - Provincial / Regional Government	6	Other Standards, e.g. material for pipes	14
Policy Documents - Local Government	7	Bibliographic database	15
Policy Documents - Regional	8	Industrial Trends through	16

Water Authorities	journals, magazines and bulletins.

4.1.3.4. Presumed Documents that form instruments of Technology Transfer.

When the questionnaires were designed, a list of documents that were thought to constitute instruments of technology transfer was drawn up. The survey assisted in either agreeing with the hypothesis or negating it. The null hypothesis was that the documents do not constitute instruments of technology transfer due to their limited use in the field. **Table 4.4** summarises the broad category of the documents that were designated as constituting instruments of technology transfer.

Table 4.4: Categories of documents thought to constitute instruments of technology transfer

Document type	Examples from the questionnaire
Raw Data	Demographic data
Processed Data	GIS data
Standards	Design standards
Policy and legislation	Regional water policy documents
Industrial reports	Journals

4.1.3.5. Response to the Questionnaire

Of the questionnaires sent out, 211 were completed and returned. **Table 3.5** gives a breakdown of the geographical spread of the respondents.

Table 4.5: Geographical origins of the responders for the questionnaire

Origin	Number of Respondents
South Africa	165
Non-South African	46

There was no clear bias in the response rate across the geographical spread. This is because the number of responders was in approximate proportions (about 25 % foreign and 75 % local) of the questionnaires originally sent out.

For the purposes of the survey, the interviewees were regarded as in junior management, middle management and senior management. Categorisation as to the management level of the responders was performed using the answers given in the position part of the questionnaire (see **Appendix 1**). **Table 4.6** gives the breakdown of the responders based on their managerial level.

Table 4.6: Geographical spread of the respondents

Managerial Level	Number of Responders
Junior Management	46
Middle Management	97

The nature of organisations responding to the query had a strong bias towards Consulting Engineers. The design of the study was of the opinion that technology transfer in water and sanitation tended to be introduced through the practising engineers. Under the circumstances, it was felt that there was a need to place subtle emphasis on practising engineers. The response thus reflected this design aspect of the study because a large proportion of the responses was received from consulting engineers. **Table 4.7** shows the distribution of the response by the nature of the organisation of the responding persons.

Table 4.7: Spread of the responders by nature of the employing organisations

Nature of organisation	Number of Responders
Water Authority	8
Consulting Engineers	118
Government	27
Aid Agency	13

Table 4.7: Spread of the responders by nature of the employing organisations

Nature of organisation	Number of Responders
UN / World Bank	4
Water and Sanitation Company	9
Construction Companies	0
Commercial Vendor	11
Academic	6
Non-Training NGO	10
Training NGO	0
Others (Professional Researchers)	5

The overall response rate was lower than what was expected. The study thus had to determine whether the samples were adequate to make deductions on the information needs for water and sanitation. Further, there was no response from construction companies. One possible reason that could explain the apathy on the part of construction companies could have been a feeling that communities rather than contractors normally handle water and sanitation projects.

In addition to answering the standard questions asked on the questionnaire, the responders raised the following as other types of information that they considered important to their operations: -

- cost recovery,
- operation and maintenance methodologies,
- demographic information,

- tender notices,
- sources of funding,
- national borehole databases,
- possible sources of funding, and
- International Companies in related business

4.1.3.6. Analysis of Data

The information needs analysis had identified the nature of information needed by professionals as the leading parameter in the analysis. On the other hand, the following factors were thought to influence the information need of the water and sanitation professionals: -

- management level of the responder,
- country of origin, and
- nature of organisation.

Each of these factors was tested in the survey to determine the extent to which they influence the information needs. Finally, a matrix of the nature of information and the factors influencing was constructed to define the needs.

Based on a suggested approach by Siegel and Castellan Jr. (1990), a frequency usage rating ranging from 1 to 4 was assigned to each of the possible answers to the questions in the questionnaire. **Table 4.8** gives the usage frequency rating assigned to each of the possible answers as reported in **Section 4.2.1.1**.

Table 4.8: Rankings assigned to the possible answers

Possible answers	Usage frequency rating (UFR)
Use the document mentioned	
primarily, pertinent to the operations	1

secondary, peripheral to the needs	2
used in extraordinary assignments	3
not used at all.	4

The usage frequency ratings were subsequently used to analyse the results as received from the field.

From the assigned numbers, an overall mean was calculated for each question as well as for various other groups of responders as designed from the study. **Table 4.9** gives an overall mean for each question and possible interpretation for the given question.

Table 4.9: Mean UFR for the questions in the questionnaire.

Question number	Overall mean	Probable interpretation
1	1.958	Use of the document peripheral to the day-to-day operations of the organisation. only used in extraordinary assignments
2	1.875	Same as 1
3	1.875	Same as 1
4	1.8	Same as 1
5	1.64	Use of the document somewhere between primary and peripheral with slight leaning towards peripheral use.
6	1.8	Use of the document somewhere between primary and peripheral with leaning towards peripheral use.
7	1.72	Use of the document somewhere between primary and peripheral with leaning towards peripheral use.
8	1.6	Use of the document somewhere between primary and peripheral with slight leaning towards peripheral use.

Table 4.9: Mean UFR for the questions in the questionnaire.

Question number	Overall mean	Probable interpretation
9	1.696	Use of the document somewhere between primary and peripheral with slight leaning towards peripheral use.
10	1.76	Use of the document somewhere between primary and peripheral with leaning towards peripheral use.
11	1.8	Use of the document somewhere between primary and peripheral with leaning towards peripheral use.
12	1.8	Use of the document somewhere between primary and peripheral with leaning towards peripheral use.
13	1.6	Use of the document somewhere between primary and peripheral with slight leaning towards peripheral use.
14	1.76	Use of the document somewhere between primary and peripheral with leaning towards peripheral use.
15	2.44	Document used for extraordinary assignments and probably rarely so.
16	2.36	Document used for extraordinary assignments and probably rarely so

The results from the mean showed a narrow range of UFR when overall mean is taken as an indicator. This was expected because the mean of the UFR from the various responders were group together regardless of the nature of their work. Similarly, the other factors thought to influence information needs had not been taken into consideration. With this in mind, the UFRs were recalculated having delineated the nature of work of the responders. **Table 4.10** shows the recalculated UFRs for various categories of responding organisations.

Table 4.10: Recalculated UFR based on the nature of the responding organisation.

Question	Nature of the responding organisation							
	A	B	C	D	E	F	G	H
1	1.8	3.018	2.521	1.988	3.944	1.059	1.977	2.018
2	1.933	1.011	1.015	1.535	3.014	2.001	1.003	2.021
3	1.8	1.989	1.013	2.151	3.012	2.02	1.009	1.979
4	1.8	1.123	1.512	1.518	3.755	2.961	1.488	2.949
5	1.786	1.101	1.63	1.972	1.013	1.962	1.486	1.032
6	1.929	1.02	1.507	2.39	1.947	1.951	1.517	1.017
7	1.857	1.03	1.09	2.549	1.93	2.039	1.61	1.025
8	1.933	1.016	1.104	2.286	1.988	1.939	1.466	1.039
9	1.533	1.105	1.696	1.356	3.841	2.878	1.455	1.009
10	1.733	2.117	1.918	1.965	1.961	1.983	1.014	1.029
11	1.733	1.02	2.377	1.91	1.946	2.954	1.922	1.056
12	1.2	2.021	1.065	1.034	1.938	1.004	1.999	1.008
13	1.333	2.878	1.499	1.49	3.731	1.005	1.951	1.053
14	1.467	3.914	1.512	2.152	1.982	1.96	1.991	1.745
15	2.467	2.992	2.825	2.531	1.918	1.947	2.506	1.907
16	1.4	1.748	1.567	2.33	2.789	2.953	2.429	1.888

A	Consulting Engineers	E	UN / World Bank
B	Water Authorities	F	Commercial Vendors
C	Government	G	Academic / Research
D	Aid Agency	H	NGO

By inspection, it was determined that there was a variation in information needs across the responding organisation. However, it would have been cumbersome to analyse the trends with the data as presented in **Table 4.10**. In any case, the value of such an analysis is doubtful. Thus, it was decided to include the nature of responding organisation in the information needs matrix.

Further, the results were analysed to test whether there was variation in responses based on the origin of respondents, i.e. South African Vs. non-South African. **Table 4.11** shows UFRs for selected questions and for both South African and non-South African responders. A percentage variation is also calculated for each of the UFRs.

Table 4.11: UFR for selected questions in the questionnaire based on the origin of the responding organisation.

Question	Local	Foreign	% age variation
2	2.046	2.215	8.3
5	1.81	1.626	-10.2
15	1.75	1.837	5
8	1.714	1.848	7.8
14	1.75	1.659	-5.2

The variations did not have a defined pattern and were limited to 10 %. Thus, it was concluded that the response was not subject to geographical origin. This gave a confidence in extrapolating the results to water and sanitation in developing countries that were not necessarily represented in the survey.

The next step was to determine whether there was a variation in the information needs of the water and sanitation professionals based on their managerial level. **Table 4.12** shows UFR results for selected questions from the survey.

Table 4.12: UFR for Information type in the questionnaire based on management level of the responder.

	Management Level			
Information Type	Senior	Middle	Junior	Logic test (fail / pass)
1	2.196	1.636	2.402	Fail
2	1.84	2.104	1.636	Fail
3	1.832	1.545	2.407	Pass
4	2.213	1.727	1.709	Pass
5	1.692	1.463	1.277	Pass
6	1.731	1.818	2.405	Pass
7	1.656	1.727	2.376	Pass
8	1.609	1.955	2.223	Pass
9	1.846	1.545	1.14	Pass
10	1.55	1.636	2.517	Pass
11	1.808	1.645	1.527	Pass
12	1.269	1.557	1.787	Pass
13	1.678	1.796	2.314	Pass
14	1.759	1.927	2.363	Pass
15	1.674	1.272	2.357	Fail
16	1.805	1.455	1.523	Pass

The logic test referred to in the last column of **Table 4.11** was conducted by inspecting the patterns in the value of UFR returned in the survey. The logic test was passed if the UFR value returned under middle management fell between the values returned by senior and junior management.

The logic test was passed in 13 of the 16 questions representing an 81 % pass rate. This high pass rate gave adequate grounds to believe that the managerial level of the responder influenced the information need, hence inclusion in the final matrix.

4.1.3.7. The Water and Sanitation Information Needs Matrix

The final phase of the information needs survey was to construct an information needs matrix based on the previous results and systematic elimination of irrelevant factors. Having established management level and nature of organisation as the most important factors influencing information needs, the information was bundled into appropriate categories and the needs matrix constructed out of the reduced data. **Table 4.13** gives the UFR values for the various levels of management.

Table 4.13: Average UFR for selected questions in the questionnaire based on management level of the responder.

	Information Type				
Management Level	Raw Data	Processed Data	Standards	Policy / Legislation	Industrial Reports
Senior Management	1.892	1.846	1.719	1.616	1.962
Middle Management	1.454	1.545	1.762	1.614	1.792
Junior Management	2.094	1.14	2.339	2.109	1.917

From the matrix, it can be discerned that there is a strong demand for policy and legislation among the members of the senior management. The same also applies to those in middle management. There is strong to moderate demand for all other type of information among middle and senior management. On the other hand, the junior management seems to have a very strong demand for processed data and little use for all other types of information.

The average UFRs for various types of information against the nature of organisation was then constructed. **Table 4.14** shows the result of the matrix.

Table 4.14: Average UFR for selected questions in the questionnaire based on the nature of responding organisation

	Information Type				
Organisation Type	Raw Data	Processed Data	Standards	Policy / Legislation	Industrial Reports
Consulting Engineers	1.844	1.533	1.4	1.739	1.889
Water Authorities	1.374	1.105	3.396	1.332	2.586
Government	1.735	1.356	1.821	2.015	2.283
Aid Agency	1.18	1.696	1.505	1.527	2.304
UN / World Bank	3.26	3.841	2.857	1.818	2.884
Commercial Vendors	2.327	2.878	1.483	1.976	1.986
Academic / Research	1.167	1.455	1.971	1.573	2.304
NGO	2.317	1.009	1.399	1.03	1.938

From **Table 4.13**, it can be seen that there is a higher definition of the UFR as nature of organisations change in comparison to changes in managerial level. From the results, it is notable that there is a very low demand for information regarding industrial trends across the board. It is also worth noting that there is a low level of interest on the part of governmental agencies on information regarding legislative as well as policy practices in other countries. This was not expected to be the case.

4.1.3.8. Conclusion on the Needs survey

From the survey, it was established that there exists a strong demand for certain types of information depending on the nature of the organisation as well as the responsibility

of the individual. It was found that the nature of the organisation strongly affects the information demand. It was also found that an organisation's demand for information shapes the needs more than the individuals. From the survey, two lessons were learnt: -

- in planning to migrate to Internet based information provision, organisations need to address themselves to the needs of other organisations as opposed to individuals. Thus, the target audience would have to be organisations rather than individuals.

- there is a disappointingly low demand for information on industrial trends. The is a dangerous because it can lead to a situation where the water and sanitation sector is developing as isolated pockets rather than in an integrated manner which is more efficient.

4.2. Survey on the Demand side of the Water and Sanitation information Continuum

The survey on the demand side aimed at investigating the level to which the technical information need by professionals in water and sanitation is met. At the same time, the extent of availability of information on the Internet was surveyed. The survey covered two levels of information availability: -

- vertical availability:- quality of information available on the individual Internet site.

- horizontal availability: – this refers to the mere presence of useful information on the Internet on water and sanitation.

4.2.1 Vertical availability

Determining the quality of information is subjective and not directly measurable. Therefore, the first challenge was to come up with satisfactory criteria for determining the quality of information (rating) that is held by the individual sites that were surveyed. Three options for conducting the rating were available: -

- direct method – in this method, the responder would be asked to log on to the individual sites and then rate them accordingly. The respondents would be professionals in the water and sanitation industry.

- semi-direct method – this method would involve using results of site ranking agents (programs) and extending the results for the water and sanitation sites.

- indirect method using shadow indicators : - the method would involve using the level of Internet usage development cycle as an indirect measure of the quality of information held on a particular site. This method is discussed in **Section 5.3.2.**

The direct method offers the best results in terms of accurately depicting the industry perception with regard to the type of information contained on the site. However, it suffers two major setbacks: -

- it is very tedious and puts too much responsibility on the part of the responder. It is unlikely that responders would be willing to devote more than 30 minutes of their time to respond to a questionnaire. Typically, a rating for a single site would take 20 – 30 minutes depending on the prevailing network traffic. This translates to between 10 and 15 hours for a survey rating for 30 sites.

- the type of information that individual users consider to be relevant to their needs varies from user to user. Thus, assigning measures of tendencies to the rating is very difficult. It is also difficult (diverse) to assign the parameters that need to be optimised.

Taking into cognisance the logistics as well as a limitation on time and finances, the method was considered unsuitable for the study. Literature by Talero and Gaudette (1996) and Tapscott (1996) reported that the increase in benefits (through improved accuracy) was negligible in comparison with the investments.

It was thus decided to use the shadow rating method for the purposes of the study.

4.2.1.1. The theory of shadow rating for the vertical demand rating

The stages of Internet applications development are derived from the application development cycle. Standish Group (1997) gives the following as the six stages of Internet application development for deployment in electronic commerce: -

- **Stage One**: Home Page - In this first stage, a company lists its background and product information.

- **Stage Two**: Market Information - In the second stage, the company will make most of its market information available, including brochures, white papers, catalogues, configurations, price lists and so on. It also may provide hyperlinks to some of its partners' home pages. Note: Few companies have ventured past stage two.

- **Stage Three**: External Business Application Integration (Internet) - When a company gets to the third stage, it is an Internet intermediate. In stage three, technical manuals, a help desk and/or a problem resolution chat line are put on the Web.

- **Stage Four**: Order Processing - There are two kinds of order processing. The first is simply an order form, which is later batched into the order processing application. The second is when the order form will edit for correct information. Later, in stage six, the order forms will go against an inventory database to provide immediate shipping information.

- **Stage Five**: - Internal Business Application Integration (Intranet) - In this stage business applications are integrated within the company's Internet firewall. Users can place orders as well as send purchase orders, expense reports, accounting information, and team product development.

- **Stage Six**: - External Business Application Integration (Internet) In stage six a company crosses over the firewall into the unstable environment. The business-critical applications are now participating in the company's business using the net. Relationships are established through the net, and electronic business-to-business deals are conducted.

It is worth noting that when Standish Group (1997) conducted the survey, the majority of the companies surveyed were still in level 2 of the application development cycle.

Kibata *et al* (1998) adapted the application development cycle for electronic commerce for use in a generalised Internet use development cycle. This cycle will have the same six stages of development. **Figure 4.1** illustrates the various levels of development in this model.

In level 1, the organisation establishes an Internet presence. This only gives rudimentary information about the organisation. Standish Group (1996) reports from their survey that such pages tend to be static. The sites at this level and are not updated in a long period. In level 2, more information about the organisation is made available. This might include a list of publications, mission statement, listing of activities, as well as links to other organisations involved in water and sanitation. In level 3, there is a low level of integration into the organisation's existing systems. This might include the

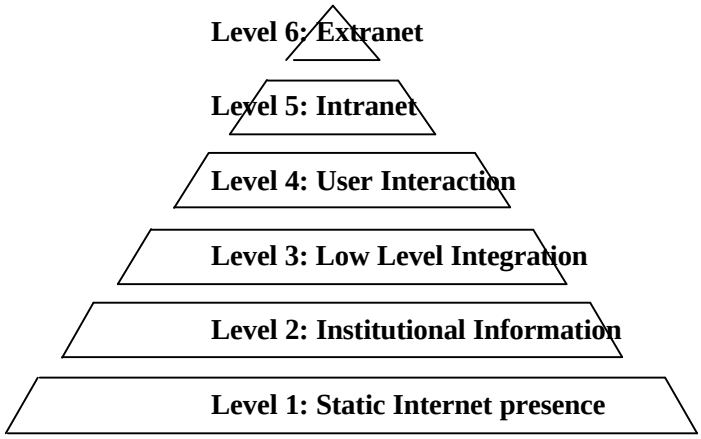

Figure 4.1: Generalised Internet Development Cycle

internal mail system as well as documentation processes. The systems can be physical as well as electronic. An example is a system whereby a policy is made to always make two versions of an organisation's newsletter; one on the Internet and a hard copy. In level 4, various forms of data handlers are incorporated in the site. At that point, there is an interactive use of the site. This enables the organisation to interact with the clients, and at the same time integrating with the existing systems. Such may include use the organisation's database to source out material suppliers for contractors or Water and sanitation trainers to register students. In level 5, the organisation matures and is able to use the Internet for its internal procedures such as project control and co-ordination. In level 6, there is eventual recognition that quality (as well as specialised) information cannot be held in the public domain. At that point, the organisation establishes a virtual private network (extranet) over the Internet. This network is used between organisations with similar interests. The organisations might charge for

quality information that flows between them. These transactions are carried out over the extranet.

The theory of shadow rating has been extended from a survey by Tapscott (1997), which concluded that there is strong evidence of correlation between the quality of information held by the sites and their level of development in the cycle. Thus, the level to which a given Internet site has developed can be considered a shadow indicator of the vertical availability of information. A limited test of applicability of the findings was conducted for the water and sanitation sector.

4.2.1.2. Test of theory of shadow rating

There are 2 parameters that the quality of information on an Internet site. These parameters are: -

- measurable parameters, and
- inherent perceptions on the part of the information user.

The two parameters can either be combined or used exclusively to define information quality. When used exclusively, the parameters ought to relate to each other in some scientific way. Hanna et al (1995) suggest that where measurable parameters exist as indicators of quality, there should be some independent and scientific means of relating the results to inherent perceptions. The test of the theory of shadow rating was thus an attempt to relate the measurable indicators (SRI) to the inherent perceptions on the quality of information on water and sanitation available on the Internet.

The theory of shadow rating was based the results of survey obtained in other sectors (Tapscott, 1997). Whereas this might be acceptable on a general basis, it was necessary to conduct limited tests to prove the applicability of the theory to the water and sanitation sector. One consideration that made it necessary to conduct the test was the probability of occurrence of peculiarities in the water and sanitation sector that might nullify the general application of the shadow rating theory.

The test involved setting up a web site (http://196.21.224.152/shadow) where sector professionals were invited to submit their personal rating of given site in terms of the quality of information held. They were asked to give a rating of 1 to 6 for the given sites. This was deliberately so in order to gather the same number of terms for use in

the tests for the validity of the shadow rating theory. Six sites were used for the exercise and were selected at random but had a site in each level of the Internet development cycle.

4.2.1.3. Test results

There were 30 responders to the questionnaire for the test. No attempt was made to analyse the nature of the respondent. It was assumed that perceptions as to quality of information had some measure of universality.

Table 4.15 shows the average quality ratings of the sites given by the responders and the corresponding SRI values.

Table 4.15: SRI values for selected sites and the corresponding quality rating values from survey.

Site	Theoretical SRI	Survey Rating	Logic test
The Pacific Water and Sanitation Programme	2	1.47	Pass
INTERWATER	2	2.33	Pass
Africa Water Page (South Africa)	3	2.8	Pass
World-Bank / UNDP Water and Sanitation Programme	4	3.83	Pass
Garnet Water Quality Node	5	4.77	Pass
Waterlit Bibliographic Database	6	5.13	Pass

The logic test referred to in the last column of **Table 4.15** was a simple test checking whether the result of the survey tallied with the SRI in terms of ranking the sites without necessarily tallying the values. In all the cases, the ranking of the sites from the survey was same as from the shadow test. It must be emphasised that it was not expected that the results of the survey and those from the shadow test would tally accurately. Siegel and Castellan (1988) have pointed out this position. However, in order for the test to be verified, it had to pass 2 tests, i.e.

- the logic test, and
- the trend test

The trend test was designed to test whether the trends on the theoretical test (the shadow-rating test in this case) and the actual survey approximately projects the same trend.

It can be seen from **Table 4.15** that the shadow-rating test passed the logic test. The next step was to conduct the trend test. In order to conduct the test, the survey values were plotted against theoretical values from the selected sites. A line x = y depicting the expected curve was also plotted. **Figure 4.2** is the plot from the test.

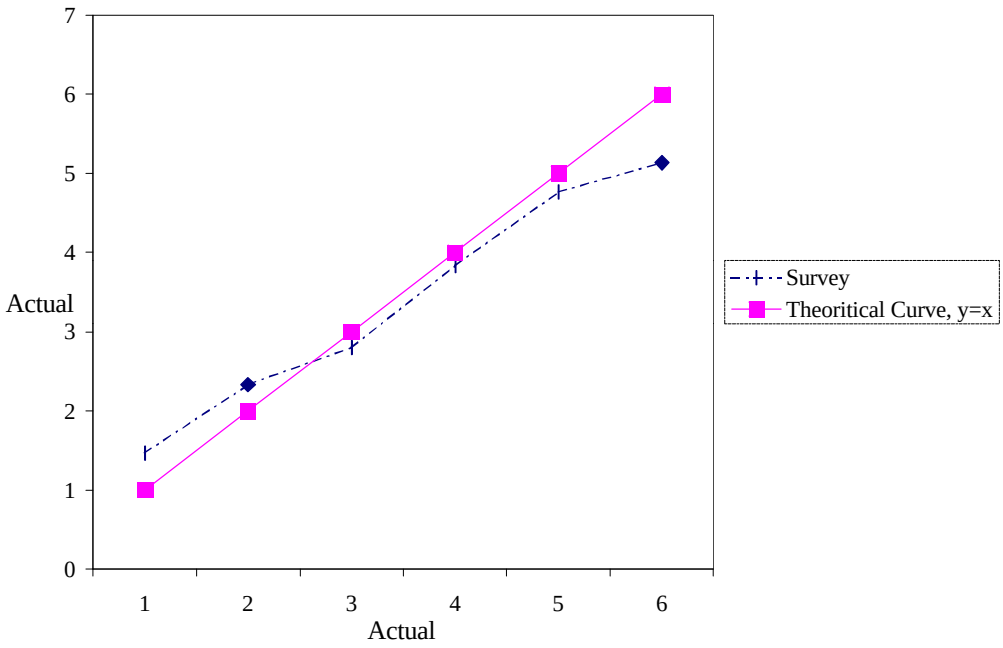

Figure 4.2: Plot of the survey rating against theoretical SRI value

From the plot, it can be seen that the trends were similar in both the theoretical and survey curves. With that test, the shadow-rating test passed both tests. It was not considered necessary to proceed with a more detailed test. Thus, the shadow rating method was adopted.

