Water, Households & Rural Livelihoods

Resources, Infrastructure, Demands and Entitlements (RIDe): a framework for holistic and problem-focussed water resources assessments

P.B. Moriarty[1], C.H. Batchelor[2], S.J. Smits[1], S. Pollard[3], S., J.A. Butterworth[4], G.V. Reddy[5], B. Renuka[5], A.J. James[6] & Y.V. Malla Reddy[5]

[1]IRC International Water and Sanitation Centre, Delft, The Netherlands
[2]Water Resource Management Ltd., UK
[3]Association for Water and Rural Development (AWARD), Acornhoek, South Africa
[4]Natural Resources Institute, University of Greenwich, UK
[5]Accion Fraterna, Anantapur, India
[6]Natural Resource and Environmental Economist, Delhi, India

Research promoting access of the poor to sustainable water supplies for domestic and productive uses in areas of water scarcity

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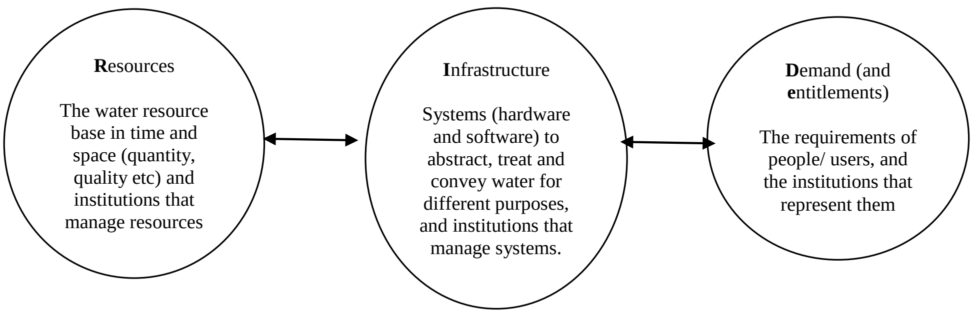
PREFACE

This working paper was prepared as a contribution to a joint Indian, South African and UK research project on Water, Households and Rural Livelihoods (WHiRL) that is focused on research to promote better water security for rural water supply. This paper, and other project outputs, can be downloaded from the project website at http://www.nri.org/whirl

EXECUTIVE SUMMARY

The Resources, Infrastructure, Demand and entitlement (RIDe) model is a simple framework with generic application. It is based on the understanding that water resources are linked to people by supply (and disposal) infrastructure, and that each of these three system elements (resources, infrastructure, users) has its own set of institutions, boundaries and other characteristics (Figure 1). In other words, that there are three sets of largely independent physical/institutional boundaries that need to be considered systematically when looking at water resource development and management problems.



The RIDe framework has been developed as part of a DFID-funded action research project in South Africa and India. The Water Households and Rural Livelihoods (WHiRL) project, looked at a range of issues relating to access by the rural poor to water. RIDe was developed to support analysis of a range of problems and issues relating to how domestic water supply did (or did not) get dealt with in wider Integrated Water Resource Management (IWRM) initiatives.

The RIDe framework was used to guide analysis at a river catchment scale in South Africa and at a village level scale in India. Starting from a water resource management perspective in the former, and user needs satisfaction in the latter. In both cases, the framework helped to bring conceptual clarity to key issues involved.

The main conclusions of the work were:

- RIDe is a useful approach to targeting water resource assessments as part of holistic, participatory, and problem focussed planning for water resource and water supply development. RIDe is not a radical departure from existing approaches, but rather a useful addition – particularly to water resource assessments which are given more structure, and become more systematic. As such it provides an important tool in helping to counter criticisms of IWRM as being too vague and lacking in a clear problem focus.

- RIDe is an analytical framework, and as such is a guide for problem, stakeholder, information and tool selection. It is not a specific set of activities. It can (and should) be implemented at different levels of resolution, with different stakeholders, and different information resolution depending on both the decisions to be taken and the stakeholders involved. A RIDe framework is as useful in a village meeting, where it can help participants differentiate between symptoms and causes of water-related problems, as it is in guiding a catchment level water resource assessment.

- By creating a framework that explicitly acknowledges infrastructure as the link between water supply and water resource management within a single conceptual framework, RIDe helps to provide critical insights into how water resources and water users interact.

- RIDe provides a framework for assembling and analysing water-related information in a way that concentrates effort and resources on analysis of causes of problems as opposed to symptoms. By definition, integrated water resources management requires that attention be given to the natural, engineering, environmental and societal aspects of water management systems. Without a structure for assembling and analysing information, it is very easy to become completely swamped by information.

- RIDe has emerged from ongoing work in South Africa and India. It was largely conceptualised after the fact, based on lessons learned and an analysis of what did and did not work. It now needs to be further tested in new environments, to be refined and further operationalised.

1. INTRODUCTION

"Water resources management and development are central to sustainable growth and poverty reduction" (World Bank, 2003, p. 2)

Around the world, and against the background of a perceived water crisis, people are working to apply the principles of Integrated Water Resource Management (IWRM) to a range of water and environment related issues (see for example the website of the Global Water Partnership, www.gwpforum.org). The objective is that finite supplies of freshwater be used as effectively, equitably, and sustainably as possible to benefit humans and the environment (Moriarty *et al*, 2004; GWP, 2000). Yet despite widespread acceptance of the principles of IWRM, the reality on the ground remains typically one of business as usual.

> The World Bank's recent Water Resources Sector Strategy document states that:
> 1) "*the Dublin Principles [for IWRM] have provided inspiration and direction for many water reform processes and .. the principles remain powerful, appropriate and relevant*"
> 2) "*progress in implementation has been difficult, slow and uneven*"
> 3) "*the major challenge was developing context specific, prioritized, sequenced, realistic and 'patient' approaches to implementation*"
>
> World Bank (2003) P. 1

One of the biggest challenges faced in IWRM is the diversity of interests of potential actors or stakeholders in water management. At least three different sets of stakeholders can be readily identified:

- **Resource managers**: are responsible for the macro level development and management of water resources. Increasingly organised on a catchment (or aquifer basis), their responsibilities typically include licensing, data collection and management, and balancing of needs and resources at the large scale.
- **System managers**: are responsible for managing water supply systems and infrastructure (usually on a sectoral basis) for domestic, irrigation, industrial or other uses. The scale of responsibility for system managers ranges from individuals managing their own water source to utilities and authorities working at a municipal or catchment basis.
- **Users (and their representatives):** are the people (and wider environment) that use water, and their representatives responsible for ensuring that needs are met. It includes individual users (who at the smallest scale are also the system managers), user groups, NGOs, regulatory authorities, and different levels of government.