4.2.1.4. Decision tree in the evaluation of the shadow rating indices.

The process of evaluating sites and assigning them an appropriate shadow rating can be subjective. In order to ensure consistency, an algorithm was developed. The algorithm

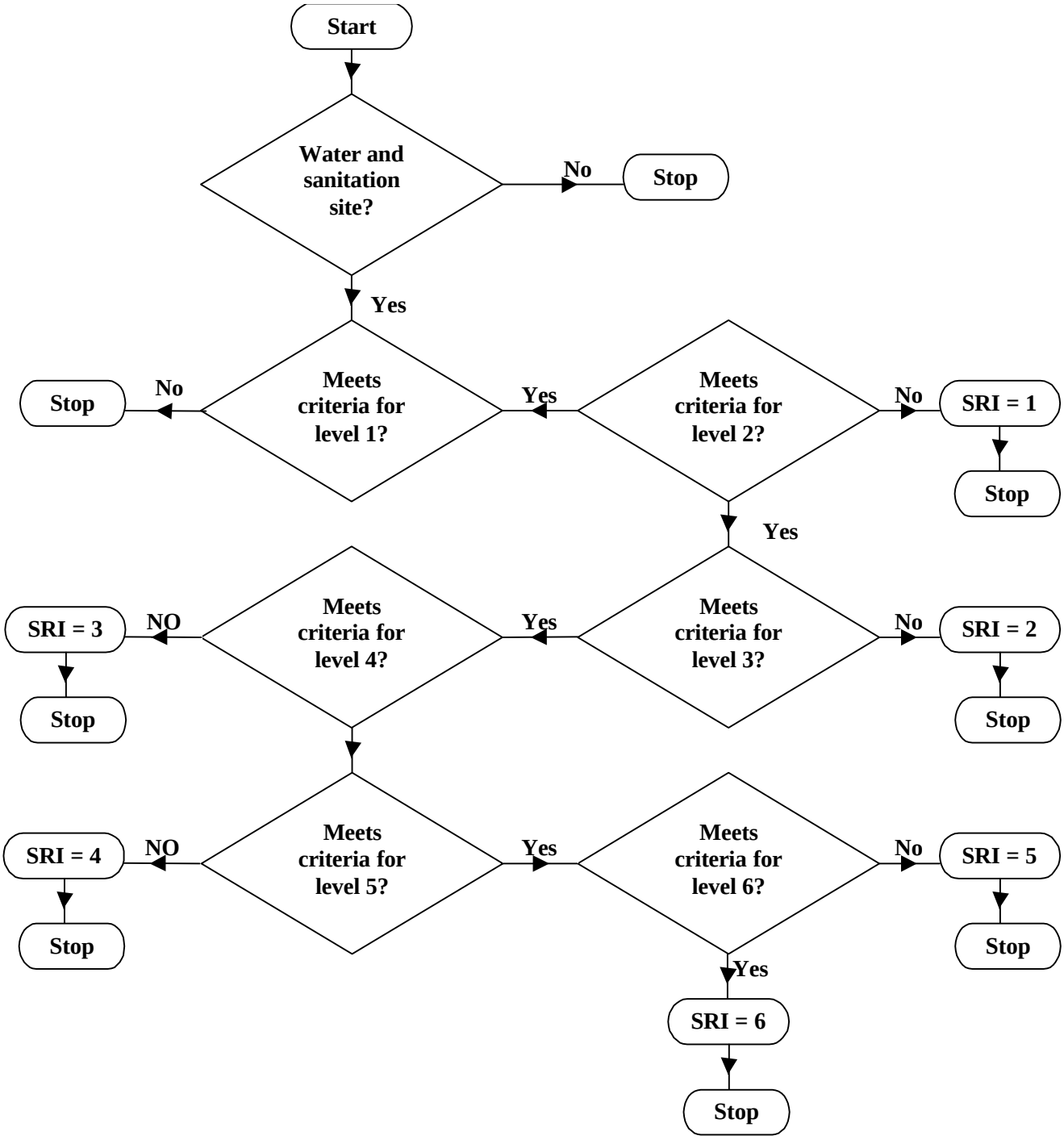

Figure 4.3: Flow chart depicting the algorithm for determining the shadow rating index (SRI) determination

was then developed to an expert system in Visual BASIC. **Figure 4.3** is a flow chart

depicting the algorithm. The program (SHADOWRATING) is provided as an attachment to the thesis. An executable program as well as the source code is provided. It should be emphasised that the version provided is only a prototype and has room for improvement taking into cognisance the dynamism of the topic. Various factors were taken into consideration were used as criteria for assigning the SRI to the various sites. **Table 4.16** summarises the criteria as used in development of the expert system.

Table 4.16: Criteria for shadow rating indices of the water and sanitation Internet sites.

Shadow Rating Index	Minimum Criteria
Pre-qualification	Internet sites dedicated to activities that relate to water and sanitation in developing countries. The sites should cover some or all of the following sector issues (these issues are derived from the IRC INTERWATER thesaurus for community water and sanitation (1987): - • sanitation promotion • urbanisation in developing countries • water quality in developing countries • water resources management and water conservation • appropriate technology • capacity building • community-based approaches including community management

Table 4.16: Criteria for shadow rating indices of the water and sanitation Internet sites.

Shadow Rating Index	Minimum Criteria
	• communication / behavioural change initiatives • economics and financing of water and sanitation • emergencies • gender / women issues in water and sanitation • health/ water-related diseases • hygiene promotion • information management • institutional options including decentralisation / privatisation • monitoring and evaluation of water and sanitation practices • operation and maintenance of water and sanitation projects.
Level 1 (SRI = 1)	All sites that satisfied the pre-qualification criteria satisfied the criteria for level 1 listing by default.

Table 4.16: Criteria for shadow rating indices of the water and sanitation Internet sites.

Shadow Rating Index	Minimum Criteria
Level 2 (SRI = 2)	• the site **must** contain information about the organisation. This could be in form of mission statement or listing of activities. • the site **must** contain links to other organisations in water and sanitation. • the site **must** contain general information on the particular activity on water and sanitation that it is involved in. The information has to be defined within the context of the overall water and sanitation (for developing countries) industry.
Level 3 (SRI = 3)	This becomes more difficult to assess. However, some indicators would be: - • the site must have a search capability • evidence of low level integration. This would be characterised by regular update of the site. For example if the organisation has a regular newsletter, it would be uploaded regularly. • the site must provide online version of its free publications. • use of dynamic HTML as well as form handlers point to evidence of integration. Examples would be files with .cgi, .asp and so on extension. • there must be presence of an information service updated regularly.

Table 4.16: Criteria for shadow rating indices of the water and sanitation Internet sites.

Shadow Rating Index	Minimum Criteria
Level 4 (SRI = 4)	• the site **must** demonstrate evidence of real time interactivity. Such evidence would include combo check boxes and online transaction data forms. • higher level of integration is required to qualify for this level. At this level, the site is updated on a regular basis (at least once a day). This is a reflection of tightness of integration of the Internet site with the overall operations of the organisation.
Level 5 (SRI = 5)	• presence and use of Intranet is difficult to assess when the assessor is located beyond the organisation's firewall. Thus, in order to tell whether the organisation is using an Intranet, one has to physically verify with the organisation. • a refusal for connection to the URL is usually strong evidence of use of an Intranet.
Level 6 (SRI = 6)	• total Internet based business transaction. • presence of an Extranet. Determined by login authentication before access to a site is authorised.

4.2.1.5. Sample size and basis of selection

In order to test the Internet for vertical availability of information on water and sanitation, it was necessary to determine the sites to be analysed. Taking cognisance of time and financial constraints, 100 sites were selected for analysis as follows: -

- the 11 sites mentioned in **Section 4.1.1**. These were selected because the IMC and Mvula Trust report (1997) cites them as important sources of water and sanitation information.

- an Internet search was conducted using 11 the major search engines for Internet sites bearing the phrase water and sanitation. The search engines used were Alta Vista (www.altavista.com), Ananzi (South African sites on www.ananzi.com), WWW Worm (www.wwwworm.com), InfoSeek (www.infoseek.com), LYCOS (www.lycos.com), WebCrawler (www.webcrawler.com), Euroseek (www.euroseek.com), Looksmart (www.looksmart.com), Search.com (www.search.com), Yahoo! (www.yahoo.com), AOL Netfind (www.netfind.com) and Excite (www.excite.com). In order to ease the search, a commercial composite search engine (a search engine that searches other search engines) known as WebFerret was used to conduct the search. The first 89 sites in terms of relevance were rated using the expert system (SHADOWRATING) developed in **Section 4.3.3**.

The tests were conducted twice, in September 1997 and again in September 1998. The tests were repeated in order to try to detect if any movements on the Internet in so far as water and sanitation was concerned. The search results yielded by the search engines were references to particular pages on a web site as opposed to the actual site. In order to rate the site, one needed to drill through the particular page to the home page. The rating was then conducted from the home page.

4.2.1.6. Results of the vertical availability search for Internet information

The search yielded 1503 hits in 1997 and 1849 *hits* in 1998. The term hits specifically refers to Internet pages that were found to contain the search term. However, the rating was for sites as opposed to pages. The documents included duplicates and were often repetitive due to variation in the search protocol used by different search engines. Thus, one should not read too much into the numbers but rather the 23 % increase in the number of total hits. The numbers will be covered in details in the section dealing with horizontal availability of water and sanitation information.

From the documents found by the search, a rating process was put in place that reduced the hits to actual sites. Only 41 sites were found out of 1503 hits in made in 1997. In 1998, the number had risen to 55. This represented a 34 % increase in the number of sites dedicated to water and sanitation. However, the corresponding increase in the number of documents was 23 %.

Table 4.17 summarises the result of the shadow rating for the 11 sites as well as the random sites for both 1997 and 1998. A printout of the individual sites and their rating is attached in **Appendix 2**.

Table 4.17: Summary of results of examination of water and sanitation sites for shadow rating.

	1997	1998	% age change
Total number of hits	1509	1849	23
No. of sites yielded through examination	41	56	34
Average SRI	1.41	1.64	16.3

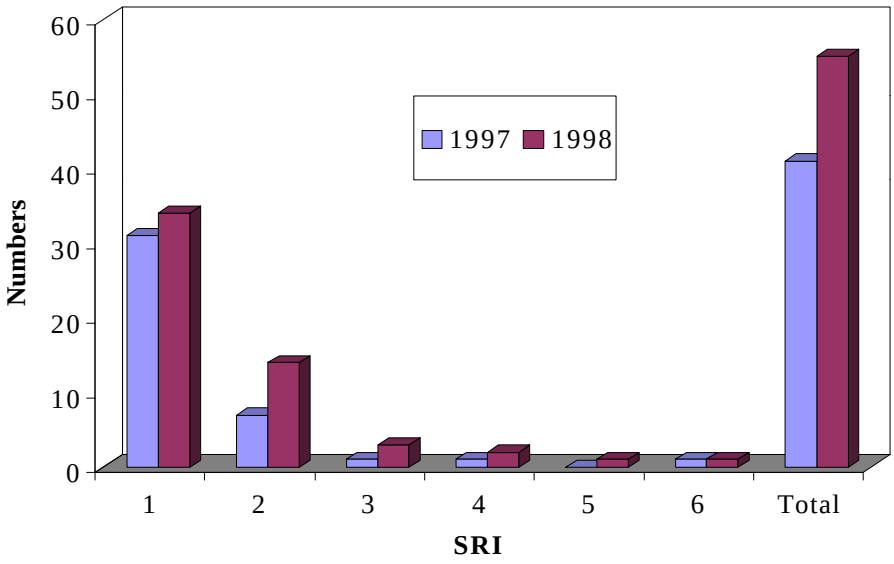

Figure 4.4: Results of the shadow rating tests for water and sanitation sites

The sites examined scored a mean of 1.41 in 1997 and 1.64 in 1998. The ideal score would be 6.00. This could be interpreted to mean that the quality of the sector information on the Internet was way below satisfactory. It could also be interpreted to mean that the potential for use of the Internet in sector information dissemination had

only been partially exploited in terms of quality. If a parallel could be drawn from industrial production, the total installed capacity was 6 (i.e. SRI 6), while the capacity in use was 1.64. Thus, there was an excess capacity of 88 %, being 6 less 1.61 divided by 6, expressed as a percentage.

Figure 4.4 illustrates the trends in Internet development cycle of water and sanitation dedicated site expressed by the rating indices.

4.2.2 Horizontal Availability

It was mentioned that horizontal availability refers to presence of information on water and sanitation regardless of the quality. In order to conduct the assessment, a quantitative technique was developed and tested. The technique known as q-test (quantity-test) was suggested by *Kibata et al*. (1998 b).

4.2.2.1. Theory of the q-test

The q-test theory was developed from the laws of probability. Siegel and Castellan (1990) argue that in a given population, the probability of occurrence of an event is directly proportional to the percentage of the event-causing object in a given sample. This has been extended in the q-test to: -

- benchmark the horizontal availability of information, and
- gauge the availability of water and sanitation information on the Internet.

Conducting a search on selected sector issues in water and sanitation on the Internet performed the q-test. The documents resulted from the search were then examined for relevance to the themes under which the search was originally conducted. For the purposes of the test, relevance was defined to mean documents that specifically contained the information on the theme as opposed to mention. For example, documents on user setting in Windows environment would be relevant under the search on Windows operating systems. Under the same search, a document describing a computer mentioning the fact that the operating system is windows would be adjudged irrelevant.

Additionally, the documents that were judged relevant had to have what in the researcher's opinion would significantly add value to a professional's knowledge of the

subject. Adding value to knowledge was thought to be possible through some or all of the following ways: -

- documentation of project processes including challenges, their solutions and lessons learnt.
- documentation of new methodologies in solution of sector problems including software.
- sector news including invitations to tender.
- comprehensive description of products and services
- drew attention to possible sources of funding for water and sanitation projects and operations.
- provided useful links to other sector players as well as sources of information.
- gave out information on professional training opportunities.

Only the documents in the top 10 % were examined for each theme. In cases where the hits were less than 10, all the documents were examined subject to a minimum of 7 hits. From the examination, a ratio of relevant to the total documents examined (relevance ratio, RR) was then calculated for the given theme. Five themes were then selected from the discipline of information technology. The relevance ratios for these disciplines were then calculated and averaged out. The average was then used as the benchmark. Whereas choice of themes from the IT sector was conducted at random, necessary care was taken to ensure that at least 1 theme was chosen from each of the major branches of IT. These are: -

- operating systems,
- networks,
- development / programming environment,
- databases, and
- packages.

In order to improve on the benchmarking, 20 group themes from the IT sector were then rated. From the results, it was possible to check on the consistency of the benchmarking process. **Table 4.18** shows results from the first group. **Table 4.19** is a summary of results from the other groups.

In order to calculate the horizontal availability index (HAI), the relevance index for the water and sanitation themes was divided with the benchmark relevance index (BRI). The HAI returned for a few other selected themes from Civil Engineering in general were calculated for comparison.

The theory of q-test makes 2 assumptions: -

- that the indexing mechanism of the search engines is consistent across the engines, and

- the entire Internet is running at the time the test is conducted. However, depending on the level of confidence limit expected from the test, lower levels of availability are acceptable. It is very difficult to measure the percentage availability of the Internet at any given time.

The choice of themes from information technology for benchmarking was made out of the knowledge that information technology sector has the highest level of development in the Internet development cycle (Tapscott, 1997). In choosing the themes, care was taken to use general terms with specific meaning in IT. For example, when choosing a theme in operating systems, Windows was chosen over Unix because the word windows has as specific meaning in IT as well as a general one.

The tests were repeated several times during the test month (September 1998) to ensure consistency. The search results over the period were stable and therefore considered reliable for use in the tests.

It should be noted that the HAI is not a measure of general availability of information but an indicator of top-level information availability. For example, a theme with a HAI of 0.500 does not mean that 50 % of all the information on the Internet on the subject is relevant. The HAI works better for use in comparison rather than an absolute measure of information availability.

Consideration was given to conducting the q-test over a period. Within the context of the information availability investigation, it was not considered necessary because the study aimed to report on information availability at the time of reporting. Due consideration is given to the trends in **Chapter 6**, dealing with technology diffusion.

4.2.2.2. Results

Tables 4.18 and **4.19** show the results of the benchmarking process. The tests were all conducted in September 1998. It was important that the tests are carried out at the same time in order to have consistent results.

Table 4.18: Results of calculation of RR from selected IT themes. The RRs were used as benchmark.

Selected IT Theme	Number of hits	Hits in top 10 %	Relevant hits in the top 10 %	RR	HAI
Windows Operating System	2034	203	143	0.704	0.979
Visual BASIC	2693	269	190	0.706	0.981
Transmission Control Protocol (TCP)	1751	175	139	0.794	1.104
Lotus Approach	1923	192	154	0.802	1.114
Vendor Packages	470	47	29	0.617	0.857
Applications Development	2032	203	141	0.695	0.965
Average				0.72	1

Table 4.19: Summary of results from the benchmarking process conducted using the IT themes.

IT group number	Calculated RR	IT group number	Calculated RR
1	0.72	11	0.714
2	0.711	12	0.717
3	0.724	13	0.691
4	0.721	14	0.701
5	0.721	15	0.739
6	0.719	16	0.724
7	0.722	17	0.669
8	0.721	18	0.785
9	0.721	19	0.723
10	0.718	20	0.734
Mean	= 0.720		

The average RR for all the IT theme groups was 0.720. This figure was ultimately used in calculation of the HAI for the water and sanitation themes as well as general Civil Engineering themes. The distribution about the mean was generally gaussian with a standard deviation of 0.0214. Using 95 % confidence limit, it was determined that the region of rejection would be 1.645 standard deviations from the mean. This would translate to a range between 0.685 and 0.755. Only 3 of the theme groups had a mean outside this range. His was interpreted to mean that the benchmarking process had been consistently conducted.

Tables 4.20 and **4.21** show the results of calculation of the HAI for the water and sanitation sector issues as well as themes from general Civil Engineering discipline.

Table 4.20: Results of calculation of RR and HAI from Water and Sanitation sector issues.

Water and sanitation Sector issue	Number of hits	Hits in top 10 %	Relevant hits in the top 10 %	RR	HAI
Appropriate technology in water and sanitation	1280	128	65	0.508	0.706
Capacity building	1850	185	57	0.308	0.428
Community-based approaches / community management	1143	114	21	0.184	0.256
Communication / behavioural change initiatives	198	20	2	0.1	0.139
Economics and financing of water and sanitation	518	52	16	0.308	0.427
Water and sanitation emergencies	585	59	23	0.39	0.542
Gender / women issues in water and sanitation	235	24	5	0.208	0.289
Health/ water-related diseases	1385	139	55	0.396	0.55
Hygiene promotion	762	76	45	0.592	0.823
Institutional arrangements	762	76	23	0.303	0.42
Monitoring and evaluation of water and	1224	122	37	0.303	0.421

Table 4.20: Results of calculation of RR and HAI from Water and Sanitation sector issues.

Water and sanitation Sector issue	Number of hits	Hits in top 10 %	Relevant hits in the top 10 %	RR	HAI
sanitation practices					
Operation and maintenance of water and sanitation projects.	1126	113	34	0.301	0.418
Water quality in developing countries	852	85	26	0.306	0.425

Table 4.21: Results of calculation of HAI from comparable themes in other fields of Civil Engineering.

General Civil Engineering Themes	Number of hits	Hits in top 10 %	Relevant hits in the top 10 %	RR	HAI
Pavement Design in Highway Engineering	1057	106	56	0.528	0.734
Hydraulic structures	1194	119	69	0.58	0.806
Dam Construction	1916	192	64	0.333	0.463
Foundation design in geo-technical Engineering	773	77	32	0.416	0.577
Catchment Management	1136	114	34	0.298	0.414
Sulphate attack on	305	31	19	0.613	0.852

Table 4.21: Results of calculation of HAI from comparable themes in other fields of Civil Engineering.

General Civil Engineering Themes	Number of hits	Hits in top 10 %	Relevant hits in the top 10 %	RR	HAI
concrete					
Design of Cable bridges	875	88	21	0.239	0.332

In order to visualise the results of the horizontal information availability, graphs were drawn comparing selected sector issues from water and sanitation with samples from IT as well as general civil engineering. **Figures 4.5** illustrate the comparison between HAI in water and sanitation and those from IT.

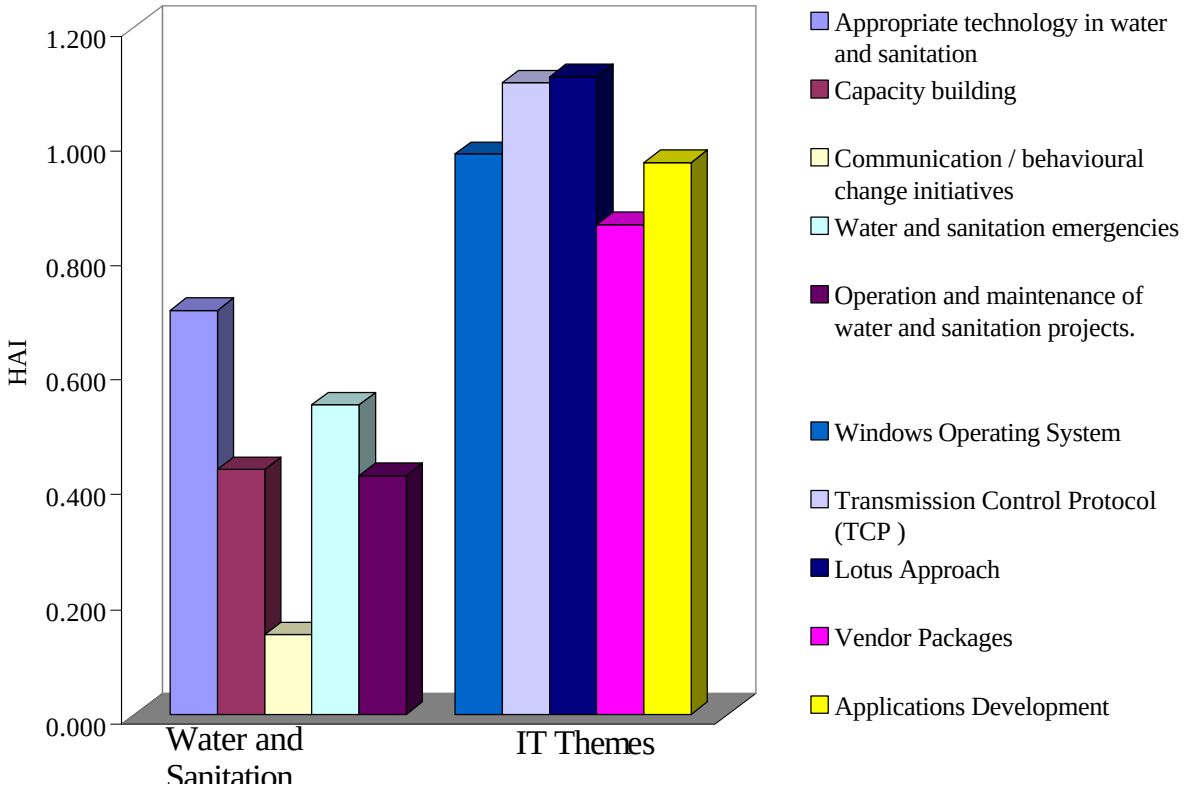

Figure 4.5: Comparison of the calculated HAI for selected water and sanitation themes against themes from the IT.

From **Figure 4.5**, it can be seen that there is a significantly higher quantity of information on Information technology on the Internet than that on water and sanitation. This is expected given that the Internet is driven from an IT perspective. Ideally, there should be as much information on the Internet on water and sanitation as there is on other subjects. Therefore, the results show a need to increase the quantity of information on water and sanitation on the Internet.

It can also be seen from the graph that the range of possible values for the HAI goes up beyond 1.000. For this particular test, the maximum value possible of HAI would have been a result of the maximum RR (in this case 1.000) divided by the benchmark RR in this case determined to be 0.720, thereby giving a value of 1.389.

Quantity of information on water and sanitation can also be compared with information

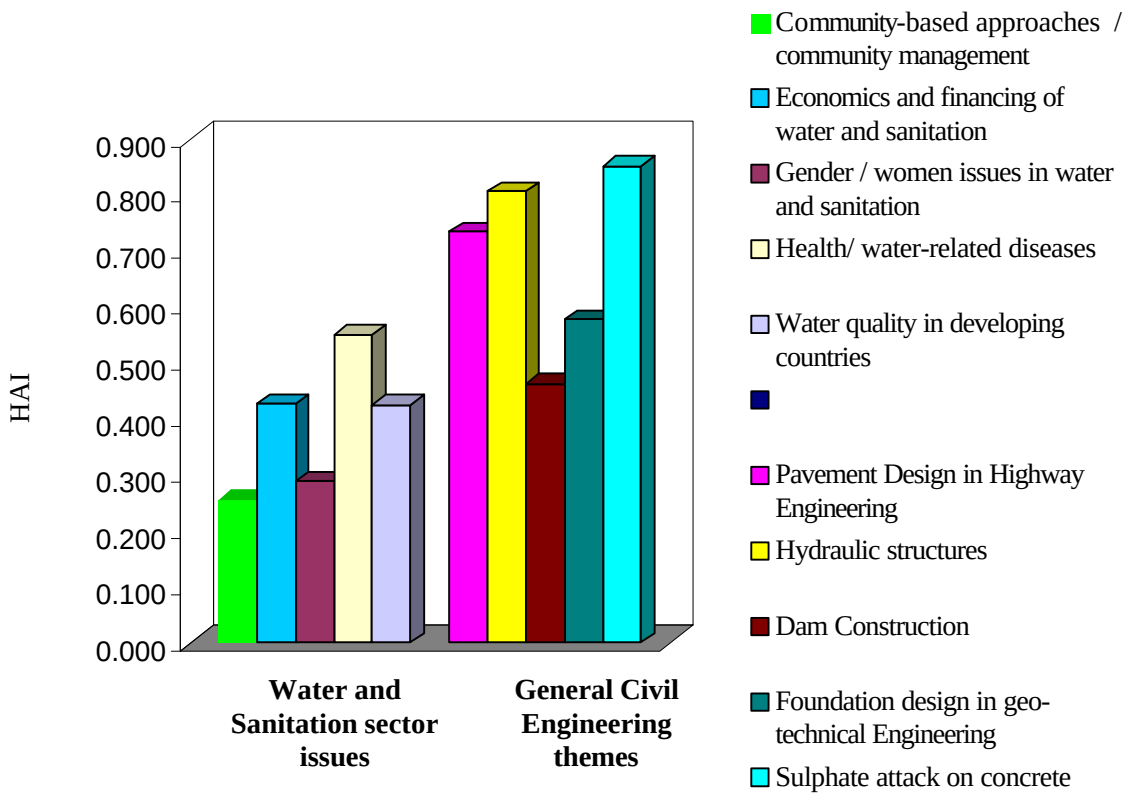

Figure 4.6: Horizontal availability of water and sanitation information on the Internet against general civil engineering themes

from other branches of civil engineering. **Figure 4.6** is the graphical representation of the comparison based on the calculated HAI figures.

From **Figure 4.6**, it can be discerned that water and sanitation lags behind the rest of the civil engineering discipline in deployment of information over the Internet. It is suspected that the same reasons that have hindered development of water and sanitation in general are responsible for the apathy in deploying information over the Internet. Iwugo (1995) lists these factors as: -

- lack of political will to deal with the provision of water and sanitation makes it hard for the government to sacrifice resources. Rarely is provision of water and sanitation (especially sanitation) made an issue in political campaigns.
- low prestige and recognition of water and sanitation sector
- ineffective promotion and low public awareness.

4.3. Summary of the findings on Information availability

The study carried out a survey of the Internet to determine the availability of water and sanitation information on the Internet at the time of reporting. The study considered both the quality and the quantity of information on the Internet. The study found that,

- the water and sanitation sector has an inherent demand for information that is packaged electronically and delivered over the Internet. Information directly related to the line of work by Engineers in water and sanitation has the highest demand. This is information related to standards as well as design reports. Peripheral importance is attached to sector information.
- with regard to quality, water and sanitation information on the Internet is unacceptable. Quantitatively, there is potential for improvements of 70 % for the information that is available.
- the quantity of information is also low especially compared with other sectors. At the time of reporting, only 56 sites the Internet were dedicated to water and sanitation issue.

Chapter 5: Internet Technology in Water and Sanitation: Disposition towards Internet-led Paradigm Shift in Computing.

The behaviour of the players in water and sanitation with regard to change to an Internet-led paradigm shift can be seen as an element of the overall Internet technology diffusion process. The diffusion aspect of the technology is investigated in details in **Chapter 6**. However, the changing behaviour is of such importance that it was decided that it ought to be investigated further and hence forms the gist of this Chapter. From **Chapter 3**, it can be seen that the process of adapting to the new technology is a difficult one wrought with human and technological challenges. This chapter looks at the disposition of the stakeholders in the water and sanitation towards making the necessary change in the working methodologies in order to take full advantage of the Internet technology.

The literature review in **Chapter 2** makes a technological and economical case for the adoption of the Internet technology in the water and sanitation sectors of developing countries. Change however benign, is always difficult and needs to be carefully managed (Kwon and Zmud, 1987).

In **Chapter 4**, it will be confirmed that a need exists for the use of Internet technology in the water sector. It was further confirmed that the amount of sector information available on the Internet is not sufficient enough to make a case for adoption. However, it is a known fact that even when an economical need exists, changing an organisation's working methodologies and probably the culture to adapt to the new way is not always easy (Cooper and Zmud, 1990).

In **Section 3.9.1**, it was argued that it takes time to change an organisation culture, to using the Internet as a source of information and a medium of information dissemination. This is slow and needs time to: -

- demonstrate
- convince
- budget for capital and recurring expenditure
- acquire equipment
- evolve information dissemination and acquisition strategy

- implement

In order to achieve the project objectives, then the above steps need to be taken cognisance of and planed for accordingly. This is illustrated in the lead-times for the various organisations, with which the pilot studies in **Chapter 3** were conducted, in **Table 5.1**.

Table 5.1: Time lags in Internet connectivity stages for the organisations surveyed in the pilot studies.

	Estimated time in months to: -				
Organisation	Demonstrate and Convince	Budget for Capital and Recurring Expenditure	acquire equipment	evolve Information acquisition and dissemination strategy	Implement the strategy
Umgeni Water	1	6	3	>36	N/A
NCWSTI	2	2	3	>36	N/A
Mvula Trust	1	12	3	>36	N/A
WaterAid	>1	>1	2	18	6
NETWAS	12	12	1	24	N/A
WISA-KZN	24	36	>36	>36	N/A

Note: Some of the activities overlapped. At the reporting time, most of the organisations had either not evolved electronic information acquisition and dissemination strategy or implemented one.

Cooper and Zmud (1990) have identified the absolute prerequisites for technological change to be either a need or innovative technology. In the case of water and sanitation sector, the need does exist and the technology is innovative (See **Chapters 2** and **3**). The question thus arises as to whether the shift to the usage of technology should be spontaneous. This chapter will examine the change mechanism with regard to willingness to change by the role players in the water and sanitation sectors of developing countries.

In modelling terms, diffusion (covered in **Chapter 6**) is different from the human behaviour modelled in this chapter in 2 ways: -

- human behaviour in this chapter is modelled using utility models. These utility models use the concept of discrete elements. In **Chapter 6**, the modelling is non-discrete and the elements are treated as such.

- The dynamism expected with the technology diffusion (as well as the technology itself) was unlikely to be reproduced with human behaviour. Cognisance was taken of this fact during the modelling design.

The human behaviour was modelled using 2 approaches: -

- Modified Asthana model proposed by Asthana (1997).

- the MCOM utility model proposed by Kibata *et al* (1998).

The remainder of this chapter will report on the 2 models.

5.1. Modified Asthana model and the MCOM Model

This section describes the theory and development of the modified Asthana model and the MCOM model.

5.1.1 The Theory of Modified Asthana Model

The Asthana model is a probabilistic model that was mooted in a study of household demand for piped water in view of the various alternative sources of water available. The model was in turn built around the theory of discrete choice analysis by Ben-Akiva and Lerman (1985) and consequent application by Madanat and Humplick (1993).

The model acknowledges that while choosing a source of water for a household is an economic decision, the decision to choose is a result of discrete elements, some of which are not economical. The model uses an indirect utility function to model the household choice.

The conditional utility function used by Asthana (1997) assumes that the household choice is a function of both the water source and the household. Similarly, the utility function for choice of information source is a function of the source of information and the user characteristics.

Thus the conditional utility function for information choice will be

$U_{ik} = U_{ik} (X_{ik}, Z_{ik})$ …….(5.1)

Where

k indicates the information source,

X is a vector of information source characteristic and,

Z is a vector of user characteristic.

The random utility theory (Ben-Akiva and Lerman, 1985) implies that unobservable or unmeasurable influences can be captured in a random term e, which can be added to the systematic term as shown in **equation 5.2**.

$U_{ik} = V_{ik} + e_{ik}$ ……(5.2)

Where

$$y_{jk} = \begin{cases} 1 \text{ if } V_{jk} + e_{jk} > V_{ik} + e_{ik} \text{ for } i, j = 1, \ldots J \text{ and } i \neq j \\ 0 \text{ otherwise} \end{cases} \quad \text{……...(5.3)}$$

V is the systematic term and e is the random term.

Let the variable y_{kj} indicate an organisation's choice of information source j as opposed to source i. This can be written as **equation 5.3**

Where

J is the total population of the information source j sampled.

In other words, if the utility of source j is higher than source i as judged by consumer (water and sanitation organisation) k. The expected value of y_{kj} is hence a probability that source j has a higher utility than source i in the opinion of consumer k.

The characteristics of the source do not influence those of the consumer and neither do the consumer characteristics influence those of the source. Thus, the consumer's utility function can be assumed to be additive.

$V_{ik} = BX_{ik} + a_i Z_{ik}$ …… (5.4)

Based on the above reasoning, both Asthana (1997) and Madanat and Lumplick (1993) concluded that an indirect conditional logit model could be used to deal with data structure containing both sets of independent variables. The logit model is expressed in **equation 5.5.**

$$P_k(j) = \frac{e^{(BX_{jk} + \acute{a}_j Z_k)}}{\sum_{i=1}^{J} e^{(BX_{ik} + \acute{a}_i Z_k)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5.5)}$$

Where

$P_k(j)$ is the probability that consumer k will choose the information choice j.

Thus, the objective of the model would be to compute the probability that the organisation will choose to source their information source electronically as opposed to hard copies.

5.1.2 Theory of the MCOM Model

The choice of information source is dependent on the source of information and on the user of the information. In order to develop the Multi-Objective Optimisation Model (MCOM), a sweep of possible criteria used by information providers and information end users were performed. It was assumed that the technical content of the information is same.

A study on the content of the information has been previously investigated and reported on by Kibata (1996) and Dindar (1997). **Figure 5.1** illustrates the criteria sweep that was conducted.

A questionnaire was circulated to various role players in the water and sanitation sector which was used to gauge their perception of what they consider to be important in choosing

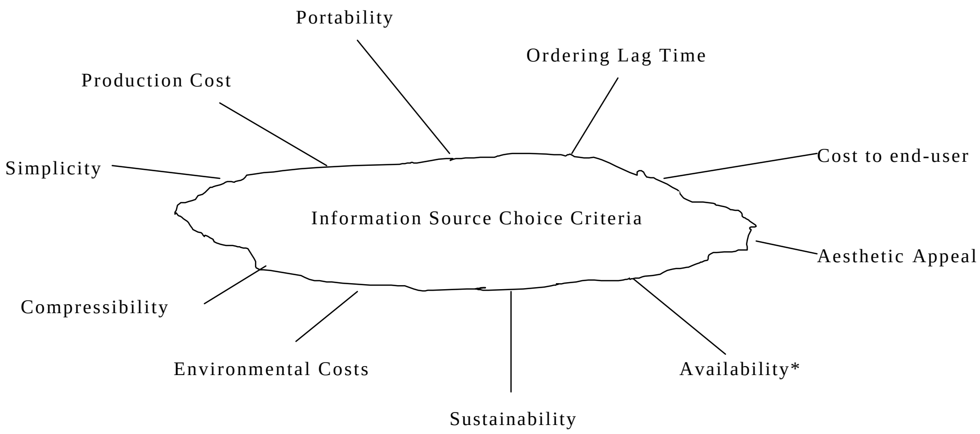

Figure 5.1: Illustration of the information choice criteria sweeps Conducted

the way in which: -

- their information is disseminated and

- the way they would like to receive their information.

In order to assist the respondents, the criteria identified (except availability) in the sweep were read out to them and they were asked to rate them. Questions were asked to how the criteria identified in the sweep influences their choice of information source on water and sanitation. The possible answers were *very much, much, moderately, somehow* and *not at all*. Each of the response was given a ranking between 0 and 4 with *very strongly* scoring 4 and *not at* all scoring 0. C_i denotes this criterion.

The next step is to calculate a specific index for each chosen criteria and the given information (note not the source but the actual information). Once again, the respondents are asked how they perceive a given piece of information on water and sanitation in view of the criteria. For example, one could have been asked question on how sustainable a given information dissemination mode is. Rankings 0 - 5 are given with possible answers being *very sustainable*, *sustainable*, *moderately sustainable*, *somehow sustainable*, or *not sustainable*. If the individual specific index is denote by S_i, then the overall information source choice index (ISCI) can be calculated from the formula: -

$$ISCI = \frac{1}{4}\sqrt{\frac{1}{N}\left[\sum_{1}^{N} C_i S_i\right]} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (5.1)$$

Where

N is the total number of criteria (excepting the availability criteria) considered in (this case 9).

The ISCI so obtained is not corrected for the availability of the information. The availability criterion is considered separately because the information from the particular source may not always be available in the given form. To correct for the availability, availability correction factor (ACF) is proposed depending on the probability of information from the given information source being available. Thus, Information form that is always available scores 1 and the one that is never available scores 0. Therefore, the ACF is calculated as

Availability = P (ACF)..……………………………………………………..… (5.2)

The corrected ISCC will thus be a measure of an individual or an organisation's disposition towards choosing the particular form or source of information taking cognisance of how readily available the information is. This will vary from 0 to 1. An ISCC of 1 suggests a very

strong positive disposition (towards the information source / form) while 0.5 suggests average disposition and 0 suggests none at all.

5.2. Application and Data Collection in the Asthana Model

The following assumptions are made in the data collection and modelling: -

- the responders had at least a rudimentary exposure to electronic publishing necessary for them to form an informed opinion.
- the consumers of the information are homogenous. This is partly true because one would expect that water and sanitation organisations would be the predominant consumers of water and sanitation information as well as the providers, and
- the elements of the utility function were indeed discrete.

The implication of the first assumption is that the Z term in both **equations 5.3** and **5.4** is eliminated. Further, the value of B becomes 1 because the source rather than the consumer solely determine the utility.

The first step in data collection was conducted in order to model the source vector characteristic in relation to the utility. An approach to model the source vector characteristics was suggested by Madanat and Humplick (1993) and somehow similar to the one suggested by Tapscott (1998) used in **Section 5.2**. In this approach, the relative importance (utility) of various elements of the source to the consumers was used to model the X vector in **equations 5.3** and **5.4**.

The elements the information choices were identified in a manner similar to the criteria sweep used in **Section 5.2**. By the same token, the elements identified were: -

- cost to the end user,
- environmental and ethical costs,
- simplicity of the message design,
- aesthetic appeal,
- portability,
- compressibility,

- sustainability of the production method,
- ease of availability,
- ordering lag time, and
- overall production costs.

A questionnaire was then sent to 189 professionals in water and sanitation who were asked to rate the importance they attach to the various elements. The responders were asked to answer questions as to how the given elements influence their choice of information source. As was the case in the MCOM utility model, the responders were asked to rate the elements as influencing their information source choice either *very much*, *much, moderately, somehow* or *not at all*. The answers were assigned a corresponding utility index (UI) of 0 to 4. *Very much* corresponded to an index 4 while *not at all* was assigned index o.

The vector X was then modelled as the sum of the probability of achieving the highest ranking for individual element while, the overall utility was the fraction of the UI over the total of the UI for all the elements.

The final step in data collection for this model was to determine how the responders perceived the 2 modes of provision of water and sanitation information in relation to the elements i.e. what was the fractional mix of the elements in each mode. It was similar to the first step, only that it specifically focused on the modes of information provision. This was done using the same wording as the utility indices. For example, asked what they thought was the cost of electronic publishing, they could respond as either *very much*, *much*, *moderately*, *somehow* or *not at all*. This would then be repeated for all the other elements and for both modes of electronic publishing. Once again, each of the answers was give an index of 0 – 4. The total of the indices was made for all the elements and the element weight calculated as the average index divided by the total. The weight was calculated for both modes of information provision.

5.2.1 Results from Asthana Model

Results were received from 67 responders representing 35 % response rate.

Table 5.2 shows the arithmetic mean of UI for the elements identified in **Section 5.1.2**.

Table 5.2: Results of the UI for the various elements of information Source

Element	Average UI	Fractional Utility (FU) = UI / Sum (UI)
cost to the end user	2.011	0.09
environmental and ethical costs	0.989	0.04
simplicity of the message design	1.546	0.07
portability	2.418	0.11
compressibility	2.345	0.10
sustainability of the production method	2.794	0.12
ease of availability	3.683	0.16
ordering lag time	3.604	0.16
aesthetic appeal	1.546	0.07
overall production costs	1.949	0.09
Total	22.885	

These results can be read as the fractional element mix of the utility of an information system. In other words, the decision to choose is influenced to the extent of the fractional utility. For example from the results, 7 % of the choice decision is influenced by the aesthetic appeal of the information source.

The second set of results was the perceived level of each of the elements in the 2 modes of information provision i.e. electronic vs. hard copy. **Table 5.3** shows the results of the weight in the 2 modes.

Table 5.3: Specific weight (W_S) of the 2 modes of provision of water and sanitation information.

Element	Electronically published		Traditionally Published	
	Index	Weight (Ws)	Index	Weight (Ws)
cost to the end user	2.933	0.124	1.889	0.168
environmental and ethical costs	3.726	0.158	0.942	0.084
simplicity of the message design,	0.242	0.010	0.326	0.029
portability	3.634	0.154	1.978	0.175
compressibility	3.897	0.165	0.158	0.014
sustainability of the production method	3.089	0.131	0.993	0.088
ease of availability	0.935	0.040	0.972	0.086
ordering lag time	0.166	0.007	2.008	0.178
overall production costs	3.008	0.127	1.029	0.091
aesthetic appeal	1.981	0.084	0.976	0.087
Total	23.611		11.271	

The results show the perceived composition of the 2 modes of information provision. Seen in another way, one can say for example that the hard copy mode of distributing water and sanitation information value consists of 17 % cost element, 8 % environmental and ethical costs etc.

Having obtained the elemental composition as well as the relative importance attached to the 2 modes of information provision; one can then model the X term as shown in **equation 5.6**.

$$X_{ki} = \sum_{i=1}^{J} w_{si} * FU_i \qquad \text{……(5.6)}$$

Where

X is a vector of information source characteristic as defined in **Section 5.1.1**,

J is the total element population,

W_s is the weight of the element, and

FU is the fractional utility index obtained in **Table 5.2**.

Taking cognisance of the assumptions made earlier in the section, **equation 5.5** can modified into **equation 5.7**.

The term X_{ik} can be obtained using **equation 5.6**. Thus, applying **equations 5.6** and **5.7** to the results shown in **Tables 5.2** and **5.3**, one is in a position to compute the probability of the water and sanitation professional choosing either of the given information provision choice. The results are shown in **Table 5.4**.

$$P_k(j) = \frac{e^{BX_{jk}}}{\sum_{i=1}^{J} e^{X_{ik}}} \qquad \text{……..…… (5.7)}$$

Table 5.4: Probability of Choice of information Provision Mode

	$\underline{X_i}$	$\underline{P_k(i)}$
Traditionally published	0.108	0.504
Electronically published	0.091	0.496

The results indicate that the organisations in water and sanitation have 50.4 % probability of choosing the traditional mode of information provision given the choice between traditional and electronic publishing. Conversely, the organisations have a 49.6 % chance of choosing the electronic mode of information provision.

5.3. The MCOM Utility Model.

Quantitative comparative study between dissemination of information as practised traditionally in the water and sanitation sectors of developing countries and the proposed Internet based methods of dissemination is difficult because the parameters involved are different. The method described

in this section attempts to perform the comparison necessary to make recommendations on Internet based information dissemination in the water and sanitation sector. Tapscott (1998) has reported a similar approach in the choice of electronically merchandised consumer goods.

5.3.1 MCOM Model Application and Results

In order to test the model, the source of information had to be homogeneous. The National Community Water and Sanitation Training Institute (NCWSTI) was chosen as the source information. The questionnaire took the form of face-to-face interview. The particular piece of information chosen for review was the NCWSTI training manual on hygiene for community leaders, which was availed to the participants both in electronic form and as a hard copy. A sample size of 30 was used and the average ISCI, which was not corrected for the availability factor, was calculated. **Table 5.2** gives the ISCI score from the survey.

Table 5.2: ISCI score for electronic and paper information dissemination

	Hard Copy	Electronic Copy (WWW)
NCWSTI	0.464	0.660
Community Leaders	0.493	0.565

These preliminary results suggest no clear preference for either of the methods of dissemination at the time of testing (Dec 1997).

The model suffers from the following generic weakness often associated with utility models in data collection: -

- hypothetical bias due to hypothetical nature of the question,
- strategic bias due to what respondents may see as an opportunity to manipulate the outcome and by extension related policy recommendation,
- compliance bias because the respondent attempts to anticipate responses the interviewer wants, and
- starting point bias with bids being influenced by interviewer's suggestions.

It should be noted here that the Asthana model described in **Section 5.2** has the same limitations given the sampling and the data collection techniques deployed.

5.4. The Utility Models

Results from the 2 models are deemed to be reasonably consistent and thus ensuring a measure of confidence. In a way, these results are a confirmation of the fact that quantification of the human behaviour is an inexact science. The results show that there is no clear cut preference for either of the 2 methods of information dissemination These results could be interpreted in 2 ways: -

- there is a level of indecision on the part of the users of information as well as the providers of the information. This could be due to a variety of reasons, but mainly due to lack of information.

- there is a genuine split in conviction on the part of the decision makers as to the efficacy of the 2 methods.

Regardless of the real reason, the results demonstrate a case for intervention. This would either take the form of advocacy or other hands-on means.

The other point worth noting is that it is to be expected that the results will continuously change as more information becomes available to water and sanitation organisations. The 2 techniques developed here can be used to monitor the effectiveness of any intervention measures that are put in place.

Chapter 6: Internet Technology Diffusion in Water and Sanitation: Technology Diffusion Environment and Modeling.

Case studies from **Chapter 3** and surveys from **Chapter 4** indicated that organisations in the water and sanitation sector had been slow in adapting to the new Internet-led paradigm in computing. This has the inherent danger of hindering growth and development of the industry. In order to understand the mechanism through which the technology component of the new paradigm diffuses into the sector, a technology diffusion model approach was suggested. It was hoped that the model would shed some light on the mechanism through which the Internet technology is diffusing into the sector.

For the purposes of the study, it is imperative to differentiate between technology diffusion from technology transfer. The neo-classical theory of technology transfer assumes that technology is readily transferable between organisations or countries and such transfers can be readily affected through the market. On the other hand, technology diffusion involves more than acquiring the technology. It involves the development of technical change generating capabilities, to adapt given technology to a widening range of needs (Mody *et al*, 1992). Continuous improvement to the use of the technology after acquisition is pertinent to the diffusion. Like the sector information needs in **Chapter 3**, the technology diffusion is influenced from both the supply side (supply of the technology) and the demand side (the recipient of the technology). The technology referred to herein refer to simple interaction between the operations of a water and sanitation organisation (or even the sector) and the Internet based computing.

It has been argued that formal representation of technological diffusion is theoretically impossible, since the object of diffusion (the technology) is different at various stages of the diffusion process (Ettlie 1980). However, Foray and Grübler (1990) have looked at the diffusion process as a series of competitions at a given time between a technology (A), which is in the middle of transformation and other technologies (B, C, D) with respect to those functions that technology A is able to assume. Thus, formal representation of the diffusion process resides in the possibility of periodising the diffusion process, with the aid of criteria, which take into account the principal transformations of the technology in question. It can further be assumed that as technology A will compete in a larger area (market) as it transforms and as it sheds its initial novelty. For example, it been mentioned in **Section 4.2.1.1** that complete adoption of the Internet technology involves 6 different stages that can be complete on their own. Thus, it can be seen that

as the technology diffuses through the organisation, the technology itself is continually being transformed adding to the complexity of diffusion studies.

Internet technology diffusion is influenced from both the supply side (supply of the technology) and the demand-side (the recipient of the technology). The technology referred to herein refers to simple interaction between the operations of a water and sanitation organisation (or even the sector) and the Internet based computing.

The investigations in Internet technology diffusion consisted of 2 phases:

- the environment within which the technology diffusion was taking place had to be contextually defined. This formed the first part of the investigations, and
- the behaviours defined in the diffusion environment definition were consequently modelled using data from the field in order to discern any patterns and if possible predict the behaviour of the technology. Possible Intervention measures could also be designed from the modelling results.

It should be noted that the terms Internet and IT / Computing are used in this chapter almost interchangeably. The reason is deliberate, stemming out of belief on that IT as practised presently will converge around a single media, the Internet. This view is shared by among others Tapscott (1996) and Drucker (1994).

6.1. Technology Diffusion Environment Definition

What makes a sector adopt a new technology? Corollary, what would make water and sanitation sectors adapt a new technology? The technology in this case, is enhanced distributed computing over the Internet. In order to answer the questions, one needs to define at the technology diffusion environment.

One definition of a diffusion environment is given by Kemp (1997) and illustrated in **Figure 6.1**. The definition had been used in manufacturing to define the environment within which cleaner technologies diffused in the industry. It was considered a useful starting point in developing a model in water and sanitation for 2 reasons: -

- the proximity of environmental issue to issues pertaining to water and sanitation.
- the historical development of the model was studied and the inherent logic judged to be applicable to the problem in question.

In Kemp's generalised model, the adoption decision is made principally out of 2 considerations as shown in **Figure 6.1**. Depending on the adoption environment, the diffusion patterns are can be discerned and modelled accordingly.

Having chosen the technology diffusion environment definition model, it was decided to mould the Internet / water and sanitation model from this backbone. The adoption decision part of Kemp's diffusion environment definition model has been partially addressed in **Chapter 5** on the user characteristics in making the adoption decision.