As we start to see, each of these groups of actors tend to function at different and multiple scales. The boundaries (both physical and temporal) of their areas of interest and responsibility seldom coincide. Water resource managers typically work at a scale of thousands of square kilometres that is determined by the physical characteristics of the water system (the river basin or large aquifer), and think in terms of the long term natural processes that drive the hydrological cycle. In contrast, people responsible for water supply infrastructure think in terms of the boundaries created by their systems (which can range from the huge to the very small), and the design life of the physical infrastructure. Users (or would be users) and their representatives tend to think of their own immediate interests (e.g. their household) or those of the groups they represent, often defined by an administrative unit (village, district etc).

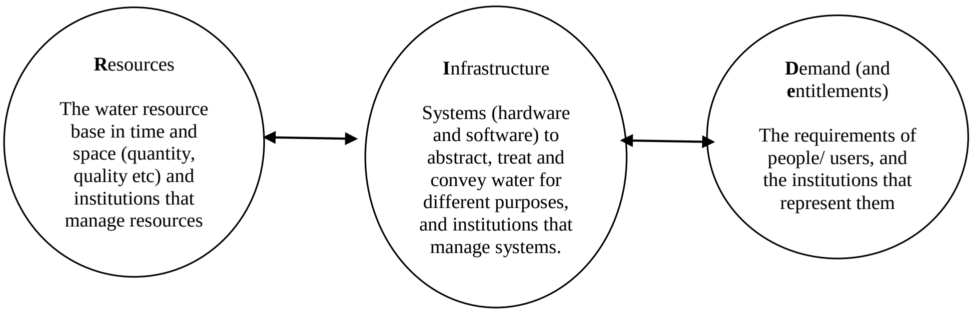
Procedures and practical tools for establishing a common understanding of the causes of water-related problems, and agreement on steps for overcoming these problems, are a vital component of IWRM. However, it is common that problems and issues become confused through lack of frameworks to simplify complex systems that span huge variations in spatial and temporal scale. Although the IWRM toolbox (GWP, 2004) provides a useful source of tools, it is currently lacking in practical tools for integrated problem identification and domain definition. The RIDe framework that is presented in this paper fulfils this need.

The framework was developed as part of the work of the WHiRL project, which looked at issues surrounding improved linkages between domestic water supply and water resource development and management generally in India and South Africa (for further details see the project website – (www.nri.org/whirl). The paper is divided into five main sections, with the first briefly describing the conceptual framework for the tool, the second and third presenting case studies of the application of the framework in South Africa and India, and the final sections detailing lessons learned in applying RIDe, and the main conclusions of the exercise.

2. CONCEPT AND DESCRIPTION OF THE RIDE FRAMEWORK

RIDe is a simple framework with generic application. It is based on the understanding that water resources are linked to people by supply (and disposal) infrastructure, and that each of these three system elements (resources, infrastructure, users) has its own set of institutions, boundaries and other characteristics (Figure 1). In other words, that there are three sets of largely independent physical/institutional boundaries that need to be considered systematically when looking at water resource development and management problems.

Figure 1 The RIDe framework



Before continuing to discuss lessons from the practical implementation of RIDe, it is first worth unpacking the terminology:

- **Resources**
  Resources are the water resources needed to meet the demand of users. Abstraction and supply of this water depends upon the infrastructure that sits in between water resources and users, so we can also talk of meeting the demand of water supply infrastructure. Because of conveyance and other losses such as illegal abstractions from pipelines or canals, the infrastructure demand may be quite different to the actual demand of legal users. Resources can be assessed in a number of ways, but typically as some combination of availability (quantity and quality) in space and time. Given that access to or use of water resources may be regulated, assessment of water resources needs also to take account of water policy and the institutions that have responsibility for managing and regulating use of water resources (including their capacity and effectiveness). Other factors that need to be considered when assessing resources are the potential impacts of short or long term land use and/or climate change and the potential impacts on water quality of agricultural intensification, demographic change and industrialisation.
- **Infrastructure**
  Infrastructure is the means by which water is conveyed from the resource to users, and returned (often at lower quality) to the resource base[1]. It refers to both the physical infrastructure (hardware) and systems and institutions (software) necessary to make this happen, to maintain

[1] Return flows can include raw or treated waste water from domestic systems, irrigation return flows, drainage from mining operations etc.

hardware and, where appropriate, to recover costs. Hardware may be hand-pumps on bore wells, or sophisticated reticulation systems with hundreds of kilometres of pipes and connections. However, infrastructure can also be a system for trucking water from a treatment plant to users. Abstractions are the interface between resources and infrastructure and can generally be represented as a point demand on a resource.

- **Demand (and entitlements)**
  Demand (and entitlements) capture the requirements for water by users at a certain time and place. Users can be considered as individuals, or groups. They may require water for irrigation, domestic, industrial or other uses. The environment is also a user, with specific needs of its own. Looking at user requirements will typically involve dealing with a range of (frequently fuzzy) figures. These may include: legally or policy driven minimum entitlements to domestic drinking water; entitlements established by abstraction licences or water rights; minimum ecological flows; actual water use; unsatisfied demand; etc. Demand and entitlements are constrained by legal, economic, and social barriers. Demand is also hugely variable across users and time, and importantly, the water use of any single user is impacted by the demands of other users.

Box 1 shows by way of an illustrative example how the RIDe framework can be used to help identify the different people who are stakeholders in water resource development and management related issues.