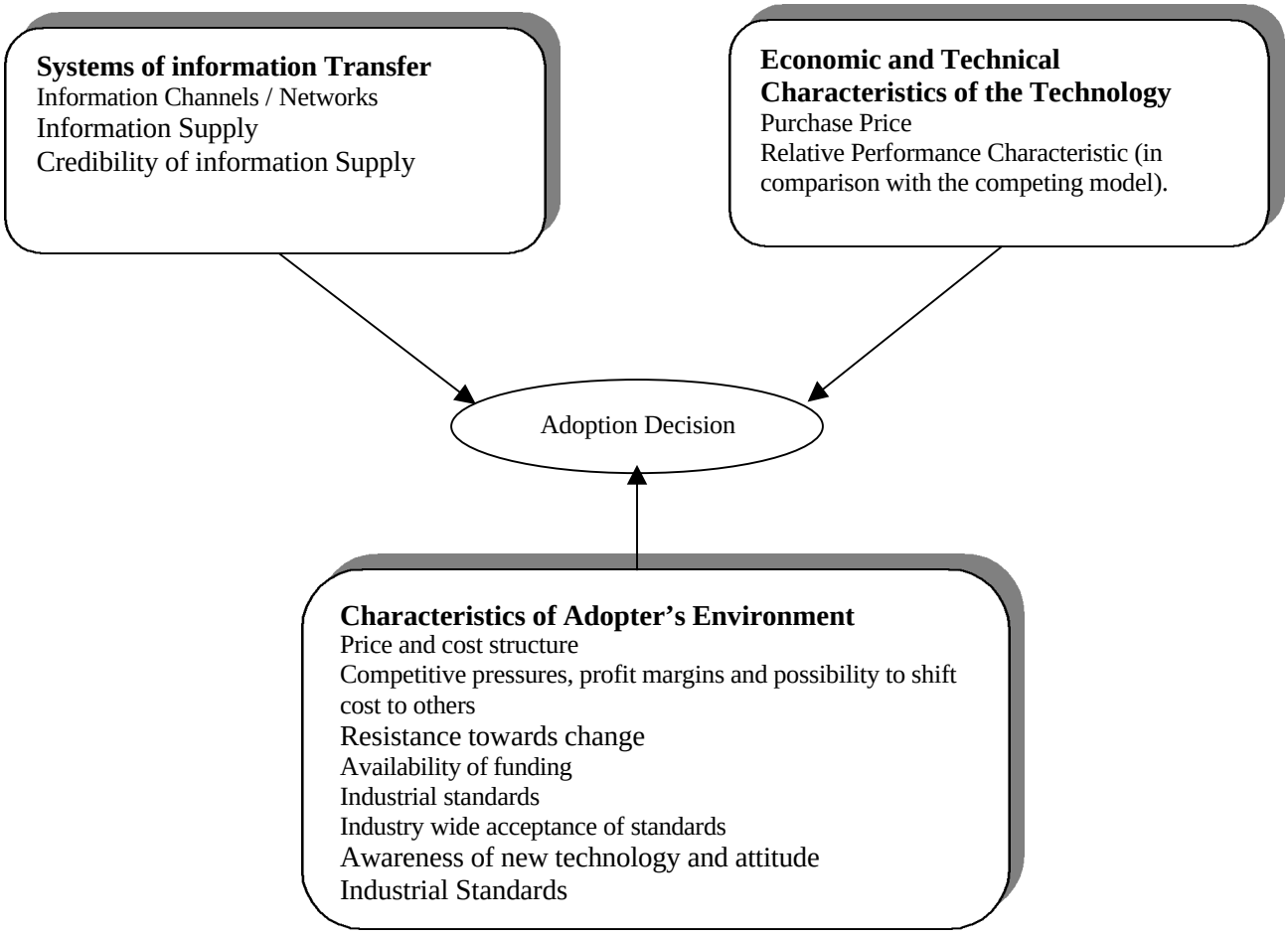

Figure 6.1: Technology Diffusion Environment Definition model by Kemp (1997).

6.1.1 Development of the Technology Diffusion Environment

Kemp's technology diffusion environment definition model (1997) was adapted from previous work by Kwon and Zmud (1987). Kwon and Zmud had previously developed the

definition for use in studies of information technology implementation. In their model (herein referred to as the stage model), Kwon and Zmud were able to demonstrate the relationship between the stage model and the more established Lewin's (1952) change model. The stage model involves 6 steps as shown in **Table 6.1**. The table also incorporates the corresponding stages in Lewin's change model.

Table 6.1: Stage Model of IT technology implementation incorporating post-adoption behaviour.

Stage	Associated Stage in Lewin's Model	Notes
Initiation	Unfreezing	**Process**: Active and or passive scanning of organisation problems / opportunities and IT solutions are undertaken. Pressure to change evolves from either organisational needs (pull), technological innovation (push) or both. **Product**: A match is found between and IT solution (Internet application in this case) and its application in the organisation.
Adoption	Unfreezing	**Process**: Rational and political negotiations ensue to get organisational backing of the IT implementation **Product**: A decision is reached to invest resources necessary to accommodate the implementation effort.
Adaptation	Unfreezing	**Process**: The IT application is developed, installed and maintained. Organisational procedures are revised and developed. Members are trained in the new procedures as well as the IT application. **Product**: The IT application is available for use across the organisation.
Acceptance	Re-freezing	**Process**: Members of the organisation are induced to

Table 6.1: Stage Model of IT technology implementation incorporating post-adoption behaviour.

Stage	Associated Stage in Lewin's Model	Notes
		commit to IT application usage. **Product**: The IT application is employed in organisational work.
Routinisation	Re-freezing	**Process**: Usage of the IT application is encouraged as a normal activity. **Product**: The organisation's governance systems are adjusted to account for the IT application; the IT application is no longer perceived as something out of the ordinary.
Infusion	Re-freezing	**Process**: Increased organisational effectiveness is obtained by using the IT application in a more comprehensive and integrated manner to support higher-level aspects of organisational work. **Product**: The IT application is used to its fullest potential.

Elsewhere, it has been reported that the actual diffusion in different scenarios differs significantly from the sequential order depicted in **Table 6.1** (Ettlie 1980, Witte 1972). However, there is growing evidence of high-level compliance with technologies that are adapted or custom made such as the Internet in water and sanitation (Pelz 1983).

6.1.2 System of Information Transfer

The importance of information transfer is well known in technological diffusion. One definition (Rogers, 1983) went as far as defining technology diffusion as a process of information transfer. It is in the process of information transfer that individuals and organisations in water and sanitation learn about the existence of the new / innovative

technology, its purpose, how to obtain it and the cost implications. Kemp (1997) argues that important in this respect are: -

- the channel through which information transfer is communicated,
- the content and frequency of information messages,
- the number of people reached through various media,
- the need for (detailed) information on the part of the potential adopters of the technology,
- the willingness of the adopters of the information to search for new information on the new or innovative technology,
- the credibility of the information supplier on the technology,
- the extent to which the information is concentrated in one party (for example the supplier of the technology), and
- the social and information networks and the frequency of social contacts.

(It must be emphasised that one should not confuse information as used in the above paragraphs with information as the active content of the water and sanitation Internet sites. The information referred to above is the information on the technical and economic aspects of adopting Internet technology into the operations of the water and sanitation organisations. This usage of the term *information* will dominate the rest of the chapter.)

Thus, this section will identify, review and evaluate the role of the systems of information transfer in diffusion of Internet technology in water and sanitation. The section will also conduct surveys to determine the nature and characteristics of the systems of information transfer and their effect on the diffusion environment.

6.1.2.1. Information Supply

Having established the importance of information in technology diffusion environment definition, it is necessary to take a look at the supply of information on the technology and how it helps shape the diffusion environment. The objective in this part of the study is to determine the source of information on the Internet technology for water

and sanitation and thereafter determine how it affects the technology diffusion environment. Additionally, the following issues relating to the supply of information on the Internet technology in water and sanitation were also addressed: -

- the need (or lack of it) for information on the Implementation of the Internet technology in water and sanitation.
- the content and frequency of the information that is communicated to the sector with regard to the Internet technology, and
- the approximate size of the audience of the various sources of information on the Internet technology in water and sanitation.

What information is communicated on the Internet technology in water and sanitation? Kemp (1997) reports that different things are communicated between different people. Suppliers doubling up as producers or retailers provide information on the benefits of the product to the users, the cost as well as instructions on the usage. Examples of such suppliers would be Internet Service Providers (ISPs), software vendors and information technology / network consultants. This helps to reduce uncertainty about the cost and benefits of adopting the product. There is also transfer of information from the users to the suppliers with regard to user needs on performance as well as cost which might help the manufacturer in redesigning / repackaging the product.

Part A of the questionnaire in **Appendix 3** forms the list of questions that were posted to 213 sector professionals. The professionals sampled were drawn from all over the world and drawn randomly. However, the sampling was restricted to medium and senior manager because they are the ones likely to affect the decision making process in any organisation. The questionnaire aimed to investigate the nature of information supply available to the sector on the Internet technology in general and the application of the Internet technology in the water and sanitation sectors generally. The questionnaire addressed the issues of Internet technology information needs, the content and frequency of the information supply and the size of the audience supplied the receiving the information.

6.1.2.2. Information Channels / Networks

Kemp (1997) reports on Information transfer as taking place through either: -

- personal contacts,
- direct mailing, or
- mass media, print and electronic.

Individuals can either seek information actively or may come across the information accidentally.

This part of the study endeavoured to find out the dominant / preferred channel of information transfer by the sector. The questions posed in **Section 6.1.2** with regard to Information channel / networks were also resolved in this part of the study. These were: -

- what are the dominating channels of information transfer to water and sanitation organisations on the Internet technology?
- what professional / informational networks are the water and sanitation organisations involved in and how they contribute to the available knowledge on the Internet technology

In order to conduct the study on information channels available for transfer of information, a questionnaire was distributed to 213 sector professional who were asked to identify their channels of information supply with regard to: -

- Internet technology, and
- application of the Internet technology in the water and sanitation sectors of developing countries.

Further, the professionals were asked to identify any existing peer networks that they use to acquire information on the Internet technology. These questions are reflected in part B of the questionnaire attached in **Appendix 3**. The questionnaires were self-administered sent to the sector professionals through a website (http://kibata.udw.ac.za/channels), through email, faxes, post office mail.

In the questionnaire, the responders were asked to identify their channel of information transfer on the Internet technology in general and on the Internet technology application in water and sanitation. From the response in the questionnaire,

conclusions could be made as to the diffusion environment as influenced by the channels of information transfer.

6.1.2.3. Credibility of Information Supply

The credibility of the information supply will affect the pace of technology diffusion in water and sanitation and hence the diffusion environment in various ways. However, the potential adopter of the technology will make the decision whether or not to adopt the technology based on the perceived credibility of the information source rather than the actual credibility (Kemp, 1997).

The source of information on a technology can serve as an indicator of the credibility of the information. The other indicator of the credibility of the information source is extent to which the information source is concentrated to one or a few sources.

Kwon and Zmud (1990) report that information transfer is not merely a physical process in which units of information get transferred but also a social process in which the credibility of the supplier matters. Information from knowledgeable friends, independent experts or professional peers is more trustworthy than information from the suppliers of the technology. This assertion is important in defining the diffusion environment for the Internet technology in water and sanitation.

In order to establish the perceived credibility of the information source, questionnaires were sent to water and sanitation professionals (Section C of **Appendix 3**) and they were asked to state the extent to which they consider their source of information on the Internet technology to be credible. Further, analysis were conducted using answers to part A of the questionnaire to determine as to whether there were any overriding factors that would compromise the credibility of the sources of information

6.1.3 Economic and Technical Characteristics of the Technology

The decision to adopt an innovative technology will to a large extent depend on the performance characteristics of the technology as well as the cost of the technology (Mody *et al*, 1992). Generally, the higher the benefits (i.e. superior performance characteristics), the sooner and more often will the technology be purchased. Ideally, the technology has to compete on the basis of performance characteristics as well as costs compared with competing technologies. The cost and benefits in turn are dependent on the purchase price,

operating costs, the performance characteristic as well as the economic life of the technology. The costs consist of: -

- investment costs,
- capital costs,
- installation cost, and
- operating costs.

Whereas the performance characteristics of the Internet technology have been reviewed in **Chapter 2**, the costing and the economic environment has not been defined. This section will conduct studies to define the costing and economic environment, briefly review the performance characteristics and relate the two to the Internet technology diffusion environment definition.

6.1.3.1. Purchase Price

The cost of the Internet technology can be divided between the capital and running costs. Whereas the capital costs are likely to be more or less uniform in the developing countries, the operating costs vary from country to country. **Table 6.2** gives the various cost elements involved in the purchase and operation of the Internet technology.

In order to define the technology diffusion environment from a purchasing price point, survey conducted from selected developing countries was giving the cost of acquiring and running the Internet technology from selected developing countries. The costs were then reduced to the cost of providing **adequate** sanitation at **minimum** level of service per person in peri-urban areas of the given country. Initial assumptions made on the level of service (for the Internet connectivity) were: -

- the organisation had a computer and a telephone line prior to the acquisition of the technology,
- rudimentary computing skills existed in the organisation negating the need for extra training other than that offered by the ISPs.
- the organisations only used the technology for the lowest level of service i.e. a dial up service.

Table 6.2: Typical Cost Elements involved in Purchase and Operation of the Internet Technology and the Corresponding General cost elements (Kibata et al, 1998).

General cost element	Associated Element in the Internet Technology
Investment Costs	Computers
	Training
	LAN Infrastructure
Operating Costs	Modems
	Telephone lines
	ISP connection, eg T1, ISDN etc
	Routers or Switches
Capital Cost	Network Cabling
	Software configuration
	System configuration
Installation Costs	Telecommunications costs
	ISP subscription costs
	Maintenance costs

The selected organisations were then asked to submit the telephone costs, the average monthly subscription cost to the ISPs, the prevailing interest rates as well as the average cost of providing adequate sanitation services to one person in a peri-urban area and minimum level of service. It should be noted that whereas the organisations that submitted the data were reputable organisations, the scientific methods used (for example in averaging out figures) could not be vouched for. However, it was felt that any greater accuracy in data collection was not likely to lead to any significant increase in the reliability of the data. **Table 6.3** gives the results from the survey.

Table 6.3: Results of the Country Cost Survey (1998 costs).

Country	Average Interest Rate (%)	Average annual Subscription to ISP (US $)	Average peak time Phone Charges (US $ / hr)	Average cost of providing adequate sanitation at minimum service level in Peri-urban areas (US $ / person)
Ghana	35	420	0.46	20
India	20	685	0.71	8
Kenya	18	600	3.33	12.35
South Africa	21.0	167	0.70	32
Uganda	19.0	120	1.11	17.7
Zimbabwe	42.5	480	2.55	7.00
Zambia	27.5	480	2.13	11.5

These results were then used to model the diffusion model as influenced by the cost of purchasing and running the technology. It must be emphasised that the costs obtained were only varied for a limited period after the study was conducted in June – July 1998. It is likely that drastic changes occurred in the pricing structure due to 2 factors:-

- entry of new players in the Internet service provision market forced the ISPs to lower their subscription costs, and
- changes in telecommunication legislation allowed for competitors in various counties such as Kenya immediately after the study, thus lowering the telecommunication costs.

It would be desirable to define the technology diffusion environment through an economic environment approach. Such a definition would of necessity look at the

economic impact of diffusion of the Internet technology into the water and sanitation sector. The impact in this regard would be to economics of water and sanitation as well as national and regional economic environment. However, thorough economic environment definition within the context of technology diffusion in water and sanitation is well beyond the scope of this research.

6.1.3.2. Performance Characteristics

Benefits that accrue from the use of a new / innovative technology define the environment within which the technology is being adopted (Kemp, 1998). The benefits in turn are determined by the performance characteristics of the technology. The projected performance characteristics of the Internet technology in water and sanitation have been discussed to a large extent in **Chapters 2** and 3.This section will only make a fleeting mention of these characteristics as well as refine some points raised earlier.

In **Section 4.2.1.1**, the six stages of the known Internet technology adoption were defined. **Table 6.4** is a tabulation of the expected benefits of use of the Internet technology both to the adapter and the customer. The adapter would typically be a water and sanitation organisation while the customer would be communities or even other water and sanitation organisations.

Table 6.4: Benefits related to the Performance Characteristics of the Internet Technology in Water and Sanitation (Kibata *et al*, 1998)

Internet Connection Stage	Performance Characteristics beneficial to the adopter	Performance Characteristics beneficial to the adopter's customer
Home Page	• the organisation is able to advertise its existence to a global audience at negligible cost. • faster and less expensive mode of communication.	• the customer's knowledge of the market players is increased. • more effective means of communicating with the supplier.
Market	• the global audience is	• the customer widens the

Table 6.4: Benefits related to the Performance Characteristics of the Internet Technology in Water and Sanitation (Kibata *et al*, 1998)

Internet Connection Stage	Performance Characteristics beneficial to the adopter	Performance Characteristics beneficial to the adopter's customer
information	informed of the activities presence of the adopter at nominal cost. • the organisation is able to advertise its products and services to a global audience at negligible cost.	scope with the ability to source products or services from a bigger pool of suppliers. • product information is delivered on faster and conveniently.
External Business Application (Internet)	• no obvious benefits. Might feel like replication of operational activities.	• faster and more efficient means of processing orders.
Order Processing	• faster and more efficient means of processing orders. • direct contact between the firm and the customers.	• direct contact between the firm and the customers. • no direct benefit to the customer. However, increase in efficiency may lead to lower costs.
Internal Business Application (Intranet)	• greater co-ordination within the organisation leading to greater efficiency and productivity. • greater transparency in running of the	• no direct benefit to the customer. However, increase in efficiency may lead to lower costs

Table 6.4: Benefits related to the Performance Characteristics of the Internet Technology in Water and Sanitation (Kibata *et al*, 1998)

Internet Connection Stage	Performance Characteristics beneficial to the adopter	Performance Characteristics beneficial to the adopter's customer
	organisation with the ensuing benefits.	
External Business Application (Extranet)	• combines all the benefits of the previous stages and a non-cumulative manner due to resulting synergy.	• combines all the benefits of the previous stages

It is within the context of the benefits of the technology that the technology diffusion environment is defined in terms of performance characteristics of the Internet technology in water and sanitation.

6.1.4 Characteristics of the Adopter Environment

The diffusion process of a technology is influenced by both endogenous and exogenous factors (Kemp, 1997). Whereas the systems of Information transfer and the performance characteristics are endogenous processes, the adapter environment is completely beyond the control of the promoters of the technology hence its categorisation as an exogenous factor.

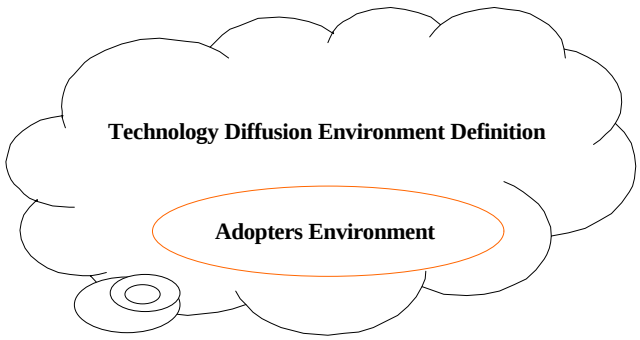

Figure 6.2: The Adopter Environment as an Element in the Technology Diffusion Environment

Factors like legislation and policies are a few examples of the exogenous factors that characterise the adopter environment.

The diffusion speed of a technology and its subsequent level of adoption also depends on the characteristics of the adopter environment such as regulatory policies, fierceness of competition and age of the capital stock (Kemp, 1998). In this way, the adopter environment plays a role in defining the diffusion environment. This may sound confusing but it can be easily visualised in **Figure 6.2** where the adopter environment is just but an element of the overall diffusion environment definition. This is the equivalent of elements used in the systems approach theory.

Policies and regulations also fall under the adopter environment in the diffusion environment definition. In instances where tax and subsidies are used by authorities as regulatory instruments, they fall in this category. The last of the adopter environment factor is the lack / presence of funding for the project that seek to encourage use of the technology (direct intervention) or support organisations that adopt the technology in their operations.

Under this section, the three most important parameters that shape the adopter environment were investigated. These were the government regulatory instruments, societal pressures and availability of funding / financing.

6.1.4.1. Government Regulatory Instruments

For the purposes of the study, four instruments of government intervention were identified as: -

- taxes,
- subsidies,
- legislation, and
- unlegislated policies.

Taxes and subsidies in most instances are used as incentives for enforcing the unlegislated policies.

Government control of the telecommunication sector was also seen as a factor that determines the adopter environment in various (mostly negative) ways. The most common are usually high telecommunication charges and inefficiencies such as long waits for a telephone line. Thus, the adopter environment definition can be conducted by investigating whether the government controls the telecommunications sector or

not. The level of control is also important in this definition. For the purposes of the study, the control was divided into fully controlled, semi-controlled and fully liberalised. Fully controlled was referred to as situations where the telecommunications company was wholly owned by the government and at the same time the government did not allow existence of competing telecommunication companies. Semi-controlled referred to situations whereby the government did not allow the existence of competing telecommunications companies but shared the ownership of the existing company with a private sector, usually a strategic one. This last instance was the case in South Africa where the country's only fixed telephones services provider, Telkoms, was jointly owned by the government (70 % ownership) and a consortium of strategic investors.

In order to define the Internet technology diffusion environment in water and sanitation, it was necessary to identify what instruments of government intervention exist in developing countries. In order to conduct this part of the study, 12 countries in Asia and Africa were surveyed for the presence / absence of instruments of legislation that encourage the use of Internet technology in water and sanitation sectors of these developing countries. The survey was conducted by email only. It involved asking reputable water and sanitation organisations in those countries to explain whether the said instruments are in existence, and if they are, their nature.

The survey aimed to find out whether these instruments existed on a general basis as well i.e. encouraged general acquisition and use of the Internet technology. The judgement of those organisations was thought to be adequate for the purposes of the study.

Table 6.5 summarises the results of the survey on regulatory instruments in the selected developing countries. The table shows the type of regulatory instruments that exist in the countries that were surveyed.

Table 6.5: Results of the Survey on Existing Regulatory Instruments in Selected Developing Countries.

Country	Taxes		Subsidies		Policies		Legislations		Telecommunication Sector
	General	Watsan	General	Watsan	General	Watsan	General	Watsan	
Ghana	n	n	n	n	p	n	p	p	pc
Uganda	n	n	n	n	p	n	p	p	pc
Bangladesh	n	n	n	n	cp	cp	cp	cp	fc
India	n	n	n	n	n	n	n	n	fc
Nepal	n	n	n	n	n	n	n	n	fc
Nigeria	n	n	n	n	n	n	n	n	fc
Burkina Faso	n	n	n	n	n	n	n	n	fc
Kenya	n	n	n	n	r	r	n	n	fc
South Africa	p	n	n	n	p	n	n	n	sc
Philippines	n	n	n	n	n	n	n	n	sc
Zimbabwe	n	n	n	n	n	n	n	n	fc

Legend n- Non Existent; WatSan- Water and Sanitation sector; p – Progressive; pc – private sector controlled; fc – Fully Government controlled; cp – Counter Productive; sc – Semi-Government controlled

The implications of the government instrument matrix presented in **Table 6.4** will be discussed later in the Chapter. However, it suffices to say that the diffusion environment as defined by the adapter's environment does not seem to derive much from the regulatory instruments at the hands of the governments in developing countries.

6.1.4.2. Funding / Financing Sources

The funding and / or financing regime of a particular technology as defined in the adapter environment will ultimately affect the rate of the technology diffusion (Astokov et al, 1990). And as with the credibility of information source (see **Section 6.1.2.3**), the perceived availability is just as important as the actual availability of funding or financing (Cooper and Zmud, 1990) in determining the rate and the extent of diffusion of a particular technology. The reasoning by Cooper and Zmud is that any organisation will make adoption decisions based on their perception of the available sources of funds for the particular technology.

In order to conduct an initial definition of the adopter environment in so far as the sources of funding are concerned, a simple survey was conducted with the multilateral and bilateral donor agencies. 15 donor agencies were asked to comment on their disposition towards projects that would assist water and sanitation in adopting the Internet technology in their operations. **Table 6.6** summarises the results of the donor survey towards the funding of Internet technology in water and sanitation.

Table 6.6: Disposition of Donor Agencies Towards funding of Internet Technology in Water and Sanitation.

Disposition Towards Funding Internet Technology in Water and Sanitation	No of responding organisations	Percentage of the total
Very Positively Disposed	5	33
Positively Disposed	8	53
Negatively Disposed	1	7
Very Negatively Disposed	0	0
Unable to decide / Haven't thought about it	1	7
Total	15	100

The survey was simply conducted by sending email messages to the information section of the donor organisations asking them to identify their organisation's

disposition towards funding the Internet technology in water and sanitation. It is also worth mentioning that all the organisations sampled replied to the questions.

The next step involved gauging the perceptions of the water and sanitation organisations with regard to funding of Internet technology diffusion projects in their organisations. The same procedure as used on the disposition (toward funding Internet technology) survey was followed. The organisations were asked to state whether they believed (and to what extent) that funding for Internet technology was available. 67 organisations doing work in water and sanitation in developing countries were sent emails messages requesting them to state their views on the availability of funding from donors for the Internet technology. **Table 6.7** shows the results of the survey.

Table 6.7: Perception of water and sanitation organisations in developing countries on the availability of funding for Internet Technology.

Organisation's views on availability of funds for Internet Technology.	No of responding organisations	Percentage of the Total
Very Easily Available	0	0
Easily Available	8	22
Available with difficulties	23	61
Not Available at all	5	14
Unable to decide / Haven't thought about it	1	3
Total	37	100

A total of 37 organisations responded to the question translating to a 55 % response rate. The response rate was considered adequate and consistent with the response rate in previous surveys to this particular target group.

6.1.4.3. Societal Pressures

Societal pressures for change in an organisation can be induced in 2 ways: -

- actively through pressure groups advocating for the adoption of a particular technology. The technology could be environmentally benign, ethically, socially or morally acceptable. In such instances, various pressure groups might press for the adoptions of a particular technology emerge. The Green Peace movement is a well-known example that pressurises manufacturer to adopt an environmentally responsible production. Under the circumstances, the manufacturers would be under social pressure to adapt environmentally benign technologies in their operations.

- inactively where it lack of usage of a technology would seem to lack the prestige associated with the particular organisation. For example, one can envisage a situation where organisations might feel compelled to install Internet services because it is prestigious to have an email address and a web site on the Internet.

Although the adoption of the Internet technology is said to have some environmental implications (less paper is used), there are no known environmental action groups that are actively campaigning for the adoption of the technology on the basis of environmental acceptability. Furthermore, little attention is paid (and even less prominence given) to the fact that the adoption of the Internet technology has some minor environmental implications. On the other hand, gauging the presence / absence / extent of inactive social pressures to adapt the Internet technology was beyond the scope of the research. For these reasons, the societal pressure to adapt the Internet technology was not investigated further in so far as the definition of the technology adoption environment was concerned.

6.2. Internet Technology Diffusion study and Modelling in Water and Sanitation.

The aim of the study as stated earlier in **Section 6.0** was, to identify the mechanism through which technology diffuses into the water and sanitation sector and thereby optimise on this mechanism. The study involved: -

- defining parameters that indicate absence / presence and extent of information technology diffusion in the water and sanitation sectors of developing countries.
- identifying impediments to the technology diffusion,
- identifying factors that enhance diffusion of the Internet technology,
- conducting pilot studies to test whether the factors that were identified as either impeding or enhancing Internet technology diffusion were making the contribution and the extent of the contribution.
- optimising on the diffusion of Internet technology in the water and sanitation sectors of developing countries.

In order to carry out the survey for the water and sanitation industry in South Africa, most of the data was gathered from the water and sanitation organisations as well as the Internet service providers.

From the technology diffusion modelling results, one would be in a position to identify the factors that influence the rate of adoption of the new computing paradigm. The diffusion was investigated for both lateral (mere adoption of the technology and probable paradigm shift) and vertical (development of the use of the technology through to all the six stages of the Internet technology as described in **Section 3.2.1.1**).

6.2.1 Modeling Internet Technology Diffusion in Water and Sanitation

Diffusion of the Internet technology in water and sanitation takes place at 2 levels: -

- at organisational level where a given water and sanitation organisation adjust its working methodologies to take advantage of the new or innovative technology (the Internet technology in this case). The *diffusion trajectory* in this case is defined by the extent to which the new technology is incorporated into the organisation's operations. This is the process continuum.
- at sector level where the organisations inculcate a culture of technology (Internet) usage in their partner organisation through various marketing techniques such as selective dissemination of information through electronic media or direct advertisement. The turning point at this level is where the adoption decision is made

and implemented. The technology diffusion trajectory in this case can be defined by the fraction of organisations in the sector / industry adopting the technology.

Thus, the identification of the indicator of the rate as well extents of technology diffusion were identified taking cognisance of the 2 levels that are in existence.

6.2.1.1. Fraction of Technological Replacement (at organisational level)

Astakov *et al* (1990) have identified the fraction of replacement of the existing methodologies with the new or innovative technology as the single most important indicator of extent of technology diffusion at organisational level.

The methodology used in the measuring the fraction replacement by the technology was used measure technology diffusion in coal mining in the former USSR. Marchetti and Nakicenovic (1979), Nakicenovic (1979) and Posch *et a*l (1987) have described details of the methodology. However, the algorithm for parameter estimation will be presented in this section because the one developed earlier was for a different sector.

The substitution of one technology by another in a process can be represented by two S-curves that are asymptotic at the end of maturity of the diffusion process. **Figure 6.3** is a representation of the technology substitution between 2 competing technologies A and B.

In the case of the illustration in **Figure 6.3**, 3 parameters are used to gauge the extent

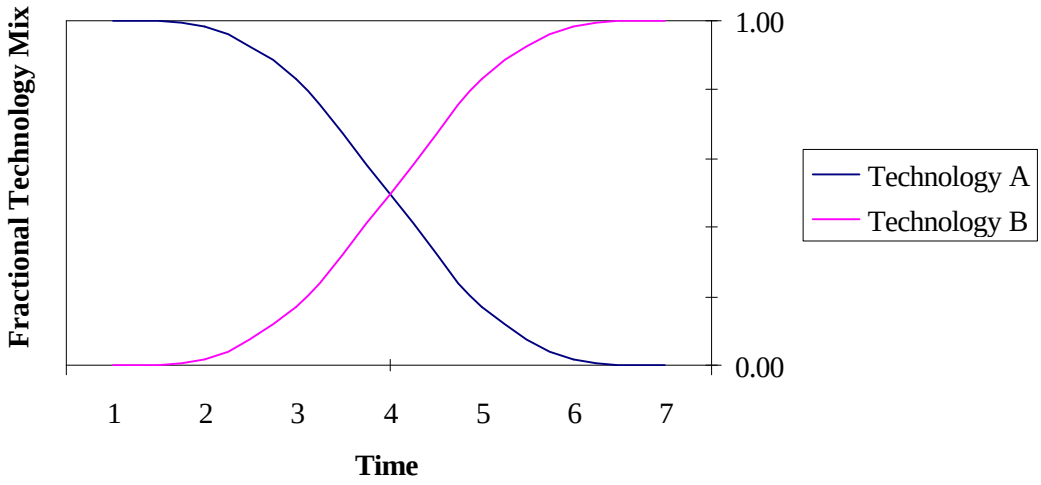

Figure 6.3: Progressive Technology substitution of Technology A by Technology B illustrating technology diffusion

of technology diffusion. These are: -

- the relative amount of time taken by the curves to reach the respective asymptotes,
- speed of conversion of the process from technology A to technology B, and
- the extent of application of the new or innovation technology (technology B in this case) when the diffusion curve becomes asymptotic.

The next step involved identifying tasks that could be quantified using the fractional technology replacement technique.

This process was intensive and a lot of time was necessary in order to obtain any meaningful results. For that reason, only pilot studies were conducted. This involved 5 of the institutions that were mentioned in the **Chapter 5**. **Table 6.8** shows the institutions (as opposed to organisations) with which the studies were conducted and the mission-critical tasks that had the potential to be enhanced through the use of the Internet technology. Please refer to **Chapter 5** for the institutional profiles of the organisations mentioned. The mission statements of these organisations (as well as further information on the organisation) can be reached from their Internet sites shown in **Table 6.8**.

Table 6.7: Mission-critical tasks selected for investigation using the percentage substitution technique.

Institution	Mission-Critical task with potential for substitution
The Mvula Trust www.mvula.co.za	Dissemination of the field experiences of the trust.
National Community Water and Sanitation Training Institute (NCWSTI) www.ccwr.ac.za/ncwsti	Training community leaders drawn from the local authorities on the basics of water and sanitation.
INTERWATER (Formerly WENDY) www.wsscc.org/interwater	Sector Information Dissemination
Water Institute of Southern Africa (WISA), KZN Branch. CWSSD. www.wisa.co.za	Notice of meetings for members.
NETWAS www.nbnet.co.ke/netwas	Training of community leaders in participatory methodologies in water and sanitation.

The following factors were taken into consideration in choosing the tasks to use in the study: -

- the chosen task had to be mission-critical. This was the only criterion that could be cross-cutting and was found to be helpful in ensuring consistency given the diverse nature of the operations of the institutions. The nature of the task (whether it was mission-critical or not) was determined by examining the institution's mission statements as well as the vision together with the tasks under consideration.

- the task had to have some measurable elements in order to be of use to the modelling exercise.

Having identified the measurable mission critical activities, the next task was to identify the measurable element and then conduct the measurements over a certain period of time. From the observations, the long-term trends could be identified.

Table 6.8 describes the procedures used to measure the trends in each of the activities identified in **Table 6.7**.

Table 6.8: Procedure for measuring the percentage technology Substitution for the selected mission-critical tasks.

Institution	Procedure used in the measurement
The Mvula Trust	• dissemination of the field experiences of The Mvula Trust is listed as a key function of the trust in its mission statement. • dissemination is currently conducted using brochures, newsletters and other occasional publications. • measured the number of publications per 2 months that were concurrently released in hard copy and paper format over a 2 year period (between Nov 1996 and Nov 1998). • fractional usage rather than percentage substitution was used to study the trends. Fractional substitution was deemed irrelevant in this respect. • fractional usage was defined as the fraction of total publications that were simultaneously released on the Internet and as hard copies during the two month period in question
National Community Water and Sanitation Training Institute	• training in water and sanitation was identified as a main role of the institution in the government white paper on water and sanitation. This white paper helped establish the

Table 6.8: Procedure for measuring the percentage technology Substitution for the selected mission-critical tasks.

Institution	Procedure used in the measurement
(NCWSTI)	institute. • training of community leaders on water and sanitation is conducted on a block release basis. The leaders are resident at the institute during the training period. • a long term vision in the usage of the Internet was envisaged whereby the institute was to gradually offer all the courses online rather than in residential block release. • fractional technological substitution was defined as the number of courses offered online divided by the total number of the course on offer during the 2 month period in question. Measurements were conducted over a period of 2 years.
INTERWATER (Formerly WENDY)	• INTERWATER was established purposely to disseminate water and sanitation information over the Internet. • every activity on the INTERWATER was hence conducted over the Internet. Thus, INTERWATER had a fractional replacement index of 1 right from inception. • INTERWATER was useful as a benchmark, having achieved 100 % fractional replacement right from inception in October 1995.
Water Institute of Southern Africa (WISA), KZN Branch. CWSSD.	• the institute lists facilitating meeting of its members for purposes of professional exchange of information as one of its objectives. • the regional community water supply and sanitation meets once every month.

Table 6.8: Procedure for measuring the percentage technology Substitution for the selected mission-critical tasks.

Institution	Procedure used in the measurement
	• fraction replacement used was the number of members attending the meeting (over a 2 month period) having received their invitation through the Internet divided by the total number of members attending. • the measurements were taken on a bimonthly basis.
NETWAS	• NETWAS has a mission of improving the living conditions of the poor through capacity building in water and sanitation. • capacity building achieved through training and using various training kits developed by NETWAS. • participatory methodology is on form of training kit developed by NETWAS for community opinion shapers. • NETWAS had a vision of offering the course online. • fractional replacement defined as course participants who registered for the course online divided by the total number of participants over 2 months. • measurements were taken over 2 years.

The results for the fractional replacement tests are presented in **Section 6.3**.

6.2.1.2. Extended SRI test

In **Section 3.2.1.1**, the theory of the shadow-rating index (SRI) was used to assess the quality of information that is held by various sites of the Internet. In this section, the SRI indices will be used as a measure of the rate of diffusion of the Internet technology in water and sanitation.

The shadow rating theory can be further extended as a measure of diffusion. It was proposed that the rate of technological diffusion with the rate of change of the SRI for various Internet sites. **Equation 6.1** illustrates this simple relationship between the diffusion process and the change in the SRI for a given site as well as for the sector in general.

$$\text{Rate of diffusion} \propto \Delta SRI / \Delta Time \qquad \text{.....6.1}$$

The SRI data for 10 selected water and sanitation Internet sites was conducted over 2 years (between Nov 1996 and Nov 1998) on a bimonthly basis. The sites were selected on random basis but taking into cognisance the strict criteria for water and sanitation sites established in **Section 3.2.1.4**. When the first test was conducted in Nov 1996, only 17 sites met the criteria for categorisation as water and sanitation Internet sites. Thus, initial sample coverage of 59 % was obtained, gradually reducing to 16 % at the end of the study period when the total number of qualifying sites increased to 64. From these SRI tests, the overall trends could be obtained with respect to the sector technology diffusion.

However, SRI tests were only indicators of the absolute trends. In for the trends to be meaningful, they had to be contrasted with trends from other sectors.

In **Chapter 3**, the spot SRI values were compared with those from sites in IT sector as well as other disciplines within civil engineering. When the SRI measurements were conducted, the IT industry was found to be far ahead. The full results of the sites tested are attached in **Appendix 4** and analysed in **Section 6.3.2.3**.

6.2.1.3. Number of Citations (Sector Level)

Padoan (1997) suggested the number of citations as a measure of establishing extent of technology diffusion. Padoan had used the number of citations in the patents applications as an indicator of the extent of diffusion of a certain technology. If a technology is represented by a patent A, any subsequent patent applications that build on that technology have to cite patent A, hence the application of the term citation.

In the study of diffusion of the Internet technology in water and sanitation, it would be difficult to cite patents application. This is because all the standards used in the Internet

technology are held in the public domain. It is also probable that given the relative young age of Internet application in general and in water and sanitation in particular, patent applications would be still in their very early age. Padoan (1997) estimates that it takes an average of 18 months for a patent application to be approved. In a way, this is the length of time that the use of the Internet technology in water and sanitation has been in existence.

In Internet technology, 2 parameters that are roughly analogous to patent citations would be: -

- number of sites with links to the particular water and sanitation Internet site. This was monitored over a period of time in order to get an indication of the rate of the diffusion of the technology. This was done using proprietary Internet software package by Digital Communications. The package was run once per 2 months over a period of 24 months between November 1996 and November 1998. This was conducted for the various sites that passed the criteria established in **Section 4.2.1.4** for water and sanitation Internet sites. By the time the monitoring of the sites was been terminated in November 1998, the number of sites that qualified had expanded to 64 sites. This was estimated to be the total number of sites on water and sanitation on the Internet at the reporting time.

- popularity of the site measured by the number of *hits* per given period of time. The test was simply conducted by gathering the Internet site access log from the responsible webmasters during the study period (Nov 1996 – Nov 1998). The procedure involved conducting a global search for water and sanitation sites on the Internet. The webmasters were then approached for assistance with the study. They were asked to submit their access logs on a bi-monthly basis. On the other hand, the global search was repeated every 2 months in order to include any new sites that could have emerged during the intervening period, after which they were invited to join the study.

Whereas the first criterion was easy to measure and investigate, the second one was more challenging. Different sites had different *hit* results. Thus, a measure of central tendency was not possible. Moreover, the hit analysis was complicated by the fact that major search engines frequently accessed the web sites for indexing purposes. The second consideration was lack of potential comparative data for use in the study. The

possibility of using total Internet usage during the study period was considered. However, this was judged unworkable because one would have been comparing the total number of Internet users against total number of access to the water and sanitation sites. A more accurate comparison would have been the total access to all the sites on the Internet against the hits on the water and sanitation sites. This was clearly unrealistic.

Having taken everything into the account, it was concluded that *hit* analysis was not useful for the purposes of the diffusion study. This conclusion goes somewhat against the conventional thinking that attaches a lot of importance to the number of *hits* being recorded on a particular site. This can be partially reconciled when one takes into account the type of technology in use by the commercial sector and the water and sanitation sector.

It became apparent that there was a technology disparity when webmasters from the water and sanitation sites were asked to submit their web access statistics for the purposes of the study. Of the original 15 to whom the request was sent, 9 sent their web access statistics for the 2 year period between Nov 1996 and Nov 1998. Whereas all the web access statistics received used plain log files, the trend in the commercial sector is to use type of files referred to as *cookies*. The *cookies* build a user's profile and helps in a more realistic analysis of the access.

Thus, until such a time when the sector adopts the more advanced cookie technology, web access statistics will not be able to yield meaningful results on the overall site usage.

6.2.1.4. Modified Lakhani Model

The diffusion techniques used in **Section 6.2.1.1 – 6.2.1.3** are useful indicators with potential for use on a large scale. However, it was deemed necessary to develop a technique that will make a point definition of the rate of diffusion. Such a technique would have to have a simple way of calculation the point growth co-efficient while at the same time is adaptable for use with the technology at hand. One such method is based on the Lakhani model. The section will only develop the theoretical model and suggest ways of implementing it. However, the amount of data available cannot accurately be modelled using this model (requires at least 5 years of data) since the technology has been in existence in water and sanitation for about 2 years.

The Lakhani Model (1975) is a deterministic model used to study and model the diffusion (in USA states) of changeover from thermal to catalytic cracking and from catalytic cracking to hydrocracking. The study was conducted to determine whether the diffusion of this technology was socially optimal and whether environmental policy accelerated the growth rate of the adoption. The investigation deployed Gompert function (also referred to as an epidemic model) shown in **equation 6.2**.

$$n_t = N\ a^{\beta t} \qquad \text{.....6.2}$$

where

n_t is the number of organisations adopting the technology at time t,

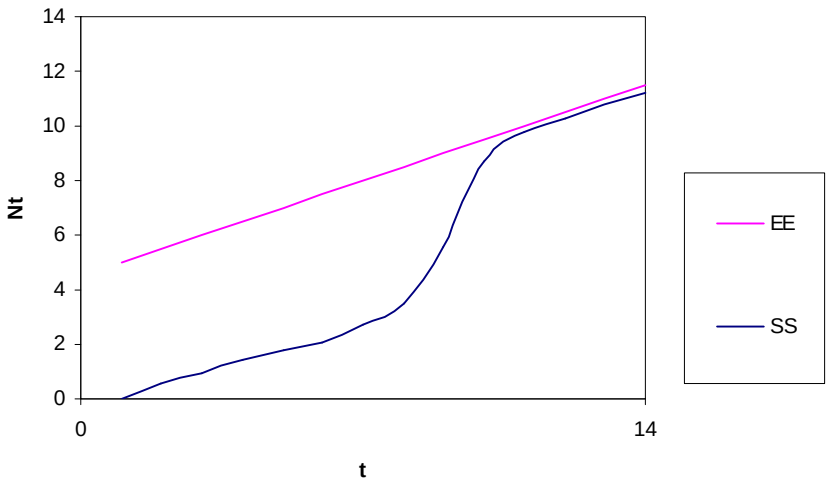

Figure 6.4: Typical Lakhani Model for technology diffusion.

N is the total population of potential adopters.

$a, \beta \in (0, 1)$

In Lakhani's study, the ceiling value N changed constantly. This particular feature of the Lakhani model made it attractive for adoption in the Internet technology diffusion study for the same reason. The most realistic way of estimating the value of N was to

use the INTERWATER guide to water and sanitation organisation. Inclusion in this guide made the organisations automatic candidates for adoption of the Internet technology because submission for listing in the directory had to be submitted electronically. Thus, the ceiling value of N changed for the potential adopters in water and sanitation as the INTERWATER directory grew. This relationship is illustrated in **Figure 6.4**.

Line EE represents the ceiling value of N as t increases. Curve SS is the yield of the N_t value for changing values of N and t.

The results of taking natural log to both sides and substituting N_t for N and replacing ln n with ln n_{t-1}, can be approximated using **Equation 6.3**.

$$\ln(n_t) - \ln(n_{t-1}) = \gamma(\ln(N) - \ln(n_t)) \qquad \text{.....6.3}$$

Where

$$\gamma = \frac{1}{\beta} - 1$$

In this case, γ is the co-efficient of growth rate (interchangeably referred to as the diffusion rate).

It is acknowledged that this method probably understated the value of N. Moreover, the model has various structural weaknesses that were conceded by Lakhani (1975). These weaknesses are well documented by Lakhani (1975) and will not be discussed here. The model also suffers from the usual weaknesses of any other deterministic models. However, but in absence of other alternatives, the method was deemed the best available alternative.

The Lakhani model has been criticised for applying the Gompetz function to study the diffusion of expensive technologies (Kemp, 1998). However, the criticism came with the qualifier that the model could be used to study the diffusion of inexpensive technologies. It has been demonstrated in **Chapter 2** that the Internet technology within the context of water and sanitation can be categorised as an inexpensive technology, thus the applicability in the study of the problem at hand.

The model provides a relatively easy way of determining the growth rate of the Internet technology in water and sanitation. The total population (N) of potential

adopters at a any given time is available from the INTERWATER directory of water and sanitation organisations whereas the number of organisations that have adopted the technology (n_t) can easily be determined using a global search on the Internet.

Data for was collected over 2 years (between Nov 1996 and Nov1998) for values of n_t and N. This data was later used to calculate the value of γ for the entire industry. However, data was hard to come by. For example, when the study was started, the value of n_t was only 16. This had eventually increased to 64 at the end of the study period. It should be pointed out that the values of N and n_t used were subjected to the rigorous criteria as for established in **Section 3.2.1.4** in order to establish whether they qualified.

6.3. Results

The Chapter has so far defined the environment within which the technology diffusion takes place and the suggested some techniques for measuring the actual diffusion at both sectoral and organisational level. This section presents the results from some of the tests in **Sections 6.1** and **6.2**.

6.3.1 The Internet Technology Diffusion Environment in Water and Sanitation

The environment within which the Internet technology diffuses into the water and sanitation sector is pertinent to the rate of diffusion. **Section 6.2** outlined the factors that define this environment as well as the various methodologies used to define the diffusion environment. Principally, the systems of information transfer, economics and technical characteristics of the technology and the characteristics of the adopter environment define the diffusion environment. This sub-section presents the definition of the environment in water and sanitation.

6.3.1.1. System of Information Transfer

Three aspects of the systems of information transfer were investigated. These were: -

- information supply,
- channels of information transfer, and
- credibility of information supply.

These are the factors are the ones that were determined to define the systems of information transfer.

It was mentioned earlier that 213 sector professionals were asked to complete and return the questionnaires by fax, email, post or by directly filing out the questionnaire on an Internet site. Of the 213, there were 114 responses representing a 53.5 % response rate.

With regard to the first question, 59 (52 %) people did not consider their knowledge of the Internet technology to be sufficient enough to make critical decisions regarding Internet application in their organisations. The other 55 (48 %) considered their knowledge to be adequate. One can draw an inference in this respect that there seems to be roughly an equal number of sector professional who consider their knowledge adequate as those who do not consider themselves adequately equipped to make decisions regarding the Internet technology in their organisations.

Table 6.9 summarises the results on sources of information on the Internet technology.

Table 6.9: Results of Survey on the Sources of Information on the Internet Technology in Water and Sanitation.

Source of Information	Percentage of responders using the Source to			
	a very large Extent	a large extent	a little extent	not at all
Internet Service Providers	3	21	63	13
Software Vendors	0	16	61	23
Other WATSAN organisations	0	1	7	92
Independent Consultants	2	91	3	4
Peer Networks	0	3	6	91

Table 6.9: Results of Survey on the Sources of Information on the Internet Technology in Water and Sanitation.

Source of Information	Percentage of responders using the Source to			
	a very large Extent	a large extent	a little extent	not at all
Professional bodies	0	0	2	98
Others	N/A	N/A	N/A	N/A

The survey indicates that the water and sanitation organisations use independent consultants as their predominant source of information on the Internet technology. The level of information supply from Internet service providers was surprisingly low. This means that the water and sanitation organisations do not consider their ISPs to be a useful source of information on the Internet technology. This in turn suggests that the ISPs have not marketed themselves as sources of information (in addition to Internet services) or a breakdown in communication between the ISPs and the organisations.

The other notable observation from the survey results is the low-level interaction between the water and sanitation organisations on the growth of the Internet technology. This apathy is replicated at the professional network / peer networks level. This could be interpreted to mean that the organisations in water and sanitation have not identified the introduction of the Internet technology as a sector issue that required joint effort from the role players.

The questionnaire also attempted to define the technology diffusion environment within the context of the type of information passed on to the water and sanitation organisations from the various information sources. **Table 6.10** shows the results of the information type survey.

Table 6.10: Results of the information type survey

Information type	Number of responders receiving the information type
Cost of Internet Technology	97
Internet Connectivity Strategy	7
The role of the Internet in water and sanitation	2
Emerging issues related to the Internet technology	9
Technical aspects of the Internet technology	56
Others	14

Note: The total number of responses does not (and should not) tally to the total number of responders because individual responders could record more than 1 issue per responder.

The results from the nature of information supply indicate low diversity in the nature of information that is passed on to the water and sanitation organisations. This is despite the fact that the single most important source of information to the organisations in water and sanitation is independent consultants. The role of the Internet in water and sanitation does not seem to gain much recognition either.

The last aspect of information supply that was investigated was the frequency at which the water and sanitation professionals update their knowledge of the Internet technology. **Table 6.11** shows the results of the survey of the frequency.

Table 6.11: Frequency with which Water and Sanitation Professionals update their knowledge of the Internet technology.

Frequency of Knowledge update	No. of professionals updating their knowledge at the given frequency	Percentage of the total

Table 6.11: Frequency with which Water and Sanitation Professionals update their knowledge of the Internet technology.

Frequency of Knowledge update	No. of professionals updating their knowledge at the given frequency	Percentage of the total
Daily	0	0
Weekly	3	3
Monthly	21	19
Bi-monthly	26	23
Quarterly	33	29
> Quarterly	29	26

The results show that more than 74 % of the sector professionals interviewed do update their knowledge of the Internet technology at least on a quarterly basis. It is common knowledge that the Internet technology is evolving at a high speed. However, there were no known studies at the time of reporting that gave indications of the speed at which the Internet technology is fundamentally evolving. However, representations by Tapscott (1998) using stripped timeline on the evolution Internet technology suggests fundamental changes were taking place every six months. The technology is still in its evolutionary stages and one would expect it to stabilise with time. Thus, it can be concluded that the professionals in water and sanitation are updating their knowledge of the technology at a satisfactory pace.

The second part of the questionnaire was designed to define the technology diffusion environment within the context of the predominant channels of information transfer on the Internet technology. This part of the study also defined the channels that the responders would prefer to receive their information on the technology. As it was mentioned in **Section 6.1.2.2**, the responders were asked to indicate their dominant channels of information transfer in order with which they are used (ranking). They were then asked to rank the same channels in order that they would prefer to receive

information on the Internet technology. The results of this part of the survey are presented in **Table 6.12**.