RIDe was not developed as a ‘new’ tool or set of activities nor is it necessarily a radical departure from some existing practice. The modelling software used in the South African work, reported in Section 2, uses what is in essence a RIDe approach to carry out water balances. Equally, looking at the flow of water from source(s) to use(s) and back to the source(s) again is part of ‘textbook’ approaches to IWRM (see for example Meays 1996). What none of these do is to deal explicitly with the political/institutional/physical realities of each of the different units identified in the RIDe analysis. The RIDe approach originated from the need to develop a focus for water resource assessments – to help to understand boundaries, linkages and overlap between systems (physical, infrastructural, institutional); to identify key stakeholders; and to support the development of platforms for the different stakeholders to communicate more effectively and efficiently. It also arose from recognition that, to be manageable and achievable, holistic analysis of water supply systems must be problem-focused and carefully structured.

The emphasis on distribution systems as a link between users and their resources is a critical one, and may represent something of a breakthrough in thinking about stakeholder involvement in IWRM. There is sometimes a tendency to speak in abstract terms, about ‘rights’ to water for example, while ignoring often insurmountable problems of infrastructure and access. A meaningful right must address not just a 'share' of water resources, but also the necessary infrastructure (and access) to take it to the point of use (Scanlon *et al*, 2003). RIDe makes this obvious, but sometimes overlooked, point explicit. To meet user requirements it is necessary to have sufficient infrastructure, and a sufficient water resource to draw upon. But it is also necessary to ensure that people have access to that infrastructure and resource, and that this is not blocked by barriers: legal or social. The approach is also useful to make explicit some of the tradeoffs that exist when difficult water-allocation decisions have to be made during, say, period of drought.

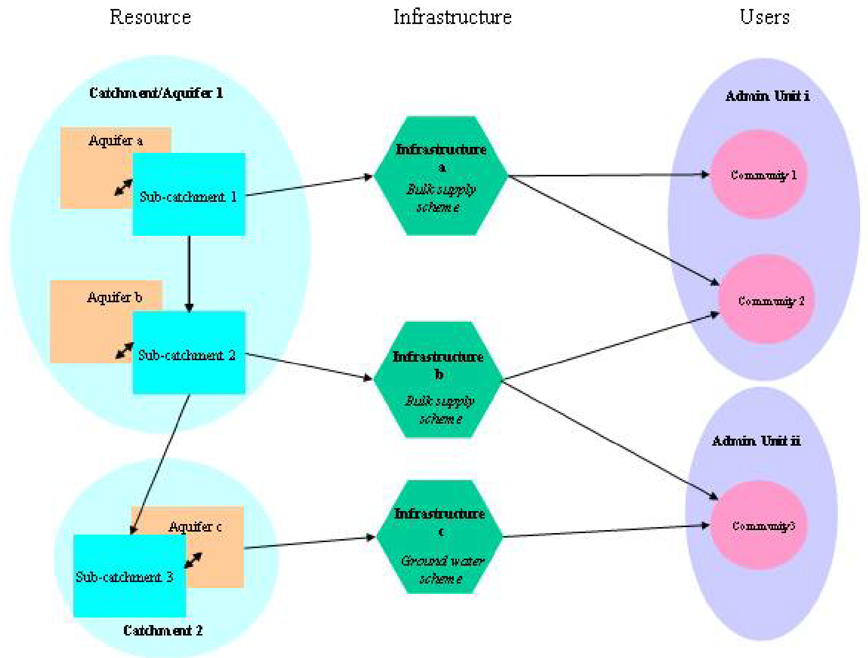
The following sections deal with the application of the RIDe framework in South Africa and India. They are followed by a final section outlining the main lessons learned in applying RIDe, as well as suggestions for further development and use

Box 1 An illustrative example

Figure 2 illustrates in more detail a hypothetical example of how hydrological units are linked to users by water supply infrastructure. This example emphasises domestic water supply, a sub-sector which because of its commitment to universal coverage tends to work with a paradigm of achieving full coverage to some agreed norm within a given administrative unit. Users and systems could equally well include farmers and irrigation schemes that might themselves be subject to different user boundaries. The figure illustrates how hydrological, administrative, and infrastructural boundaries seldom coincide; how systems may serve multiple users; and how users may depend upon multiple systems.

A RIDe approach helps to makes clear who should be involved in IWRM activities, and at what levels: why catchment management agencies and forums should not limit representation to the physical inhabitants of their management area; and why (and when) managers of urban utilities should ensure they are represented on catchment councils or river basin organisations

Figure 2 Representation of a domestic water supply systems using RIDe



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3. USING THE RIDE FRAMEWORK TO IDENTIFY WATER REQUIREMENTS FOR EQUITY AND SUSTAINABILITY IN THE SAND RIVER CATCHMENT, SOUTH AFRICA

3.1. Introduction

South Africa is one of the world's more water-stressed countries, with low average rainfall of about 450mm per year giving rise to nationwide annual per capita availability of freshwater of 1,154 cubic metres (FAO, 1995). Many of the country's rivers are severely degraded (Davies & Day 1998), and water resources are of insufficient quantity or quality to meet demands (DWAF 2002). Moreover, the legacy of apartheid policies and planning are such that today extreme inequities in access to water exist for many. In response to these challenges, the democratic government embarked upon massive changes in policies and legislation governing water resources management and water services. Many of these legislative changes are now in place and attention has turned to their implementation (see Pollard *et al*, 2002).

Box 2 The Reserve

The **Reserve** is a statutory requirement, enshrined in the National Water Act (Act 36, 1998), to ensure sufficient water both for the protection of the environment and access to water for basic human needs. The Reserve comprises two components: (1) the Ecological Reserve (ER), which is the water needed (together with an appropriate flow regime) to ensure the sustainability of the water resource base, and the (2) Basic Human Needs Reserve (BHNR) which refers to a right for a minimum amount of water to meet basic needs such as drinking, cooking and washing. The Reserve must be identified and safeguarded prior to *any other* allocation of water, which takes place through the granting of licences.