Table 6.12: Average ranking for Channels of Internet technology information transfer to the water and sanitation sector

Transfer Channel	Present average ranking	Preferred average ranking	Percentage difference
Print Media	3.52	4.07	-16
Radio	7.36	7.36	0
Brochures	4.35	3.33	23
Seminars, workshops, etc	6.89	3.97	42
Formal instructions	8.73	7.88	10
Television	6.14	6.93	-13
Internet – WWW	3.29	2.09	36
Internet – email	2.94	1.77	40
Others	8.47	8.50	0

From the survey, the Internet itself (WWW and email), print media and flyers were identified as the main channels within which information on the Internet technology was being transmitted.

The results showed that on average, the responders preferred the less TV and print media as a channel for transfer of information on the Internet technology. On the other hand, all the workshops, email, www, and flyers were cited as channels which the responders would have preferred an increase in the usage. Whereas it is possible to increase the usage of email, flyers and workshops through direct intervention, the WWW would require a different approach. In other words, the bottleneck with regards to email, flyers and workshop is availability (of the information through these

channels). On the other hand information is readily available on the WWW but the problem is user access to the information.

The last aspect of information supply that was investigated was the credibility of information supply in the eyes of the water and sanitation professionals. Having identified the sources of information on the Internet technology to the water and sanitation sector, it was necessary to determine whether those sources were credible and whether they were perceived as such by the users. **Table 6.13** shows the results of the survey on the credibility of the information sources.

Table 6.13: Results of the survey on the credibility of information sources

Information Channel	Number considering the source to be credible	Percentage
Print Media	202	95
Radio	194	91
Brochures	209	98
Seminars, workshops, etc	211	99
Formal instructions	211	99
Television	198	93
Internet – email	202	95
Internet – WWW	204	96

From the results, it can be seen that majority of the responders considered all the information sources (including those with vested interests such as software vendors) to be credible. In terms of the diffusion environment, it means that the credibility of the information source is not likely to influence the diffusion environment.

6.3.1.2. Economics and Technical Characteristics of the Technology

The cost of the adoption of the Internet technology was analysed in terms of the opportunity costs of the adoption. Using the results from **Table 6.3**, the actual cost of

adapting the technology was calculated. The following assumptions were made in the calculations: -

- the life of the technology was 5 years. This is considered reasonable in view of the speed at which fundamentals of the Internet change (Tapscott, 1998).

- the prices will remain stable during the lifetime of the technology. This is a contentious assumption given that the inflation rates in all the countries surveyed was higher than 9 % and going as high 47 % in Zimbabwe. However, this is contradicted by the fact that the cost of the various components of the Internet technology has been going down world-wide (Tapscott, 1998). Thus, this assumption can be considered to be conservative.

- the organisations were logged on for 30 hours a month.

The net present value of the investment was made using **equation 6.4**. This equation assumes a fixed annuity (annual operations cost)

$$\mathrm{PVT} = \frac{\{(1+i)^{N} - 1\}}{i(1+i)^{N}} A \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.4$$

where

PVT is the present value of technology,

A is the annual operating costs of the technology.

N is the useful life of the technology,

i is the prevailing interest rate

Table 6.14 shows the results of the calculations of the present value (cost) of the technology and the opportunity cost of the technology.

Table 6.14: Results of calculation of the opportunity cost of purchasing the Internet.

Country	Present Cost (US $)	Opportunity cost
Ghana	2626	131
India	2341	293
Kenya	4115	333
South Africa	1087	34
Uganda	1240	70
Zimbabwe	7216	1031
Zambia	4201	365

Note: Opportunity cost is the equivalent number of people who can be provided with adequate sanitation at minimum level of service for the cost of the technology within its useful life.

The results of the cost of technology can be visualised using a bar chart in **Figure 6.5**

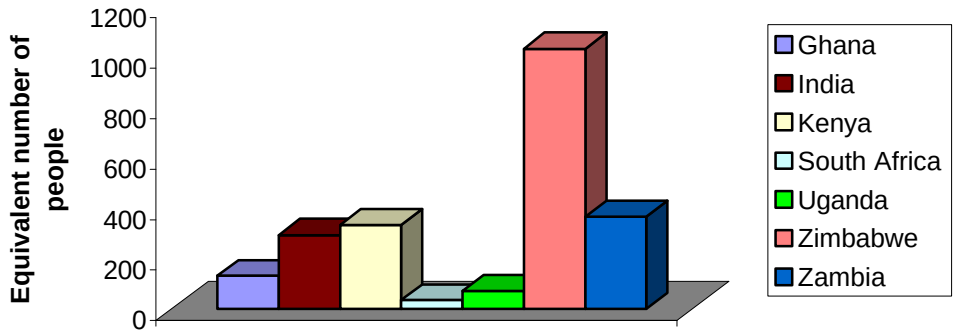

Figure 6.5: Opportunity cost of adapting the Internet technology in water and sanitation

The results of the calculation of the cost of the technology present a dilemma for the managers in water and sanitation. Investing in the technology means that between 34 (South Africa) and 1031 people (Zimbabwe) will forego provision of basic sanitation

services in order to finance the technology. This is a complicated matter for many water and sanitation services.

The results also bring out another unexpected aspect of the technology. It has always been assumed that the cost of adopting the technology ranges from low to mild (Tapscott, 1998). However, the results suggest otherwise. The reason behind this discrepancy is the fact that the costs that are usually being referred to are costs in developed countries rather than developing countries.

The definition of the diffusion environment within the context of the cost of the technology can thus be summarised as that of a technology whose opportunity cost is quite high.

6.3.1.3. Characteristics of the Adopter Environment

The study carried out a survey of the government regulatory articles in operation in a number of 11 developing countries. The articles tested were taxes, subsidies, policies, legislations as well as regulatory regime in existence in the telecommunication sector. The results of the survey are presented in **Section 6.1.4.1**. These results are analysed in **Table 6.15**.

Table 6.15: Government regulatory instruments affecting the Internet technology in developing countries.

Regulatory Instrument	No. of countries with benign approach	Percentage of the total
Taxes	1	9
Subsidies	0	1
Policy	2	18
Legislation	0	0
Telecommunication sector control	4	36

Note: Fully private sector controlled and semi-government controlled telecommunication sectors were considered to be benign.

In addition to the benign regulatory instruments surveyed, it was found that Bangladesh had policies and legislations that discouraged growth of the Internet technology in general and by extension in the water and sanitation sector.

From the results, the adoption environment can be defined as that in which there are little or no government regulatory instruments in developing countries that encourage the diffusion of the Internet technology. Furthermore, in 82 % of the countries surveyed, the government still controls the telecommunication sector, further increasing the cost of adoption. Finally, there was no evidence of government regulatory instruments in force specifically aimed at the water and sanitation sector.

The other aspect of the adoption environment that was studied was the availability of funds for adoption of the Internet technology. The results of the survey revealed an interesting trend. Whereas 88 % of the bilateral and multi-lateral donor agencies surveyed were either very positively disposed or positively disposed towards funding Internet technology in water and sanitation, 75 % of the water and sanitation organisations surveyed did not believe that funding was easily available.

Thus, it can be said that the with regard to funding, the adopters environment is defined by a situation where the recipients are unaware of the disposition of the funding agencies towards funding the Internet technology.

6.3.2 The Technology Diffusion Model Results

Having defined the environment within which the Internet technology in water and sanitation, four approaches was used to model the technology diffusion. Each of the methods was aimed at modelling specific aspects of the technology diffusion. Technological fractional replacement test was aimed at gauging the extent of diffusion of the Internet technology in water and sanitation. The extended SRI test also modelled the extent of technology diffusion in the selected organisations using an approach slightly different from the one used in the fractional technology replacement test. The number of citations was a test targeted at the intra-sectoral diffusion process. Lastly, the modified Lakhani model was used to generate point indicators of the diffusion rate.

6.3.2.1. Fractional Technological Replacement

The procedure for data collection using this technique was described in **Section 6.2.1.1**. The detailed results are appended in **Appendix 5**. Five institutions were used

in the study. INTERWATER was used as a benchmark in this case, having attained a fractional technological replacement of 1 right from inception. When the calculations were conducted, it was noticed that it was not possible to get a meaningful trend from month-on-month technological replacement indices. Thus, a new index (referred to as the cumulative technological replacement index, CTRI) was introduced. This index was simply calculated by dividing the cumulative total number of publications simultaneously published on the Internet by the cumulative total number of publications, beginning November 1996. The new index did not change the gist of the presentation but merely improved on the differentiation of the trend.

Figure 6.5 shows the graphical representation for the institutions used in the study.

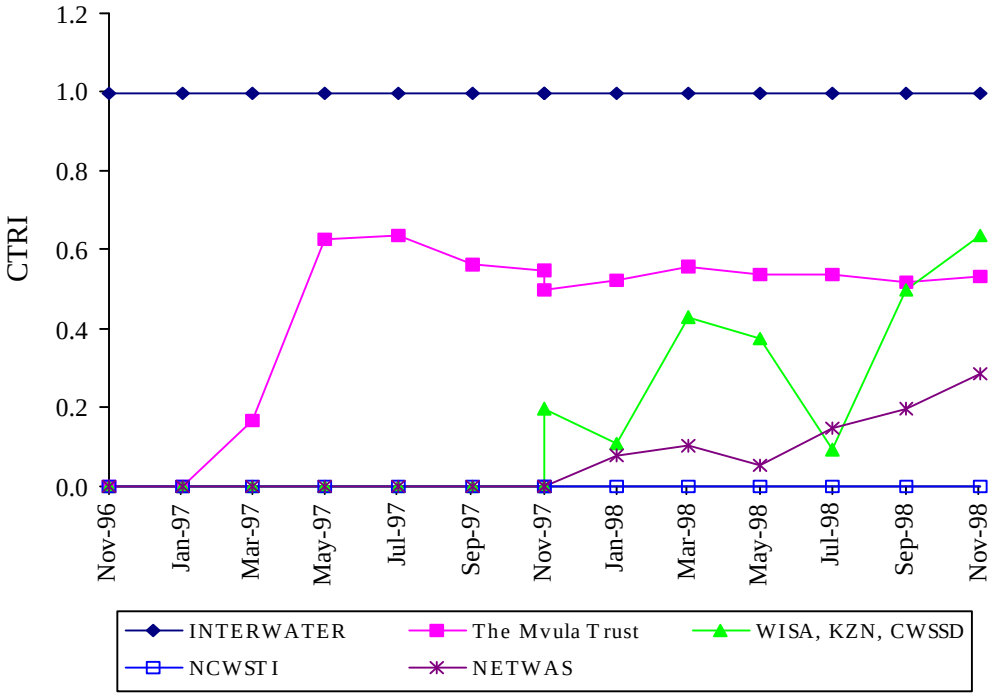

Figure 6.6: Graphs showing the results of the fractional technology replacement technique in technology diffusion

The trend-lines for the community water supply and sanitation division (CWSSD) of the water institute of Southern Africa (WISA), KwaZulu Natal Branch (KZN) is somehow distorted by the fact that that the data used contained attendance for the AM which is held in July. The division members as well as representatives usually attend the AGM from the communities. The community representatives do not have access to

the Internet and thus, the FRI is somewhat depressed in the month of July for both years.

With the exception of the National Community Water and Sanitation Training Institute, all the other institutions showed an upward trend in their fractional technology replacement. However, there was an indication that the upward trend was flattening out for the Mvula Trust at a FTRI of about 0.5, well below the maximum of 1. This could possibly mean that the trust had reached a ceiling in Internet development within the confines of the information supply available to the organisation. This technique can thus be used as a useful indicator on the need for Intervention in order to encourage Internet development. This can possibly be achieved through increased exposure to more information on the part of the water and sanitation organisation in question.

The technique clearly set out the point, which organisations ought to target for their planning in Internet development. However, it gives no indication of the rate at which the diffusion process is desirable. The technique has other potential applications when investigating the effects of various conditions on the diffusion process. More will be discussed in **Section 6.3** and **Section 6.4**.

Several questions can be raised about the methodology adopted in this technique. For example, how representative were the mission-critical tasks chosen in the sampling? Are these tasks a fair representation of the overall operations of the organisation and its diffusion trends? It was recommended that these questions be answered in a study will extend the current study.

6.3.2.2. Extended SRI Method

The extended SRI method gives a snapshot of the industry-wide trend. Whereas it is limited in terms of the information it produces, the technique is useful for policy makers. The results from the survey are represented in a graph in **Figure 6.6**. Detailed results and calculations are presented in **Appendix 4.**

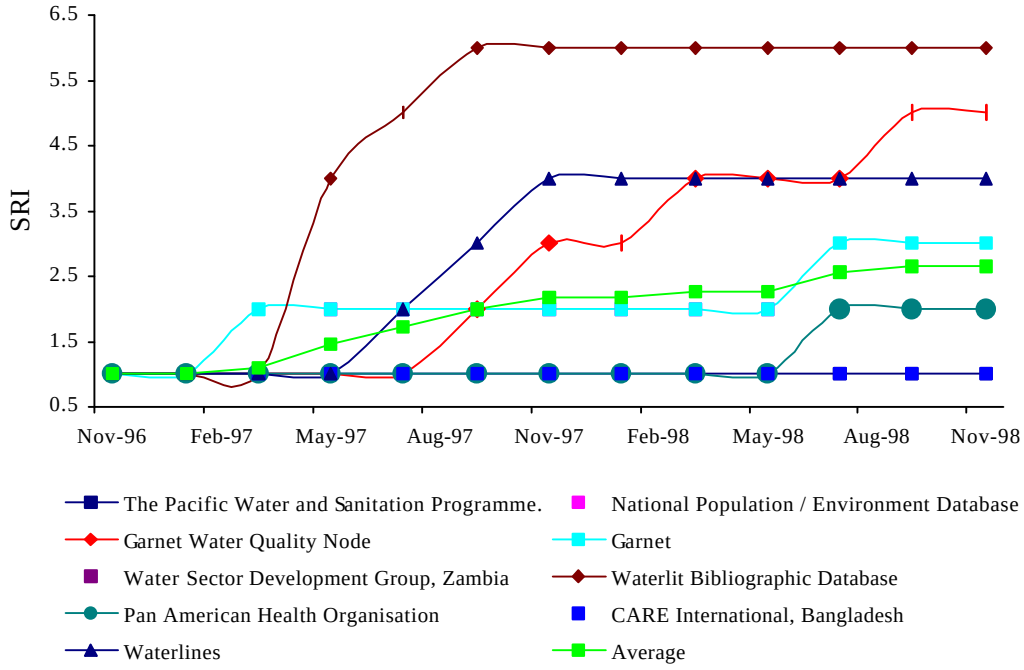

Figure 6.7: Plot of the results of the extended SRI test for technology diffusion

The trend-lines from the graph show that the rate of diffusion measured using the extended SRI method varies from organisation to organisation. Similar results in this aspect were obtained using the fractional technology replacement technique.

The overall average trend was upward.

The technique had limitations that were similar to the ones observed with the fractional technology replacement test i.e. it only gave a targeted SRI value but no indication of the desirable or attainable diffusion rate.

6.3.2.3. Number of Citations

Listings of the full results are attached in **Appendix 6**. As imentioned in **Section 6.3.2.2**, only 16 sites met the criteria for inclusion as water and sanitation sites at the beginning of the study period in November 1996. Thus, these original sites were used in the citations approach to technology diffusion.

The number of sites with links to the original 16 sites was monitored over a period of 2 years. The trends were then tabulated and plotted in the **Figure 6.7**. The data was divided between the upper quartile and lower quartile as well as the overall average

number of links. It was possible to average out the number of links from each individual site because all Internet sites have equal chances of attracting links.

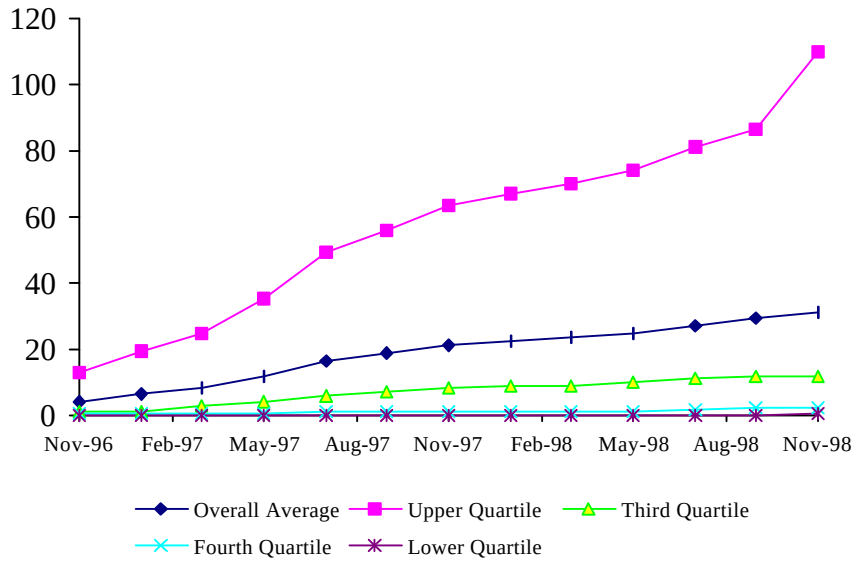

Figure 6.8: A plot of the number of sites linked to the water and sanitation sites during the study period

From **Figure 6.7**, it can be seen that results from the citations approach are consistent with the other methods i.e. modified SRI and fractional technology replacement methods. They show an upward average trend in the number of Internet sites that are linked to the water and sanitation sites. The method does not make a link between the rate of diffusion and the various factors that affect the rate of diffusion. The method does not give an indication of a desirable rate of diffusion either.

6.3.2.4. Modified Lakhani Model

The theoretical basis of the modified Lakhani model was laid out in **Section 6.2.1.4**.

Equation 6.3 can be modified to yield **Equation 6.5**.

$$\text{Ln}\frac{n_t}{n_{t-1}} = \gamma[\text{Ln } N - \text{Ln } n_t] \qquad \text{……..6.5}$$

It was thus reasoned that a plot of Ln n_t/n_{t-1} against (Ln N - Ln n_{t-1}) would give a straight line with gradient γ.

The results of data collection are shown in **Table 6.16**.

Table 6.16: Results of the data survey on the number of actual and potential adopters

Month	N	n_t	n_{t-1}	Ln n_t/n_{t-1}	Ln N – Ln n_t
Sep 96	56	15	-	-	-
Nov 96	61	16	15	0.065	1.34
Jan 97	72	16	16	0.000	1.50
Mar 97	87	17	16	0.061	1.63
May 97	102	18	17	0.057	1.73
Jly 97	121	20	18	0.105	1.80
Sep 97	154	21	20	0.049	1.99
Nov 97	187	22	21	0.047	2.14
Jan 98	198	25	22	0.128	2.07
Mar 98	231	27	25	0.077	2.15
May 98	254	34	27	0.231	2.01
Jly 98	287	43	34	0.235	1.90
Sep 98	303	50	43	0.151	1.80
Nov 98	342	64	50	0.247	1.68

As was pointed out, the data available was not enough to accurately construct a modified Lakhani model for the diffusion of the Internet technology.

From the data, a plot was made of a plot of Ln n_t/n_{t-1} against (Ln N - Ln n_{t-1}). From the plot, various trend-lines were added to test whether any degree of co-relation existed between the two values as suggested by the Lakhani model. These were linear, exponential and polynomial (using order 2, 3, 4, 5 and 6).

Figure 6.8 shows the plot of the series as well as the some trend lines.

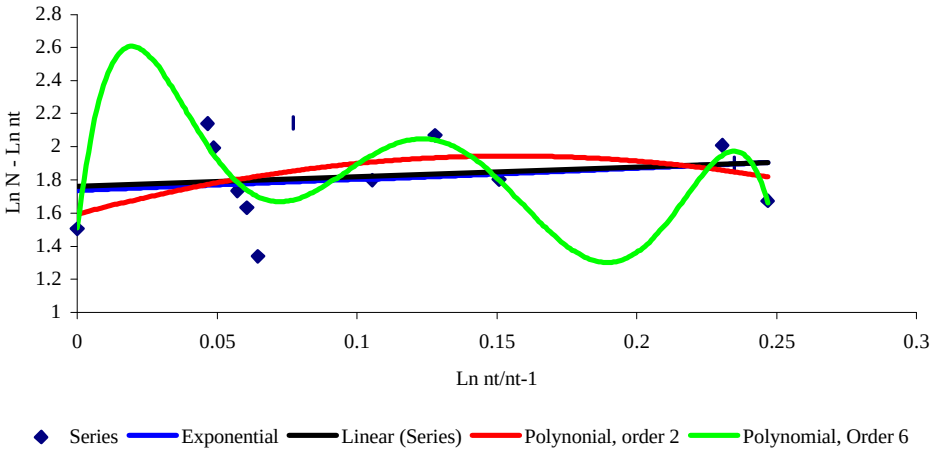

Figure 6.9: A plot of Ln n_t/n_{t-1} against Ln N –Ln n_t

From the values, R^2 values from the trend-lines were calculated. A very poor fit was obtained using linear trend-lines contrary to the predictions by the Lakhani model. **Table 6.17** shows the various values of R^2 obtained using the various types of trend-lines.

Table 6.17: A plot of R and R^2 values for the various types of trend-lines

Type of Trend-line	R^2	R
Linear	0.0354	0.1881
Polynomial (order 2)	0.1283	0.3582
Polynomial (order 3)	0.1290	0.3592
Polynomial (order 4)	0.2072	0.4552
Polynomial (order 4)	0.2101	0.4584
Polynomial (order 6)	0.4391	0.6626
Exponential	0.0459	0.2142

From the results, one can deduce that the Lakhani model is not suited for use in the technology diffusion studies. This could be for many reasons. These are the ones suggested: -

- inadequate data,
- it may be probable that the diffusion of the Internet technology does not follow the epidemic Gompetz function. If this is indeed the case, there is a need for search for a more appropriate model. In order to arrive at this conclusion, it is necessary that more data be collected.

It is thus recommended that in future, the model be subjected to testing using more comprehensive data than is currently available, after which a decision as to suitability can be made.

6.4. Qualitative Analysis of the Factors affecting the Diffusion Process

The study has thus far defined the diffusion environment within which the technology diffusion is taking place. The diffusion modelling has been also been conducted using 4 approaches. 3 of the 4 approaches were found to be reliable. The fourth approach was inconclusive probably due to inadequate data. However, the models could not draw correlation between the factors that influence diffusion and the diffusion process itself. A qualitative approach was thus suggested.

This section will thus conduct a qualitative analysis of factors that are known to either impede or enhance the rate of technology diffusion and their likely effect on the Internet technology.

Various approaches to identifying constraints to technology diffusion have been suggested. Principally, the approach by Kwon and Zmud (1987) seems to be widely accepted and recognised. Kwon and Zmud categorised IT technology diffusion process research as: -

- factors research,
- process research, and
- political research.

Factors research focuses upon a variety of individual, organisational and technological forces, which are important to the effectiveness of IT, implementation. The factors that were found to have a significant influence were: -

- top management support of the implementation,
- good IT design,

- appropriate user designer interaction and understanding.

On the other hand, process research examines social change process and suggests that implementation success occur when: -

- commitment to change and the implementation effort exists,
- extensive project definition and planning occurs, and
- management of the process is guided by the organisational change theory.

Seen within the context of Internet in water and sanitation, Kwon and Zmud (1987) suggest that successful diffusion of the Internet technology depends on the ability of the organisations involved to see the Internet as an integral part of their operations and plan accordingly.

Political research recognises that the diverse vested interests of the stakeholders affect the implementation and the consequent diffusion of the IT (Internet) technology. Thus, successful diffusion would depend on recognising and managing those interests (Cooper and Zmud, 1990). However, investigation of the political research was well beyond the scope of the research and was not carried further.

6.4.1 Organisation's Capacity to absorb new Technology

Effective use of IT in general and Internet technology in particular requires much more than the introduction of the computing infrastructure and software (Tapscott, 1997). It requires profound transformation in the internal organisation of the firm and its inter-connection with the market and suppliers. The successful absorption of Internet technology thus requires not just technical capabilities but also effective planning and organisational capability i.e. good managerial skills and entrepreneurship. Hanna and Boyson (1993) also share this concern.

6.4.2 Cost of Technology Diffusion and availability of Finance

From the diffusion environment definition (**Section 6.1**), it was found out that the opportunity cost of adopting the Internet technology for water and sanitation is quite high. Water and sanitation organisations are likely to have moral (and management) dilemma in making the decision to adopt the technology at the cost of provision of basic water and sanitation services. That leaves the external financing as the only other available source.

The diffusion environment definition revealed an environment where the donors are willing to fund the projects and recipients whose perceptions are that the funds are not available.

Hanna *et al* (1995) report that the classical theory of demand and supply equally apply to the diffusion process of information technology i.e. the pace of diffusion will be dictated by the price of the technology. It can thus be expected that the pace will pick up as prices continue to drop.

6.4.3 Regional Opportunities and Constraints

Padoan (1997) has alluded to a fact that technology accumulation and diffusion has a regional dimension. With regard to Internet technology in water and sanitation, the regional dimension would affect technology diffusion at 2 levels: -

- Internet technology requires a functional telecommunication infrastructure in order for it to perform at optimum levels (Erberg, 1994). However, telecommunication infrastructure in developing countries tends to develop piecemeal as opposed to regionally. This could well be a constraint to diffusion and accumulation of the Internet technology in water and sanitation.

- policy with regard to both telecommunication and Internet technology is uncoordinated in some instances across a region. This has the potential to disrupt any diffusion of the Internet technology.

It is also possible for the regional dimension in technology diffusion to enhance diffusion of the Internet technology in water and sanitation. This would be the case if the regional synergies were effectively used to enhance the diffusion process.

6.4.4 Awareness of technical information and potential benefits of increased use IT technology in general and Internet in particular

McFarland (1992) cites lack of awareness of the benefits in improved use of information technology as the single most important factor that serves as an impediment to diffusion of the IT technology in both developed and developing countries. Seen in the context of water and sanitation in developing countries, the factors cited by Mcfarland had to be tested further. **Table 6.18** summarises the result of the most widely cited factors that were though to be responsible for impeding the pace of technology diffusion in developed countries.

Table 6.18: Most frequently cited factors that impede IT technology diffusion in developed countries (McFarland, 1992).

Factor	% age of the sample cited
Lack of organisation Co-ordination	100
Lack of management support	94
Training - Understanding of the Technology	62
Availability of Staffing / Recruitment	50

These results were derived from 16 pilot projects. The researchers analysed results from these studies for the factors that were cited as obstacles to technology diffusion. Thus, the figures in the second column of **Table 6.18** are the percentage of the studies, which cited the given factor as an obstacle to technology diffusion.

Hanna *et al* report that lack of awareness is particularly true of small and medium-sized enterprises. This makes out a strong case for testing lack of awareness as an obstacle towards technology diffusion given that majority of organisations in water and sanitation can be classified as SMEs (Seregeldin, 1995).

6.4.5 Human Capital

Choudhury *et al* (1998) report human capital as the most likely bottleneck in the development of Information technology. This assertion is supported elsewhere by Tapscott (1998) and Allaire *et al* (1995). Thus more than anywhere else, the diffusion of information technology is very likely to be influenced by availability of highly skilled human resources.

Other reasons that render the diffusion of IT technology (and Internet technology in particular) susceptible to the existing level of human skills have been put by Lall (1987) as: -

- the acquisition of a new technology requires a basic knowledge in order to evaluate the various technological options available. This will necessitate a search for an appropriate supplier, procure appropriate system configurations as well as enter into acceptable service contracts.

- any transfer of technology requires various levels of modification in order to suit local conditions. Furthermore, different countries have different engineering standards and any cross-border transfer of technology requires some level of re-engineering in order to suit local standards.

- minor process changes on the part of the adopter may at times lead to savings in say energy consumption or increased productivity on the part of the adopter.

The skills are at times unavailable and especially so in developing countries (Rosenberg, 1985). In this way, the initial decision to adopter will be put off until the adopting management is confident of the availability of the necessary skills.

6.4.6 Research and Development

Gambardella (1992) argues that scientific knowledge generated by academia and other public domain knowledge organisations is not as freely available as is the common perception. The organisation in question has to invest in research and development in order to take full advantage of this kind of science.

Cohen and Levinthal (1990) separate research and development into 2 forms: -

- research and development as a direct input to innovation, and

- research and development as a means of absorbing external knowledge.

Similarly, Pavitt (1991) suggests that research provide skills, methods and professional contacts necessary in order for an organisation to exploit external technical findings.

Research has generally been traditionally associated with generation (of technology) rather than diffusion (Hanna *et al*, 1995). However, the realisation that research and development consists of 2 forms leads to conclusion that indeed the level of research and development in an organisation does affect the pace of technological diffusion.

6.4.7 Co-ordination Between Water and Sanitation Organisations and Knowledge Institutions

Hanna *et al* (1995) report that innovation is an interactive process and its success depends not only on the quality of its elements but on the synergy among them as well. However, this

synergy comes at a cost. One such synergy can be built around knowledge institutions in water and sanitation and service providers.

The potential for synergy borne of increased co-ordination can be seen in the context of other sectors. One example is the health sector where medical organisations run an Internet based information services (Healthnet) for use by the medical professionals. Invariably, the medical professionals are inclined to trust one their professional peers and hence improve on the chances of adopting the technology.

Within the water and sanitation sector, INTERWATER was an effort to increase the co-ordination between the water and sanitation organisations and thereby improve on the rate of diffusion. The impact of INTERWATER on the diffusion process has not yet been quantified.

6.5. Optimising Internet Technology Diffusion

What is the desirable rate of Internet technology diffusion in water and sanitation? The Chapter has so far been investigating the rate at which the Internet technology is being adopted and diffusing in water and sanitation as well as the issues surrounding the diffusion process. However, the overriding question is whether the diffusion process was found to be acceptable. If it was not, how can the process be positively influenced? Thus, there is a need to optimise the diffusion process in view of the findings of the previous sections in the chapter.

The four techniques that were developed had 2 limitations: -

- the techniques did not bring out the desirable rate of diffusion. However, these techniques gave a good indication of the trends that were associated with the Internet technology diffusion in the water and sanitation.

- a clear mathematical relationship between the factors influencing the rate of diffusion (identified in **Section 6.4**) and the actual rate of diffusion. This is probably a criticism of the whole process rather than the development of the techniques. In essence, if a satisfactory method for measuring these factors were developed, then it would be possible to quantify the effect of the various factors on the diffusion process. However, the fundamentals of the techniques would not be changed. The techniques would be complementary.

So, if the techniques developed were not able to make a connection between the rate of the Internet technology diffusion on one hand and the technology diffusion environment as well as

the individual factors in the diffusion environment, what value does it add to the understanding of the subject? This question can be answered in light of the fact that 4 independent techniques were developed for gauging the rate of diffusion. Of the techniques, 3 gave results that were similar. The fourth one (modified Lakhani) was not completed due to unavailability of data. Thus, a measure of confidence could be assigned to the workings of the techniques.

The need to optimise on the diffusion of technology has been brought out in the study as well as the results. However, the data available is not enough to conduct an optimisation of the diffusion. This can be seen in the fact that there were only 16 Internet sites (on water and sanitation) that had more than 2 years of data. On the other hand, the study had identified 9 factors that have been cited in other studies as impacting on the rate of technology diffusion. Any attempt at optimisation under the circumstances would have thus been futile. However, there is evidence from other studies on various factors that either enable or hinder the diffusion of technology in general (see **Section 6.4**). There is a case for extending these results to the water and sanitation industry.

Chapter 7: Conclusions

This chapter summarises the conclusions that can be made from the research conducted in the thesis. From **Section 1.4**, the research objectives had been stated as: -

- to develop a model for Internet based communication in the water and sanitation sectors of developing countries,
- to investigate and determine whether the Internet is a useful tool for retrieval and dissemination of information in water and sanitation sectors of developing countries.
- to identify the information needs of water and sanitation sectors of developing countries and develop strategies of improvement of delivery of these services through enhanced communication based on the Internet,
- to develop a management regime for an Internet based information network for water and sanitation so as to avail information efficiently and in a manner useful to engineers,
- to compare the inherent perceptions of the stakeholders in water and sanitation on the various sources of information pertinent to their operations, including the Internet, and
- to investigate the rate of diffusion of the Internet technology into the water and sanitation sector and develop an appropriate model to optimise the rate of diffusion.

These objectives are to be seen within the overall research goal, which was to improve on delivery of services in the water and sanitation sectors of developing countries. This goal was to be achieved taking cognisance of the recent paradigm shifts that have taken place in mode of water supply and sanitation in developing countries as well as developments in the information technology and the Internet.

The research conclusions were drawn into state of the water and sanitation sector with regard to the Internet technology. Conclusions are also made on the sector information needs that can be addressed using the Internet technology, statement of best practices as well as conclusions as to

the diffusion of the Internet technology in the water and sanitation sectors of developing countries. A section is also included on the products (tangibles) from the research.

7.1. The research and the overall research goal

From the research, it has been demonstrated that the water and sanitation sector in developing countries is bogged down by many problems. Principally, there are: -

- low level of funding in the sector,
- rising costs in provision of water and sanitation services,
- rising population that is increasing the water and sanitation backlogs, and
- reduction in quantities of economically available water resources due to over-exploitation and deteriorating quality due to environmental degradation.

A new technology (the Internet) has been successfully applied in the commercial sector to improve productivity and reduce the operation costs. The research modelled the effects of introducing the technology from four perspectives. These were: -

- user information needs as well as availability,
- user disposition towards changes in working methodologies that incorporate the new paradigms in computing and Internet technology,
- case studies outlining best practices, and
- Internet technology diffusion in the water and sanitation sector.

The research demonstrated 3 principal objectives in introducing the Internet technology in water and sanitation: -

- lowering of costs,
- greater efficiency in information and technology transfer, and
- ultimately, higher rate of service delivery in the sector.

From the research, it can be deduced that the Internet technology has the potential to achieve all the 3 objectives and ultimately meet the research goal of improving on the delivery of services in water and sanitation.

7.2. The State of the Water and Sanitation Sector.

The research findings indicate that the water and sanitation sector is likely to be dominated by 2 changes that are taking place. These are: -

- the paradigm shift in the philosophy of provision of water and sanitation services, and
- the advances in information technology and in particular the Internet that have taken place from mid 1990s onwards.

The effect of the first change has been increased uncertainty as service providers embarked on a learning curve. Incidental to the operations in this learning curve was increased costs of service provision. Furthermore, when new evidence to support different approaches came to light, the sector found itself unable to respond fast enough to realise significant gains given the moribund information systems in place.

In the meantime, another revolution within the information technology sector was taking place. Institutions in the commercial sector had realised increase in productivity through innovative use of the information technology. Evidence from the research shows that the gains made in the commercial stream have not permeated into water and sanitation sector in appreciable quantities. However, the research shows that there is evidence to support the theory that the gains in the commercial sector triggered by advances in information technology can be translated into enhanced service delivery in water and sanitation. The research further identifies the opportunities for harnessing the power of information technology (the Internet) in water and sanitation.

7.3. Sector Information Needs

The research identified the various information needs of the water and sanitation sector. Based on the realisation that the sector needs an efficient system of transferring sector information (in view of the dynamics pointed out in **Section 7.3**), the research focussed on distribution of sector information as one area in which the Internet could make a significant contribution in enhancing

delivery of services. To this end, the research identified information type that the sector role wished to have on the Internet immediately, in the medium and long term.

The research revealed that sector players are mainly interested in information that impacts directly on their line of work. Conclusions could be drawn that the sector professionals are interested in improving their productivity through enhanced use of the Internet. It is expected that this can in turn translate into a more effective delivery of services. In the long run, the sector professionals are interested in using the Internet to improve on their knowledge of the sector, technically and institutionally.

A survey of the Internet as constituted at the time of research revealed that the sector information needs are not adequately addressed. Thus, in order to reconcile the sector expectations with the potential of the Internet technology, some intervention is necessary.

7.4. Statement of Best Practices

The research revealed some best practices that were seen as responsible for optimum usage of Internet connectivity. These are: -

- the organisation seeking to use the Internet in its operation has to have a clear vision as well as a connectivity plan. Furthermore, the vision has to take cognisance of the fluid nature of the dynamics involved in the Internet technology and plan accordingly.

- the Internet should be seen as a tool for enhancing productivity rather than a capital expenditure. In this way faster (and hence more productive engagement) integration of the Internet in the organisations operations is achieved.

- training is essential for higher productivity. However, given the nature of scarcity of suitably qualified manpower in IT and the demand for the skills, water and sanitation organisations have to draw up strategies for retaining the skills so trained within the organisation as well as the sector.

- high level commitment is essential to success of any IT connectivity strategy. The financial implications might not justify high-level participation at times. Nevertheless, it is important that the participation takes place given the potential of

the Internet technology, market dynamism as well as the novelty, which requires careful guidance in implementation.

- good IT design helps facilitate smoother use interaction. This ultimately has a positive effect on the probability of success of the Internet technology adoption by water and sanitation organisations.

- appropriate user designer interaction and understanding helps to stimulate interest in the activities of the water and sanitation organisation. Seen from a worker's perspective, a well-designed interface reduces time spent in forming a relationship with the Internet technology.

7.5. Human Behaviour in Technology Choice

The research developed 2 modelling techniques to predict the disposition of the actor in water and sanitation towards the changes necessary in order to take advantage of the potentials offered by the Internet. The Research found out that there was no clear bias towards any particular mode of information provision despite the advantages afforded by the Internet. The results make out a case for intervention and at the same time offer tools for monitoring the success of intervention measures adapted in the form of the modelling techniques developed.

From the results of the models, it can be seen that implementation of sustainable Internet connectivity program is likely to be wrought with resistance hence a case for advocacy.

7.6. Diffusion of the Internet Technology in Water and Sanitation.

The research investigated 2 aspects of diffusion of the Internet technology in water and sanitation. These were: -

- the environment within which the Internet technology was supposed to diffuse into the water and sanitation sector, and

- the rate of diffusion of the Internet technology in water and sanitation.

The research, having considered the various factors that define the technology diffusion environment concluded that the diffusion environment was conducive to diffusion of the Internet technology in water and sanitation. However, the study of the rate of diffusion revealed that the rate of diffusion was not satisfactory.

The following were identified as mechanisms that affect the technology diffusion in water and sanitation: -

- organisation's capacity to absorb new technology influences the rate of Internet technology diffusion in that before the decision to adopt is made, the organisation has to have adequate knowledge of the technology,
- the cost of the technology and availability of finance have a bearing on the rate of diffusion,
- government regulation of the telecommunication industry is likely to hinder the technology diffusion,
- level of prevailing IT skills in a water and sanitation organisation influence the rate of diffusion,
- co-ordination between water and sanitation organisations enhances the rate of technology diffusion, and
- research and development expenditure in water and sanitation organisations is likely to increase the probability of adoption.

Despite the conducive technology diffusion environment identified, the research nevertheless identified legacy information systems (manual) in existence that may not be responsive to the changing dynamics in provision of water and sanitation services.

In the diffusion studies, various tools for gauging the diffusion rate were developed.

7.7. Research Products

The following products were produced by the research: -

- an expert system coded in the computer program, SHADOWRATING, used to systematically rate the level of Internet development of a particular water and sanitation organisation's Internet site and by extension the organisation's level of Internet development. This expert system can be used by organisations in water and sanitation for monitoring and evaluation of their Internet application development programmes.

- the research developed algorithms (Asthana and MCOM utility model) for gauging the disposition of the role players in water and sanitation towards electronic publishing. This is a useful tool that can be used to monitor the success of intervention measures in terms of advocacy programmes aimed at increasing the usage of the Internet in the sector.

- the research developed algorithms for use in testing the quality of information contained in a particular water and sanitation Internet site. This was developed based on some observed relationships between the quality of information on a particular site and other quantifiable behaviours of the site. The algorithms were tested and confirmed to hold true in the research.

- from the laws of statistical probabilities, simple methodologies for testing the quantity of sector information on the Internet using indicators were developed. The indicators were used to benchmark the quantity development of water and sanitation information of the Internet for such studies in the future as well as for use in monitoring Internet development in the sector.

- With regards to technology diffusion, the research created four approaches to modelling of the rate of diffusion in the sector. In two of the approaches, the research was able to benchmark the processes for use in future studies of similar kind.

- The research also produced a technique for determining when Intervention is necessary in order to encourage Internet growth in an organisation. This technique was demonstrated using the fractional technology replacement model that was developed in course of the study.

7.8. Scope for further Research

The research is a pioneer study in its area. As is expected of pioneer research, more questions are asked than are answered. Thus the study identified several areas with potential for further researchs. These are: -

- the technology diffusion modelling using the fractional technology replacement technique could not adequately come up with criteria for identification of tasks that are representative of an organisation's operations. Furthermore, the technique only

identified the targeted FTR index but failed to identify the desirable diffusion rate. This provides an opportunity for widening the scope of the study.

- none of the technology diffusion models were able to make a distinct connection between the various factors that are known to affect the rate of technological diffusion. Thus, scope exists for expanding the study to make the connection and ultimately to quantitatively optimise the technology diffusion.

- the study of human behaviour in technology change showed that there was no clear inclination towards any of the modes of information provision. However, it is believed that the situation will change with time. It is important to revisit this study from time to time for monitoring purposes.

- the need analysis produced a technique for measuring the quality of water and sanitation Internet site. Further development and standardisation of the technique can be conducted as an extension to the study.

Chapter 8: Recommendations

The research came up with various findings on the state of Internet usage in water and sanitation. These findings are presented in **Chapter 7**. Further, the study identified various structural weaknesses in the sector that could be addressed using the Internet as a mode of intervention. Lastly, the findings highlighted the challenges and opportunities for Internet-led service delivery. This chapter makes recommendations for overcoming the weaknesses identified, strategies for taking advantage of the opportunities identified and overcoming the inherent challenges.

The thesis thus recommends: -

- the finding that the Internet has the potential to improve on the delivery of services in water and sanitation for developing countries has important implications for the sector. The thesis thus recommends a high-level sector commitment to improve on the level of Internet connectivity and usage for the sector. Such commitment should be led by high profiled sector role players such as the Water Supply and Sanitation Collaborative Council (WSSCC), the United Nations Development Programme – World Bank Water and Sanitation Programme, WEDC and IRC among others. This probably means that the sector will have to make a policy shift and directly encourage the water and sanitation organisations to cut operating costs by using tools (Internet based computing) that encourage higher productivity and passing the ensuing benefits to the communities.

- it is incumbent upon the water and sanitation sector in developing countries to develop strategies for translating the potentials of Internet into concrete gains. The role of the Internet should go beyond the traditional intervention in lowering communication costs and exchanging technical material. The strategy so developed should fundamentally change the *modus operandi* in water and sanitation and encourage a stage where the majority of the water and sanitation organisations reach level 6 of their Internet development. This will require a higher level of information sharing among water and sanitation organisations as well as a higher level of integration in sector activities. Traditionally, this has not been the case. In this way, substantial saving that could go into increasing coverage (in water and sanitation) would be realised.

- the research concluded that the professionals in water and sanitation are primarily interested in information that impacts directly on their line of work. Sector information is of secondary interest to them. If a demand responsive approach were to be applied, it would be recommended that the type of information that impacts directly on the duties of the professionals should be availed on the Internet on a *fast-track* basis. The implications of such move would be three-fold. First, a culture of Internet usage among the water and sanitation professionals would be kick-started. Secondly the ensuing high traffic would create a new but related industry based on merchandising the information as well as advertising on the Internet. Ultimately, an enhanced culture of Internet usage among sector professionals would permeate and have the professionals using the Internet beyond their direct line of work. This might necessitate a redefinition of the role of sector professionals while at a minimum could redefine the work ethics in the sector. This way, well-informed human resources that constantly refresh their knowledge will drive the sector growth. Examples of such information are design standards and previous design reports.

- a manual on the best practices on Internet connectivity should be published and distributed to the water and sanitation organisations active in developing countries. Such manual should be updated regularly as new information comes to fore. On the other hand, the manual should not muzzle creativity but rather encourage innovative use of the Internet in dealing with the problems of water and sanitation. Incidentally, flexibility and innovation are considered to be the cornerstones of the exponential growth and development of the Internet industry.

- the research concluded that moribund information systems are still in place in the water and sanitation sector. The study also revealed a lack of information on the part of the water and sanitation professionals on Internet technology. Active Intervention is required if the information gap is to be bridged. The research recommends that the intervention be carried out through traditional media and peer networks. This way, a greater coverage and meaningful impact are likely to be achieved.

- as a transition measure, the research recommends training and development of a handful of professional Internet assistants for use in the industry. These

professionals (also known as Internet miners) will search the Internet for water and sanitation information, catalogue it and send it in a convenient form to the originator. This is likely to spur interest in the use of the Internet and in the process encourage the diffusion process and possibly improve on the rate of diffusion of the Internet technology in the sector.

References

Allaire, P., Young, J., and Vest, C., (1994), Breaking the barriers to the national information infrastructure, The Council on Competitiveness, Washington DC.

Astakov, A., Grübler, A., and Mookhin, A., (1990), Technology Diffusion in the Coal-Mining Industry of the USSR, Technological Forecasting and Social Change, Elserveir Publishing, London. PP 223-256

African National Congress, (1994), Reconstruction and Development Project, African National Congress, Pretoria.

Asthana A. N., (1997), Household choice of Water Supply System, Proceedings, 23rd WEDC conference, Durban.

Ben-Akiva M. and Lerman S, (1985), Discrete Choice Analysis, Cambridge Mass, MIT publication, 1985.

Blum, D. and Feachem, R. G., (1983), Measuring the impact of water supply and sanitation investments on diarrhoeal diseases: Problems of methodology. International Journal of Epidemiology, 12, pp 357 - 365, London.

Boot, M., (1995), Hygiene Education in Bangladesh, UNICEF, New York.

Buckley, C. A., Odendaal, P., Kibata, N., Dindar, M., (1996), Water and Sanitation for Developing Countries: Information Server, Proceedings of Biennial Conference and Exhibition, Water Institute of Southern Africa, Port Elizabeth, May 1996.

Buckley, C. A., and Hurt, Q. E., (1996), Why Water Scientists and Engineers must use the Internet, Proceedings of Biennial Conference and Exhibition, Water Institute of Southern Africa, Port Elizabeth, May 1996.

Buckley C. A. and Kibata N., (1996), INTERWATER; A gateway to water and sanitation information on the Internet, Proceedings of International symposium on Environmental Technology, Merdeka University, Indonesia

Cerf, V., (1997), Computer Networking: Global Infrastructure for the 21st Century, Computing Research Association, Washington DC.

Choudhry, S. R., Bhattacharra, P., and Gupta, S. S., (1998), ManPower Planning with Case Based Reasoning: The Selector, Proceedings of International Conference on Knowledge Based Computer Systems, National Centre for Software Technology, Mumbai, India.

Cross, P., (1997), Water and Sanitation in South Africa: Institutional Management Options, Proceeding: 9th ITN Africa Conference, Pretoria.

Cooper, R. B. and Zmud, R. W., (1990), Information Technology Implementation Research: A Technological Diffusion Approach, Management Science Volume 36 Number 2, Institute of Management Science, Los Angeles, California.

Department of Water Affairs and Forestry, (1994), Water Supply and Sanitation White Paper, Department of Water Affairs and Forestry, Pretoria.

Dindar, M.C., (1997), Rural Water Supply and Sanitation: A Transfer of Technology Through the Internet, MScEng thesis, University of Durban-Westville, Durban.

Drucker, P., (a) (1994), The age of social transformation, The Atlantic Monthly pp 13 -17, Washington.

Drucker, P., (b) (1994), Trade lessons from the world Economy, Foreign Affairs Vol 73, Washington.

Erberg, J., (1994), Telecommunication for Sustainable Development, Proceedings of the World Telecommunication Development Conference (WTDC-94), Buenos Aires.

Edwards, D. B., (1988), Managing institutional development projects: water and sanitation sectors, WASH technical report No. 49, USAID, Washington D. C.

Ettlie, J. E., (1980), Adequacy of Stage Models for Decision on Adoption of Innovation, Psychological Report No. 46, New York

Feachem, R., (1980), Bacterial standards for drinking water quality in developing countries, Lancet, 2 pp 255 - 256, London.

Francey, R., (1990), Institutional development: moving the boundaries, proceedings of the UNICEF orientation / training workshop for water and sanitation staff, pp 87 - 104, New York.

Gorre-Dale, E., De Jong, D., and Ling, J., (1993) Communication in Water Supply and Sanitation; Resource Booklet, International Reference Centre for Water and Sanitation, The Hague.

Hanna, N., and Boyson, S., (1993), Information Technology in the World Bank Lending, World Bank Discussion Paper Number 246, Washington, DC.

Hanna, N., Guy, K. and Arnold, E., (1995) The Diffusion of Information Technology: Experience of Industrial Countries and Lessons for Developing Countries, The World Bank, Washington DC.

Howard, G., (1995), Pollution control and water resources protection in developing countries, Waterlines, July volume 14 No. 1, pp 23 - 27.

Idelovitch, E. and Ringkong K., (1995) Private sector participation in water supply and sanitation in Latin America, The World Bank, Washington D. C.

IMC and Mvula Trust, (1997), Report on Survey of Information Resources on Community Water Supply and Sanitation, Department of Water Affairs and Forestry of South Africa.

Institute of Water Engineers and Scientists, (1983), Water Practice manuals Volume 3: Water supply and sanitation in developing countries, Institute of Water Engineers and Scientists, London.

IBM Canada, (1997a), Transforming Developing Countries with Network Computing, White Paper in the series *Living in the Information Society*, IBM Corporation Canada, Toronto.

IBM Canada, (1997b), Understanding the Global Information Infrastructure, White Paper in the series *Living in the Information Society*, IBM Corporation Canada, Toronto.

IBM Canada, (1997c), Understanding the Internet Content Principle White Paper in the series *Living in the Information Society*, IBM Corporation Canada, Toronto.

Iwugo, K. O., (1995), Sustainable water pollution control technology in the south - issues and options. Waterlines, July Volume 14 No. 1, pp 14 -17.

Kemp, R., (1997), Environmental Policy and Technical Change: A Comparison of the Technological Impact of Policy Instruments, Edward Elgar Publishing Ltd., Cheltenham, UK.

Kibata, N., (1996), Water and Environmental sanitation for developing countries: Information server, MScEng thesis, University of Durban-Westville, Durban.

Kibata, N., (1997), Water and Sanitation in Developing Countries: Internet Based Information Provision, Proceedings of the nineteenth annual symposium on Information Technology in Engineering, South African Institute of Civil Engineers, Mafikeng, South Africa.