While the processes and tools for setting the ER in rivers are relatively advanced, those for the BHNR remain under-developed. Not even the definition of what constitutes the BHNR is entirely clear although there is an emerging consensus around the concept of it being synonymous with the resource required to supply the 25 litres per capita per day (lpcd) minimum norm of the Reconstruction and Development Programme RDP; or the similar $6m^3$ per family per month of Free Basic Water policy (Pollard *et al*, 2002).

Against this background, the South African NGO the Association for Water and Rural Development (AWARD) is working in the Sand River catchment in Limpopo province to facilitate and mediate the introduction of new policy, and to support its practical implementation for both water resource management and water services provision. One of these programmes - known as the Save the Sand - is a pilot project that focuses on achieving catchment water security through integrated water resources management as envisioned in the new National Water Act (Act 36, 1998). As part of this work a scenario planning exercise based upon the Resource, Infrastructure, Demand and Entitlement (RIDe) analytical framework was undertaken, with the general objective of better understanding the current situation in terms of water resource availability and service provision, and the specific objective of increased clarity as to how to implement the Basic Human Needs Reserve (a policy provision to protect water resources for domestic supply). The outcomes of the exercise were (and continue to be) used by AWARD as part of its larger programme of capacity building work with catchment stakeholders.

This paper details the application of the RIDe analytical framework using the Sand River as a case study. Importantly, the development of RIDe was underscored by the need for an approach that has national applicability. We start with a description of the current water resource situation in the catchment and then go on to examine the implications of various developmental scenarios in the Sand. We conclude by briefly examining the main outcomes of the exercise with regard to the water resources of the Sand, and also the lessons learned in applying the RIDe framework.

3.2. Background - the Sand river catchment – a description and critical issues

The Sand is a tributary of the transboundary Sabie River which flows from northern South Africa into southern Mozambique. It has its head waters in the Drakensberg Mountains and rapidly descends to the semi-arid lowveld and the boundary with the Kruger National Park where it joins the Sabie River. It has a 'semi-rural' population of between 270,000 and 294,000[2] people concentrated in the middle reaches of the catchment with the upper and lower parts dominated respectively by commercial forestry and private game ranches. In addition there are a number of irrigation schemes in the middle catchment (Figure 3). All of the Sand's population fall under the administrative jurisdiction of the Bohlabela District Municipality. In addition to the population within the catchment, water from the catchment is used to supply communities outside the catchment with a population of between 68,000 and 81,000

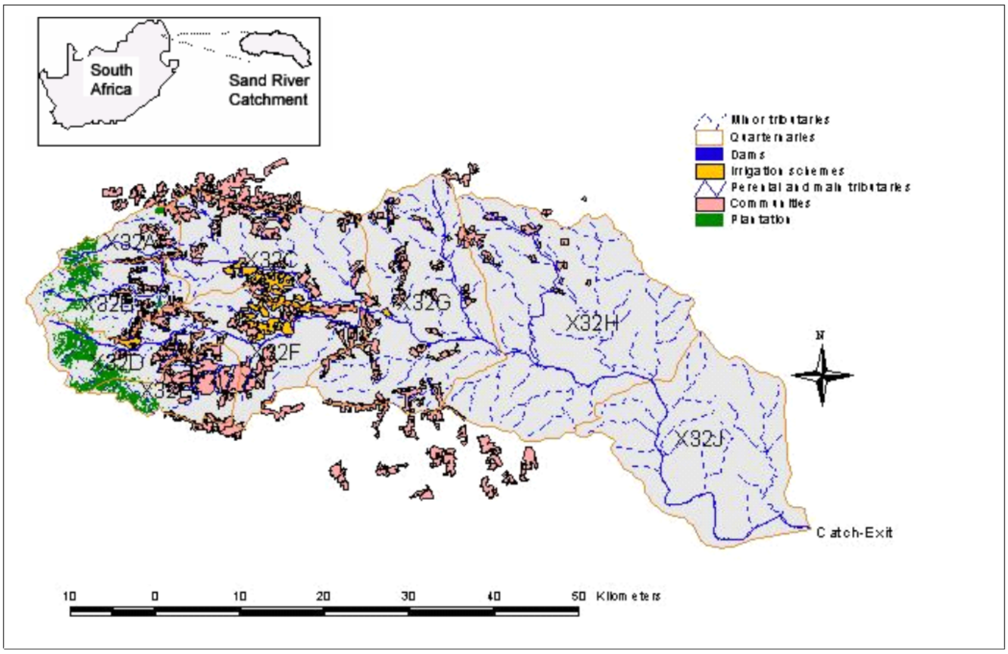

Figure 3 Map of the Sand showing catchment location in Southern Africa

[2] The lower figures for population come from DWAF estimates and the upper from AWARD's direct estimates (Pollard *et al*, 1998). AWARD's figures are probably more accurate, but in general DWAF's were used due to the desire to create an easily replicable methodology.

Access to both domestic and irrigation water are critical developmental issues within the Sand. Any consideration of contemporary water issues within the catchment, and indeed in many areas of rural South Africa, must be set within the wider historical context. Prior to the advent of democratic change in 1994, the catchment comprised not only an area demarcated as the Republic of South Africa but also the former homelands of Gazankulu and Lebowa. Each of these had its own policies and development schemes leaving a legacy of fragmented infrastructure and institutional arrangements. Today, access to water for much of the population is poor and unreliable, posing a huge challenge to the district municipality to whom the responsibility of water services has been devolved. In terms of planning, access to both domestic and irrigation water are critical developmental issues within the Sand Catchment.

An important aspect of this situation is that earlier hydrological studies (Pike *et al*. 1997) indicate that the water resources of the Sand are probably over-committed (see Pollard *et al*. 1998). With the advent of the new laws (NWA 1998; Water Services Act (WSA 1997)) and policies (National Water Resources Strategy 2002; catchment management strategies) that give statutory recognition to the Reserve, the issue of understanding the water demands within the context of catchment water resources has become obligatory. For a large number of closed catchments (i.e. all water resources are used) in South Africa, Reserve compliance is a critical issue. Indeed more than half of South Africa's 19 Water Management Areas are in water deficit (DWAF, 2002). The implication is that if the Reserve is not being met water will have to be re-allocated from other users or alternative water resources have to be secured. Clearly, tools that allow water institutions to diagnose the status quo and that allow for scenario-planning are essential to this process. In the last decade, water resources in the Sand River are increasingly contested. Not only has the recent drought highlighted the fact that the Environmental Reserve is be contravened but people continue to suffer inadequate and erratic access to water. Despite this, new developments that require water are proposed and planned - seemingly in a vacuum.