Kibata, N., Buckley C.A and Otieno, F., (a) (1998), The Internet and computing in the next millennium and beyond: Opportunities and Challenges for the water and sanitation sector. Proceedings of the twentieth annual symposium on Information Technology in Engineering, South African Institute of Civil Engineers, Port Elizabeth.

Kibata N., Buckley, C. A., and Otieno, F. A. O., (b) (1998), The Promotion of the Internet as a Source of Information on Water and Sanitation, WRC Report No. K5/735/0/1, Pretoria (In Print)

Kibata N., Buckley, C. A., and Otieno, F. A. O., (c) (1998), Can the Internet be a useful Tool for enhancing effective delivery of Services in Water and Sanitation Sectors of Developing Countries?, Proceedings, Water Institute of Southern Africa Biennial Conference and Exhibition, WISA, Cape Town.

Knight, P. and Boostrom, E. (ED), (1995), Increasing Internet connectivity in Sub-Saharan Africa: Issues, Options, and World Bank group role, Internal working paper, World Bank, Washington DC.

Kwon, T. H., and Zmud, R. W., (1987), Unifying Fragmented Models of Information Systems Implementation in Borland and Hirschheim (Ed), Critical Issues in Information Systems Research, John Wiley and Sons, New York.

Lakhani, H., (1975), Diffusion of Environment-saving Technological Change- A Petroleum Refining Case Study, Technological Forecasting and Social Change, Houston.

Lall, S., (1987), Learning to Industrialise: The Acquisition of Technological Capability by India, Macmillan Press, London.

Leatherdal, D., (1987), INTERWATER Thesaurus for Community Water Supply and Sanitation, International Reference Centre for Community Water Supply and Sanitation. The Hague, Netherlands,

LaFond, A., 1993, A review of sanitation programme evaluations in developing countries, US Agency for International Development, Washington.

Leonard, D. K., 1987, The political realities of African management, World development, Vol 15, No 7, Pergamon journals, London.

Lewin, K., (1952), Group Decision and Social Theory, in Newcomb and Hartley (Eds), Readings in Social Psychology, Henry Holt and Company, New York

Madanat, S., and Humplick. F., (1993), A model of Choice of Water Supply System Systems in Developing Countries, *Water Resources Research*, Vol. 29, No. 5.

Mara, D. D., (1976), Sewage treatment in hot climate, John Wiley and Sons, London.

Mara, D. D. and Silva, S. A., (1979), Sewage treatment in waste stabilisation ponds: recent studies in northeast Brazil, Progress in water technology, 11 pp 341 - 344, Leeds.

Marchetti, C., and Nakicenovic, N., (1979), The Dynamics of Energy Systems and the Logistics Substitution Model, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Marks, R. F., (1991), Appropriate sanitation options for Southern Africa, Proceedings of international conference on appropriate waste management technology, Perth Australia, International Association on Water Quality (IAWQ), Oxford.

McFarland, (1981), Portfolio Approach to information Systems, *Harvard Business Review* (September / October 1981), Harvard Press.

Mejia A, (1996), Brazil; Municipality and Low-Income Sanitation, World Bank Position Paper, The World Bank, Washington DC.

Mody, A., Suri, R., and Sanders, J., (1992), Keeping pace with Change: Organisational and Technological Imperatives, World Development, Special Issue on Diffusion of Information Technology: Opportunities and Constraints, Volume 20 Number 12, World Bank, Washington DC.

Morgan, P. R., (1977), The Pit Latrine revived, Central African journal of medicine no. 24, pp 1 - 4.

Morgan, P. R. and Mara, D.D., (1982), Ventilated improved latrines: recent developments in Zimbabwe, TAG working paper no. 2, World Bank, Washinton D. C.

Murray, R., (1997), South Africa - An overview of the Domestic Rural Water Supply Sector, Proceedings of the Network for Water and Sanitation International (NETWAS) workshop on Community Management and Partnership with Civil Society, Nairobi.

Nakicenovic, N., (1979), Software Package for Logistics Substitution Model, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Narayan, D., (1995), The Contribution of People's Participation: Evidence from 121 Rural Water Supply Projects. Environmentally Sustainable Development, Occasional Papers No. 1, The World Bank, Washington DC.

National Sanitation Task Team, (1995), National sanitation policy; draft white paper on sanitation, South African Government of national unity, Pretoria.

Ndege, M. M., (1992), Rainwater harvesting in Kenya: state of the art, Proceedings of the second national conference on rainwater catchment systems in Kenya, Nairobi.

Nyirenda, P., Uta, J. J., Labelle, R., (1995) Sustainable Development Networking in Malawi, United Nations Development Programme Project Document, UNDP, Lilonge, Malawi.

Okun, D. A. and Ernst, W. R., (1987), Community piped water supply in developing countries: A planning manual, World Bank Technical Paper No. 60, Washington DC.

Padoan, C. P., (1997), Technology Accumulation and Diffusion: Is there a Regional Dimension? World Bank Policy Research Working Paper Number 1781, World Bank, Washington DC.

Pelz, D. C., (1983), Quantitative Case Histories of Urban Innovations: Are there innovating Stages?, Transportation Engineering Management, EM-30 2, New York

Pickford, J., (1977), Water treatment in developing countries, in water, wastes and health in hot climates, Feachem, R., McGary, M. and Mara, D. (eds), pp 162 - 191, John Wiley and sons, London.

Pinidiya, H. and Minnatullah, K. M., (1994) Urban sanitation issue in Sri Lanka, Proceedings of 20th WEDC conference, Colombo, Sri Lanka.

Pavitt, K., (1986), Chips and trajectories: How will the Semi-conductors Influence the Sources and Directions of Technical Change? In MacLeod R. (ed) Technology and the Human Prospect, Essays in Honour of Christopher Freeman, Francis Pinters Publishers, London.

Posch, M., Grübler, A., and Nakicenovic, N., (1987), Methods of Estimating S-shaped Growth Functions: Algorithms and Computer Programs, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Richardson D., (1996), The Internet and Rural Development: Recommendations for Short Term Strategy and Activity, United Nations Food and Agriculture Organisation, Milan.

Ringkong and Reader-Wilstein, (1995), Private Sector Participation in Water Supply and Sanitation in Latin America, The World Bank, Washington DC.

Rogers, E. M., (1983), Diffusion of Innovations, Free Press, New York.

Rosenberg, N., and Frischak, C., (1985), International Technology Transfer, Praeger Press, New York.

Rosenberg, N., (1990), Why do Firms do Basic Research (with their own money)? Research Policy, Volume 19, No. 2, Washington DC.

Salwen, P., (1996), Sticking with the web, Civil Engineering pp 37 - 41, Volume 66, number 6, American Society of Civil Engineers, New York.

Seregeldin, I., (1995), Water Supply, Sanitation and Environmental Sustainability; The financing challenge, The World Bank, Washington DC.

Sherman, S. (1993), How to bolster the bottom line, Fortune Special Report on Information Technology, New York.

Siegel, S. and Castellan Jr., J., (1990), Non-parametric statistics for the Behavioural Sciences, McGraw-Hill, New York.

Smith, R. and Gibbs, M., (1994), Navigating the Internet, Sams, Indianapolis.

Standish Group, (1997), Whitepaper: The Internet Goes Business Critical, IBM Corporation, Canada, Toronto.

Steven, M. and Defenderfer, D., (1996) The Internet as a tool for community development, Proceedings of the 28th annual conference of the Community Development Society, Melbourne, Australia, 22 July 1996

Talero, A, and Gaudette, P., (1996), Harnessing Information for development; A proposal for World Bank Group strategy, The World Bank, Washington DC.

Tapscott, D., (1997), The Digital Economy: Promise and Peril in the Age of Networked Intelligence, McGraw-Hill, New York.

The Mvula Trust, (1998), Guidelines to Community Managed Water and Sanitation Services, The Mvula Trust, Johannesburg.

United Nations Development Programme, (1983) TAG tech note 3. Ventilated Improved double pit latrines. Construction manual for Botswana, United Nation Development Programme / World Bank, Washington, DC.

Wilson, C., (1995), Engineers on the Internet: A New World of Information at your fingertips, Proceedings Inet '95, pp 365 - 378, Honolulu.

Witte, E., (1972), Field Research on Complex Decision-Making Processes – The Phase Theorem, International Studies of Management and Organisation, New York.

World Bank (a), (1992), World development report 1992; Development and the environment, Oxford press, New York.

World Bank (b), (1992), World development report 1992; investing in infrastructure, Oxford press, New York.

World Health Organisation, (1986), Institutional Developments in Community Water Supply and Sanitation, World Health Organisation, Geneva.

Zabouskous, T., (1998), Empowerment 2001: Government technology for the 21st Century, White Pare, Microsoft Corporation, Seattle.

Zambrano, R. and Daudpota, I., (1995), the sustainable Development Networking Programme: Concept and Implemetation, Proceedings of Inet' 95, Honolulu.

Appendix 1: Questionnaire used in Information needs Survey

Department of Civil Engineering

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Tel: (031) 204 4288

Fax: (031) 204 4291

Hi. I am conducting a survey on that will hopefully lead to recommendations on the most effective methods on the Internet usage by Civil Engineers involved in Water and Sanitation Works. Please spare me a few minutes and answer the questions to the best of your knowledge.

Personal

Name	
Firm representing	
Position	
Contact Address	
Email	
Tel	
Fax	

Question: If a source of information were made available on the Internet, to what extent would you use the under mentioned information?

Use the following ranking system to score each suggested source of information.

1. Primary needs. Necessary for the primary operations of the design office.
2. Secondary needs. Peripheral to the needs of the design office but still useful.
3. Used in extra-ordinary W & S assignments e.g. consumer surveys, sanitation situational analysis surveys, etc.
4. Not used at all.

Information	**Usage frequency score.**			
	1	**2**	**3**	**4**
Previous Design Reports				
Community Survey • Social data • Economic data • Social data				
Climatic data				
Policy Documents • National Government • Provincial Government • Local Government • Regional Water Authorities				
GIS data				

Information	**Usage frequency score.**			
	1	**2**	**3**	**4**
Legislations • Water • Environmental				
Design Standards / Guidelines				
Design and Materials Specifications				
Other Standards, e.g. material for pipes				
Bibliographic database				
Industrial Trends through journals, magazines and bulletins.				
Others (please specify)				

Thanking you.

N. Kibata.

Appendix 2:A printout of SRI Results for the individual sites and their rating is attached

Site Description	URL	SRI		Comments
		1997	1998	
INTERWATER	www.wsscc.org/interwater	1	2	
International Reference Centre for Water and Sanitation (IRC)	www.irc.nl	1	3	
Africa Water Page (South Africa)	wn.apc.org/afwater	2	3	Failed Pre-qualifying test
Department of Water Affairs	www-dwaf.pwv.gov.za	1	2	
South African Water Information Centre	-	-	-	dead links
The World Health Organisation.	www.who.int/peh/specprg.htm	1	1	
United Nations Children Education Funds (UNICEF)	www.unicef.org/	-	-	Failed Pre-qualifying test

Site Description	URL	SRI		Comments
		1997	1998	
United States Agency for International Development (USAID)	www.info.usaid.gov/environment/	-	-	Failed Pre-qualifying test
The Water, Engineering and Development Centre	info.lut.ac.uk/departments/cv/wedc	2	2	
UNDP-World Bank Water and Sanitation Project	www.wsp.org	-	4	Established after 1997 survey
Environmental Health Project	www.access.digex.net/~ehp/	1	1	
WaterAid	www.wateraid.org.uk	1	2	
VL Public Health: Water and sanitation	www.uni-ulm.de/public_health/vl/top/top-wat.htm	-	1	Established after 1997 survey
Liberia water and sanitation (watsan)	lifewater.ca/liberia.htm	-	1	Established after 1997 survey
Liens Nationaux	www.cwwa.ca/flinks.htm	-	-	Failed Pre-qualifying test

Site Description	URL	SRI		Comments
		1997	1998	
International Water Services Association (IWSA)	www.iwsa.org.uk/	-	-	Failed Pre-qualifying test
consultoría colombiana s.a. Water and Sanitation	www.concol.com/english/water.htm	-	1	Established after 1997 survey
The Pacific Water and Sanitation Programme.	http://202.62.0.150/wasp/	1	1	Established after 1997 survey
CARE International, Water and Sanitation Programme	www.care.org/programs/healthpop/w&shome.html	1	1	
Water and Sanitation in Developing Countries (SANDEC)	www.sandec.ch	1	1	
IDA in Action: Water and Sanitation	rocks.worldbank.org/html/extdr/ida_act/socwtr.htm	-	1	Established after 1997 survey
Water and Sanitation	www.peacecorps.gov/www/vrs/VRS131.html	-	-	Failed Pre-qualifying test

Site Description	URL	SRI		Comments
		1997	1998	
Engineering				
Working Paper Released: Water and Sanitation Services	www2.nas.edu/wstb/217a.html	-	-	Failed Pre-qualifying test
Water and Sanitation	edie.cprost.sfu.ca/gcnet/ch2000_2/pn_hartv.html	-	1	Established after 1997 survey
National Community Water and Sanitation Training Institute	water.ccwr.ac.za/ncwsti/	1	1	
Water Resources Management	www.soc.titech.ac.jp/uem/water/water.html	-	1	Established after 1997 survey
Lifewater International	www.lifewater.org/	1	2	
National Institute for the Environment, Population / Environment Database	www.cnie.org/pop/pophome.htm	2	2	
Women, Ink. Books WATER AND SANITATION	http://www.womenink.org/water.html	2	2	
Médecins Sans Frontières -	ns.msf.org/aboutus/expert/guidewat.htm	1	1	

Site Description	URL	SRI		Comments
		1997	1998	
Water and Sanitation				
CHYN: Water and Sanitation in Emergency Situations	www-chyn.unine.ch/watsan.html	-	1	Established after 1997 survey
Rural Water and Sanitation Programme, Pakistan	www.un.org.pk/90013.htm	1	1	
Health, Development, Information and Policy Institute (HDIP)	www.hdip.org/	-	1	Established after 1997 survey
The Handpump TechnoIogy Network	wn.apc.org/afwater/HTN.htm	1	1	
Water Supply and Sanitation Corraborative Council	www.wscc.org	-	2	Established after 1997 survey
Garnet Water Quality Node	www2.idrc.ca/garnet/	3	5	
Garnet	info.lut.ac.uk/departments/cv/wedc/garnet/grntback.	2	3	

Site Description	URL	SRI		Comments
		1997	1998	
	html			
Water Sector Development Group, Zambia	www.rsu.org.zm	1	2	
Waterlit Bibliographic Database	star.csir.co.za/star/wlit.html	6	6	
Umgeni Water	www.umgeni.co.za/operations/uplift/index.htm	1	1	
Maldives - Drinking Water and Sanitation	www.maldives-info.com/People/water.htm	1	1	
Water in armed conflicts	www.icrc.org/unicc/icrcnews.nsf/	1	1	
Rand Water	www.waterwise.co.za/	-	1	Established after 1997 survey
Tamil Nadu Water Authority	www.twadboard.com/first.htm	-	2	
SKAT, Water and Sanitation	www.skat.ch/focus/water/frameset_water.htm	-	1	Established after 1997 survey
International Rivers Network Library	www.irn.org/pubs.html	1	1	

Site Description	URL	SRI		Comments
		1997	1998	
Pan American Health Organisation	http://165.158.1.153/	1	2	
Water for People - Blacksburg Chapter	www.vt.edu:10021/org/water/wfp/project.html	1	1	
CARE International, Bangladesh	www.care.org/programs/healthpop/llbang.html	1	1	
Waterlines	www.oneworld.org/itdg/journals/waterlines.html	4	4	
OHIO RIVER VALLEY WATER SANITATION COMMISSION	www.orsanco.org/press/swpwin.html	-	-	Failed Pre-qualifying test
Danida	www.ing.dk/danida/1995-4s.txt	1	1	
IHE-Delft projects: Sana'a University Support, Yemen	www.ihe.nl/he/projects/sanaa.htm	1	1	
Glover Development Engineers	users.iafrica.com/z/za/zaszc32/HOME.htm	1	1	

Site Description	URL	SRI		Comments
		1997	1998	
(HomePage) G.D.E				
PALMER DEVELOPMENT GROUP	www.inect.co.za/clients/pdg/	1	1	
El Porvenir Water Projects for Nicaragua	www.elporvenir.org/	1	2	
Global Water Partnership	www.sida.se/gwp/gwp/welc.html	1	2	
GTZ/ Water Resources, Water Supply, Sanitation and Waste Management	www.dainet.de/gtz/divengl/div414e.htm	1	1	
Islamic Relief Organisation Water and Sanitation Programme	www.islamic-relief.org.uk/wsp.htm	1	1	
The Mvula Trust	www.mvula.co.za	2	2	
Inter American Development	www.iadb.org/cont/evo/evo_eng.htm	-	1	Established after 1997 survey

Site Description	URL	SRI		Comments
		1997	**1998**	
Bank				
Water Environment Federation	www.wef.org/	-	-	Failed Pre-qualifying test
World Water Council	www.walrus.com/~abe/wwc/home/home.htm	1	1	
UN Statistics Division	www.un.org/Depts/unsd/social/watsan.htm	2	2	
Water Resources and Third World Development	www.arts.mcgill.ca/152-497b/h2o/water/twater/index.htm	1	1	
	Tally			
	SRI = 1	32	34	
	SRI = 2	7	15	
	SRI = 3	1	3	
	SRI = 4	1	2	
	SRI = 5	0	1	
	SRI = 6	1	1	

Site Description	URL	SRI		Comments
		1997	**1998**	
	Total	42	56	

Appendix 3: Questionnaire used to evaluate the Prevailing Information Systems

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Tel: +27(031) 204 4288

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Hi. I am conducting a survey on that will hopefully lead to recommendations on the most effective methods on the Internet usage by professionals involved in Water and Sanitation Works. Please spare me a few minutes and answer the questions to the best of your knowledge. This particular phase of the study involves the study of diffusion of the Internet technology in the water and sanitation sector. However, before embarking on the study, one needs to look at the systems of information you the professional use to gain information on the Internet technology in general and its application in water and sanitation. The questionnaire is divided into 3 parts, i.e., the information supply, Information transfer channels and credibility of the information.

Personal

Name	
Firm	
Position	
Email	
Tel	
Fax	

Part A: Information Supply

1. Do you consider your knowledge of the Internet technology sufficient enough for you to make critical decisions regarding Internet application in your organisation? Yes or No
2. Irrespective of your answer to question 1 above, please indicate the extent of your usage of the sources of Information on the Internet technology using the following ranking system:-
3. To a very large extent - 1
4. To a large extent - 2

- Internet Service Providers
- Software Vendors

5.	Little	-	3
6.	Not at all	-	4.

- Other water and sanitation organisations
- Independent Consultants
- Professional bodies to which you are affiliated
- Peer Networks
- Others

7. Please answer this question if you have given rating of either 1 or 2 in question 2 above. Is this type information is contained in the information systems that you rated 1 or 2 in question 2 above? Yes or No.

- Cost of the Internet technology
- Internet Connectivity Strategies
- The role of Internet in Water and Sanitation
- Emerging Issues in Internet Technology

		• Technical aspects of the Internet technology • Others
8.	Please answer this question if you answered question 3 above. Approximately, how frequently is your knowledge of the Internet technology updated from systems you rated 1 and 2 in question 2 above? You can tick more than once.	• Daily • Weekly • Monthly • Bimonthly • Quarterly • Longer than quarterly
9.	Part B: Information Channels / Networks	
10.	Please rank the following channels of information transfer in order of frequency with which you receive information on the Internet technology. Use rank 1 - 9.	• Print Media • Radio • Brochures • Seminars, workshops, etc. • Formal instructions courses • Television • Internet – WWW

11. Please rank the following channels in order of preference with which you would like to receive information on Internet technology application in water and sanitation. Use rank 1 - 9.

- Internet – Email
- Others
- Print Media
- Radio
- Brochures
- Seminars, workshops, etc.
- Formal instructions courses
- Television
- Internet – WWW
- Internet – Email
- Others

Part C: Credibility of the Information Supply

12. Do you consider the information supply you named in **Question 3** to be credible? Yes or No.

- Internet Service Providers
- Software Vendors
- Other water and sanitation organisations

- Independent Consultants
- Professional bodies to which you are affiliated
- Peer Networks
- Others

Thanking you.

N. Kibata.

Appendix 5: SRI for sample sites between Nov 1996 and Nov 1998

INTERWATER

Month	FRI
Nov-96	1
Jan-97	1
Mar-97	1
May-97	1
Jul-97	1
Sep-97	1
Nov-97	1
Nov-97	1
Jan-98	1
Mar-98	1
May-98	1
Jul-98	1
Sep-98	1
Nov-98	1

The Mvula Trust

Month	Total number of publications during the study Period (T_p)	Cumulative Total (CT_p)	Total number of publications published on the Internet Simultaneously (T_i)	Cumulative Total (CT_i)	CFRI (CT_p /CT_i)
Nov-96	3	3	0	0	0.000
Jan-97	2	5	0	0	0.000
Mar-97	1	6	1	1	0.167
May-97	2	8	4	5	0.625
Jul-97	3	11	2	7	0.636
Sep-97	5	16	2	9	0.563
Nov-97	4	20	2	11	0.550
Nov-97	2	22	0	11	0.500
Jan-98	1	23	1	12	0.522
Mar-98	2	25	2	14	0.560
May-98	1	26	0	14	0.538
Jul-98	0	26	0	14	0.538
Sep-98	1	27	0	14	0.519
Nov-98	3	30	2	16	0.533

Water Institute of Southern Africa, KZN, CWSSD

Month	Total Number of attendees (T_a)	Attendees Invited through the Internet (T_i)	TRI (T_i/T_a)
Nov-96	12	0	0
Jan-97	11	0	0.00
Mar-97	7	0	0.00
May-97	9	0	0.00
Jul-97	36	0	0.00
Sep-97	6	0	0.00
Nov-97	13	0	0.00
Nov-97	10	2	0.20
Jan-98	9	1	0.11
Mar-98	7	3	0.43
May-98	8	3	0.38
Jul-98	43	4	0.09
Sep-98	10	5	0.50
Nov-98	11	7	0.64

National Community Water and Sanitation Training Institute

Month	Total Number of Courses Conducted (C_c)	Total Number of Courses Conducted Online (C_o)	FRI (C_c/C_o)
Nov-96	3	0	0
Jan-97	3	0	0
Mar-97	1	0	0
May-97	1	0	0
Jul-97	1	0	0
Sep-97	3	0	0
Nov-97	1	0	0
Nov-97	1	0	0
Jan-98	1	0	0
Mar-98	4	0	0
May-98	4	0	0
Jul-98	1	0	0
Sep-98	1	0	0
Nov-98	4	0	0

Appendix 6:Number of sites linked to water and sanitation sites between Nov 1996 and Nov 1998

Site	**Nov-98**	**Sep-98**	**Jul-98**	**May-98**	**Mar-98**	**Jan-98**	**Nov-97**	**Sep-97**	**Jul-97**	**May-97**	**Mar-97**	**Jan-97**	**Nov-96**
The Water, Engineering and Development Centre	148	136	128	114	112	108	102	89	78	56	33	32	28
National Institute for the Environment, Population / Environment Database	127	121	115	109	102	98	89	78	65	43	31	22	13
Environmental Health Project	109	100	91	88	81	76	74	65	63	44	31	27	11
INTERWATER	57	54	51	43	39	36	36	33	31	27	25	15	12

Site	Nov-98	Sep-98	Jul-98	May-98	Mar-98	Jan-98	Nov-97	Sep-97	Jul-97	May-97	Mar-97	Jan-97	Nov-96
WaterAid	21	21	20	17	17	17	17	14	9	7	5	2	2
The Mvula Trust	12	12	11	11	9	8	6	5	5	4	3	0	0
Waterlines	9	9	8	8	7	7	7	7	6	5	2	2	1
Water and Sanitation in Developing Countries (SANDEC)	5	5	5	4	3	3	3	3	3	1	1	1	1
Waterlit Bibliographic Database	4	4	3	3	3	3	3	3	2	0	0	0	0
Garnet Water Quality Node	2	2	0	0	0	0	0	0	0	0	0	0	0
Garnet	2	2	2	2	2	2	2	2	2	2	2	2	2
The Pacific Water and Sanitation Programme.	2	2	2	0	0	0	0	0	0	0	0	0	0

Site	Nov-98	Sep-98	Jul-98	May-98	Mar-98	Jan-98	Nov-97	Sep-97	Jul-97	May-97	Mar-97	Jan-97	Nov-96
CARE International, Bangladesh	1	0	0	0	0	0	0	0	0	0	0	0	0
National Community Water and Sanitation Training Institute	1	1	1	0	0	0	0	0	0	0	0	0	0
Umgeni Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Pan American Health Organisation	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Nov-98	Sep-98	Jul-98	May-98	Mar-98	Jan-98	Nov-97	Sep-97	Jul-97	May-97	Mar-97	Jan-97	Nov-96
Overall Average	31.25	29.31	27.31	24.94	23.44	22.38	21.19	18.69	16.50	11.81	8.31	6.44	4.38
Upper Quartile	110.25	86.40	81.00	74.20	70.20	67.00	63.60	55.80	49.20	35.40	25.00	19.60	13.20
Third Quartile	11.75	11.75	11.00	10.00	9.00	8.75	8.25	7.25	5.75	4.25	2.75	1.25	1.00
Fourth Quartile	2.50	2.50	1.75	1.25	1.25	1.25	1.25	1.25	1.00	0.50	0.50	0.50	0.50
Lower Quartile	0.50	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00