It is against this context that this work on an analytical framework and decision-support tool was undertaken. In its entirety, the RIDe framework was developed as a tool for analysis and decision-making concerning key water resource management within a catchment, and as a means to communicate these. In the Sand River case study, the RIDe analytical framework was used to draw together the results of existing work for the Sand River, as well as to address a number of critical water resource issues in the catchment. These centred principally on the following questions:

1. Can both the BHNR and ER be met under current and future development scenarios in the catchment?
2. Can the current infrastructure deliver the domestic demand in the catchment?
3. What are the possibilities for meeting the water requirements of other sectors in the catchment?

3.3. Using the RIDe framework in the Sand catchment

The RIDe analysis in the Sand was carried out in two principal phases of i) data collection and analysis, and ii) scenario building and further analysis when required.

3.3.1 Data sources

Nonetheless, much of these data are confusing and contradictory, particularly with respect to the extent and effectiveness of water supply infrastructure for domestic use and irrigation demand. In addition, the institutional arrangements or water resources management and water services are evolving rapidly. The Inkomati Catchment Management Agency, tasked with water resources management in the Sand Catchment will be gazetted in March 2004. In terms of water services, the Bushbuckridge Water Board has recently taken over responsibility for bulk supply from the

Department of Water Affairs and Forestry (DWAF), and the Bohlabela District Municipality is the new water services authority (WSA). Moreover, a major interbasin transfer (the Injaka IBT) is being brought on line. The surveys carried out for the RIDe study are therefore a snapshot of a dynamic and evolving situation as it was between late 2002 and 2003. The main considerations in collecting data are listed below for each element of the RIDe analysis.

Resources

Earlier studies for the Sand River Catchment had developed several different sets of hydrological data (DWAF 1990; Pike *et al* 1997). However, because part of the objective of the work was to develop a simple approach applicable elsewhere in South Africa, the nationally WR90 dataset was used to estimate surface water resources availability (Midgely *et al*, 1994). The WR90 dataset provides a simulated 70-year sequence of runoff for every quaternary catchment in the country. The Sand catchment contains 9 quaternary catchments, so the WR90 dataset had the added advantage of facilitating analysis at this scale.

In addition to the surface resource information provided by WR90, groundwater availability was also assessed. Again, although there are some relatively detailed analyses of available groundwater resources available, this is only for certain locations. Thus, for a more widely applicable approach, a simple calculation of recharge to groundwater as a percentage of mean annual rainfall (calculated over three year) was used. This was done for ‘low’, ‘medium’ and ‘high’ recharge scenarios of 2%, 5%, and 10% of long-term average rainfall respectively (again sourced from the WR90 dataset).

3.3.2 Infrastructure

A desk survey of domestic and irrigation supply infrastructure was commissioned and DWAF and consultants (EVN) data was used to identify:

- i) the proportion of each community nominally covered by each bulk scheme;
- ii) the number of boreholes developed in each community;
- iii) the number of equipped boreholes and their nominal supply capacity; and
- iv) the nominal supply capacity of the different irrigation schemes.

In addition, data was collected on the DWAF licences for each of the major domestic bulk supply schemes to give a nominal demand for each system. It should be noted that the bulk supply data is uncoordinated and confusing and again reflects the history of ad hoc development with too little planning.

No information exists on system losses, but these are likely to be high due to relatively poor maintenance and also owing to a large number of unauthorised connections (Robert Mbawana, advisor BDM, pers. Comm.).

The Injaka IBT is deigned to transfer water from the Injaka Dam on the Marite River into the Mutlumuvi River in quaternary X32D (Figure 3). The maximum capacity is estimated at 25 Mm^3 per annum.

3.3.3 Demand and entitlements

In assessing the demand and entitlements to water a number of needs were considered. Given that South Africa has a clear policy commitment to providing a minimum domestic water supply to every household in the country (the free basic water policy), this was taken to be a basic *entitlement.* This entitlement equates to a reliable per capita daily supply of 25 litres of acceptable quality water delivered within 500m of a persons dwelling.

Domestic. Domestic demand was assessed based upon the population in each of the communities in the Sand as identified by DWAF. All communities whose water supply is drawn from within the catchment were considered (see Table 2). Needs were based on the current and projected future population in each of the communities, using simple scenario's based on people receiving the 25 $lc^{-1}d^{-1}$ of their entitlement, and higher levels of 80 and 100 $lc^{-1}d^{-1}$.

Environmental Flow Requirements (ER). Environmental needs (the ER) were represented by Instream Flow Requirements or IFR's developed in 1998 (DWAF 1998; see Table 2).

Agriculture. Irrigation demand was assessed on the basis of crop type per scheme and crop water requirements from the literature. Two figures for the areas under irrigation were considered: maximum area and a 'realistic' annual area. The maximum area was determined from remote sensing images (see Pollard *et al*. 1998). A more 'realistic' area based on field interviews conducted by DWAF were used for calculations (DWAF 2002; Table 2).

Forestry. In South Africa commercial forestry must be licensed as a water user. As a stream flow reducing activity, forestry represents a non-point demand that is not dependent on abstraction infrastructure. The impact of foresty on stream flows is complex, but in the RIDe analysis it was modelled as simply another water user, using figures, based on remotely sensed forest area and the WR90 methodology (Table 2). All commercial forestry will be removed from the upper Sand river catchment by 2006 and thus this constitutes one of the future scenarios

3.3.4 Initial analysis, modelling, and scenario testing

The analysis of data was carried out in three steps. An initial analysis of the data looked in particular at the ability of existing infrastructure to meet both demand and entitlements, and also simple quaternary and catchment level water balance calculations looked at the degree to which the system was stressed. This was followed by two steps of scenario building and modelling. Firstly, using a simple excel spreadsheet model based on a water balance which looked exclusively at the ability of water resources to meet infrastructural demand lumped at the quaternary scale; and secondly a more complex modelling exercise using commercial modelling software (AQUATOR) which looked in more detail at both system demand and supply to communities.

In the first step of analysis simple water balance calculations were carried out on a monthly time step. These used median and lower quartile flows, generated from the WR90 data set, to estimate the extent to which resources in a given quaternary catchment in a given month were sufficient to meet the needs of existing supply infrastructure. At the same time an analysis was made of the potential service level provided to communities by (nominally) existing infrastructure.

The second step was to further develop the simple spread-sheet model to take the analysis forward by looking at the dynamics of upstream-downstream relationships and dam storage. This model used the entire set of simulated monthly quaternary level runoff figures from the WR90 data-set to calculate a monthly water balance in each of the nine quaternary catchments. All demands were lumped at a quaternary level, as was storage, which was modelled on the principle that all flow in excess of demand in that quaternary catchment would be routed to storage as long as there was spare capacity, and that in turn, water would be released from storage on the basis of any downstream demand.

The spreadsheet-based approach therefore provided lumped results at a quaternary catchment level. While these were useful for looking at the 'resource to infrastructure' side of the RIDe analysis, the approach lacked the ability to model individual systems or communities, and the extent to which their demand and entitlements were met. Also, in a system with a relatively sophisticated and complex network of bulk water supply, storage, and irrigation canals, the precise positioning of infrastructure with relation to other (upstream or downstream) demand becomes important. To provide a more detailed view, two different commercially available modelling packages were evaluated, and one, AQUATOR (Oxford Scientific Software, 2002.) was used to carry out a more detailed assessment that provided deeper insight into the role of the complex water supply delivery infrastructure of the Sand in meeting (or failing to meet) the demand of catchment communities.

Both the spreadsheet and AQUATOR models were used to test a number of developmental scenarios. The scenarios were developed from AWARD's ongoing work with catchment stakeholders, and looked at a range of critical issues including:

- Current use, with a focus on domestic requirements using minimum RDP and "realistic" actual gross demands (modelled at 25 lpcd and 80-100 lpcd)
- The impacts of reduced or eradicated plantation forestry
- The likely impacts of a proposed additional irrigation scheme
- The impacts of the Injaka inter basin transfer (IBT)

3.4. Results of the RIDe assessment:

Based on the logic of the framework the results of the RIDe analysis are presented under two main headings. The first is the ability of the water resources of the catchment to meet the demands placed upon them by supply infrastructure and environmental needs; the second being the ability (current and future) or water supply infrastructure to meet the demands of water users. For the RIDe exercise in the Sand, the focus was particularly on the extent to which a) domestic and b) environmental needs are and can be met both currently, and under future use scenarios.

Table 1 provides an aggregate overview of all the information collected during the RIDe analysis. It allows total infrastructure and environment based demand for water to be compared to total resource availability, and total infrastructure capacity to be compared to total user demand. It also reflects much of the ambiguity and uncertainty found while carrying out the RIDe analysis. The entries for forestry and ecological needs under both 'demand/entitlement' and 'infrastructure' columns reflects their special status as water users that do not rely on infrastructure. Figures for forestry and agriculture show great discrepancies depending on source (as was briefly discussed in the previous section); only the bold figures were used in calculating totals. The infrastructural element of agricultural demand is based on simple analysis of crop water requirements – not on a knowledge of actual off-takes at weirs, etc.

Description		Resource	Infrastructure	Demand/ Entitlement
Surface-water availability	Median	**75,200,000**		
	Lower quartile	**48,830,000**		
Ground-water	DWAF est.	8,000,000		
	2%recharge	30,902,127		
	5%recharge	77,255,319		
	10%recharge	154,510,637		
ER	IFR 50% probability of exceedanc		***38,620,800***	***38,620,800***
BHNR/RDP	25 lpcd			2,466,907
Domestic	100lpcd			**9,867,629**
	Bulk (drawn from the Sand)		**6,329,100**	
	Bulk (supplied to Sand communities)		5,901,533	
	Groundwater		5,110,000	
Agriculture	AWARD		*22,286,129*	22,286,129
	DWAF		***12,170,000***	**12,170,000**
Forestry	DWAF		*4,888,415*	4,888,415
	AWARD		***6,755,706***	**6,755,706**
Total (no transfer)	**Median**	**75,200,000**	**64,060,806**	**62,489,335**
	Lower quartile	**48,830,000**		

Table 1 Desktop RIDe analysis of the Sand River Catchment, its infrastructure and communities

Table 2 shows output from the scenario modelling exercise showing how at a catchment level, and for different levels of certainty, the flow required to meet ecological requirements compares to available water remaining in the river after abstraction. The modelling exercise focussed on the 1980s, a notably dry decade. The months shown in the table show one rainy season (February), one transitional (April) and one wet season month, each with different levels of agricultural demand (high in February, lower in April, and rising again in October). Aggregate requirements for the monthly ER at 50% and 90% frequency of occurrence are respectively 39 and 12 million metres cubed annually.

As is to be expected in a river in a semi-arid region, most flow takes place in the wet season months, with the result that meeting needs for domestic and irrigation activities is only possible by using storage infrastructure to manage the rivers natural flow regime. More importantly, the model suggested that under current use scenarios, the amount of water available, at a catchment level during the 1980s, over and above the ecological reserve varied from 7 to 10 million metres cubed depending on the level of certainty. In other words approximately equivalent to domestic abstraction (see Table 1). (Smits *et al*, 2004)

	Frequency of occurrence	ER	Virgin (WR90)	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		Ml/d		Ml/d	Ml/d	Ml/d	Ml/d	Ml/d
Feb	90%	**56**		30	26	46	45	97
	50%	**187**		190	186	235	232	285
Apr	90%	**36**		48	45	55	51	103
	50%	**123**		133	129	146	143	196
Oct	90%	**25**		22	18	28	28	80
	50%	**48**		30	26	30	30	82

Table 2 Requirement for ecological reserve (expressed as percentage of time a given flow is exceeded), compared to modelled water availability for the dry 1980s.

3.4.1 Ability of the water resources of the system sufficient to sustainably meet demand

Table 1 would seem to suggest that, at a catchment level, there is currently not a serious problem with over allocation. However, annual figures obscure the potential vulnerability of the catchment. A key characteristic of catchments of the lowveld is their inherent variability (Davies *et al*. 1995). Critical period in terms of low flows arise over the dry winter months (May – September) and it is these months that need to be closely examined in terms of balancing water availability and demand. The more detailed modelling shows that during the 1980s, unless the ER was to be breached, there was only sufficient water available to meet domestic needs and not those of irrigated agriculture. Scenarios representing current use showed that in the majority of months (including the wet season when irrigation demand peaks) there was failure to meet ER requirements.

Figure 4 shows similar data, but as a graph of monthly water balances that show the demand of each of the main water uses, as well as the surplus (or deficit) found by subtracting the sum of all demands from the available stock (median flows). What this temporal dissagregation shows is that while resources are adequate to meet needs most of the time (but not in October or November), when the ER (expressed as the IFR at 50% certainty) is also to be met the river is already over-committed. Once further resolved to a quaternary level, analysis is hampered by a lack of IFR estimates. However, the situation is likely to be more serious still, with the quaternaries in the middle reaches of the catchment (with larger populations and irrigation schemes) being severely over allocated.

Even without the need to meet ER it is apparent that, in the absence of inter-basin transfers, storage is necessary to assure domestic and irrigation supplies to the necessary level of security. The implication of a deficit at such high frequency is that more detailed analysis is needed, including modelling of the suitability of dams (existing or planned) to ensure continuity of supply is to be assessed.

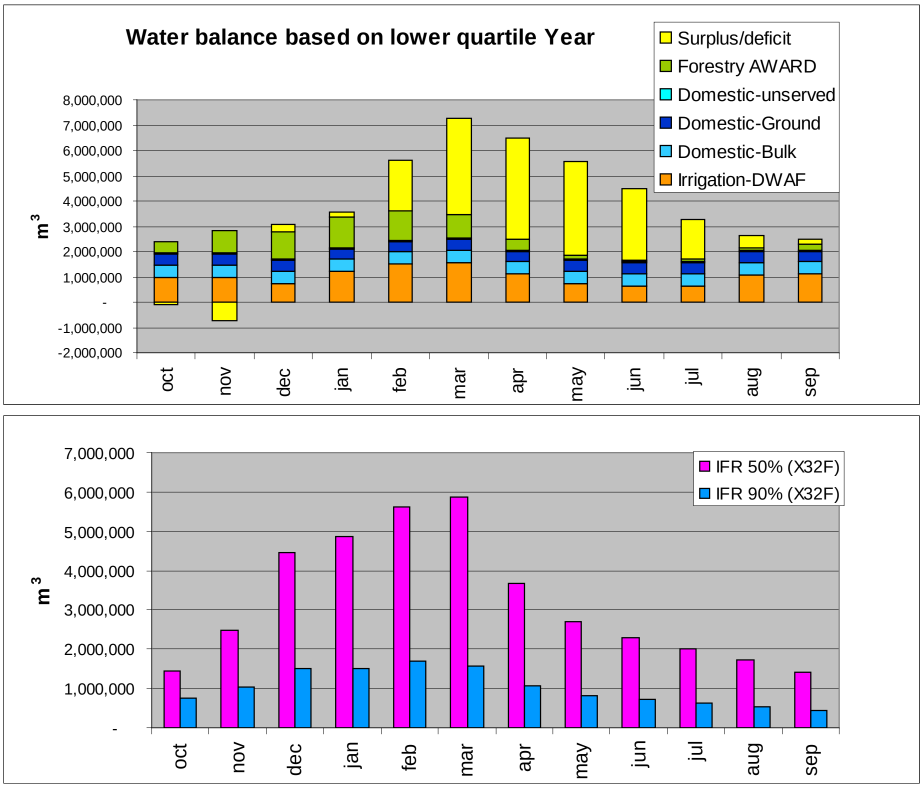

Figure 4 A monthly water balance based on lower quartile flows for the Sand Catchment with indication of the ER (as represented by 50% and 90% frequency of occurrence).

3.4.2 Ability of infrastructure to meet user requirements?

A quick look at Table 1 would seem to suggest that the capacity of domestic water supply infrastructure a higher (100lpcd) level of user demand as well as meeting irrigation needs. However, as was the case with the water resources side of the RIDe analysis, the high level of aggregation masks a far more complex reality.

As was previously mentioned, the institutional situation within Bohlabela District Municipality and the Sand catchment is evolving very rapidly. This has impacted on the accuracy of the RIDe assessment, with information generally hard to come by, often contradictory, and frequently unreliable when ground-truthed. The last issue is of special concern as the opportunity to ground truth data was very limited, but what has been done suggests great disparities between what is believed or claimed to exist in terms of supply infrastructure and actual water received by communities. In this the case of the village of Utah A (Box 3) is illustrative.

Box 3 What people really get – the case of Utah A

According to the RIDe survey, the village of Utah A has a complement of 11 boreholes, of which 4 are equipped, and is also served by a bulk water supply. Together this infrastructure is capable of supplying a total of 92 lpcd. Yet the reality on the ground is that only one of the boreholes has an engine, and the bulk scheme (of which Utah is a tail end community) has not supplied water for several years. Monitoring by AWARD suggests that what the average Utah citizen receives at the tap is closer to 10 lpcd. This sort of experience is the rule rather than the exception for much of rural South Africa. Infrastructure within the Sand is generally poorly maintained, frequently broken and often parts are stolen. In addition:

- there is widespread failure to keep records of equipment up to date;
- illegal connections to bulk schemes are common meaning that water never reaches some of its intended recipients;
- there is a lack of willingness on the behalf of communities to pay for diesel to operate systems; and
- poor maintenance of the local level distribution systems leads to wastage and inequitable supply within communities.

All this goes to show that neither installing infrastructure nor ensuring the safeguarding of sufficient water resources alone is enough to guarantee levels of supply. Operation and maintenance, equity of access, and leak management must all be dealt with if a functioning services is to be maintained.

However, even without taking into account the disparities between the theoretical capacity of water supply infrastructure and the reality on the ground, the figures for installed infrastructure provide interesting and useful information. Figure 5 below shows potential service under two scenarios, 100% efficient supply, and inefficient supply, set arbitrarily as being 50% for bulk, and 75% for groundwater schemes. The graph shows that between seventy and eighty thousand people are below minimum RDP norms depending on the scenario used. While the graph is capped at 400 lpcd its maximum is 1,260 lpcd. In other words, while around 30% of the catchment community has yet to achieve RDP minimum standards of 25 lpcd, some people have a (potential) supply of well over 1,000 lpcd.

Figure 6 shows the geographic distribution of the different service levels enjoyed by different communities. Service levels show great disparities, but in general it can be seen that the smaller communities who in general rely more on groundwater, are among those with the highest potential service level. The RIDe assessment treated communities as homogenous. In fact, survey work carried out by WHiRL shows that this is not the case, and that even within communities there are great differences in access to water, driven by issues of wealth and location with respect to supply infrastructure.

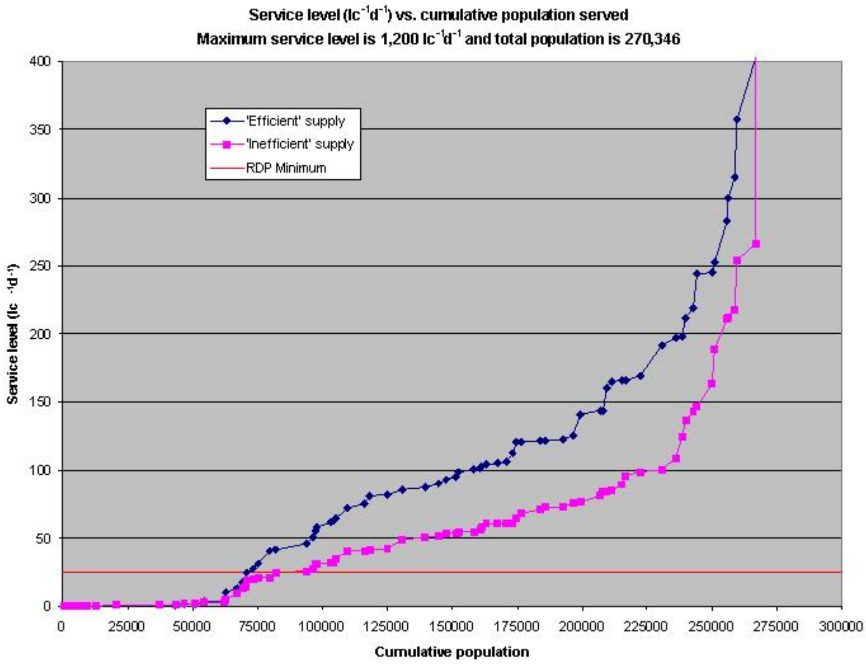

Figure 5 Cumulative population served

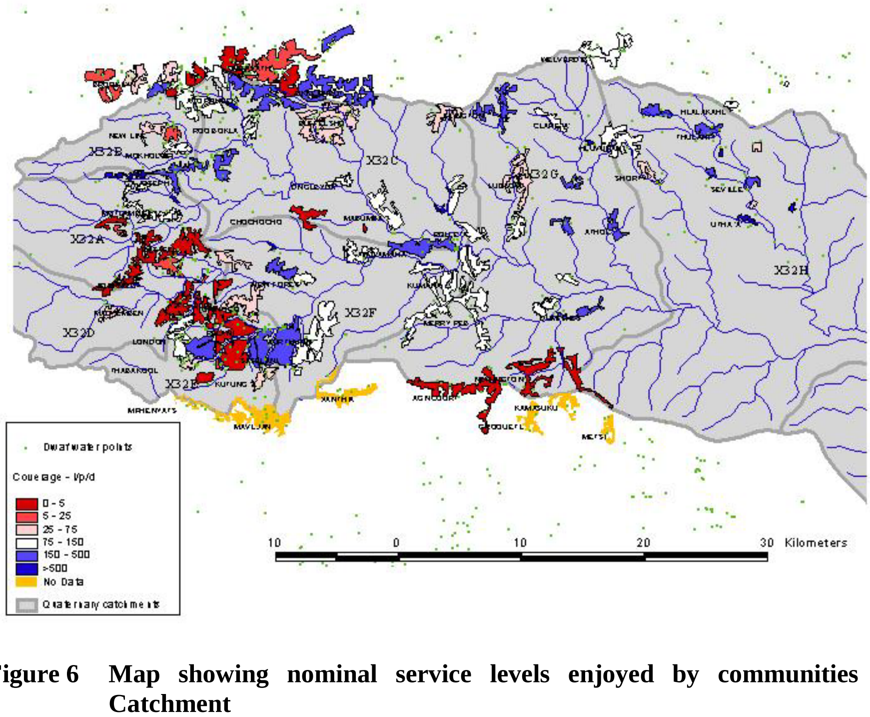

Figure 6 Map showing nominal service levels enjoyed by communities in the Sand Catchment

3.5. Principal conclusions of the RIDe analysis in the Sand

3.5.1 Available resources

Surface water:

- The catchment is currently, at least partially, overcommitted. While surface water resources are generally sufficient to meet current demand for domestic, irrigation, and forestry use, this is only at the cost of failing to meet the ER much of the time. Given that effective rationing within large water delivery systems is difficult or impossible caution should be observed in licensing further abstraction. If a high level of security is required for the ER then licensed abstraction should probably be reduced from current levels, until the inter-basin transfer is operational.
- The Injaka inter-basin transfer, once it comes fully on line, will create a radically altered picture. Looked at from the catchment scale, water resources would then be sufficient to meet all planned needs and satisfy the requirements of the Ecological Reserve. However, the real impact of the IBT will be to cut the catchment in half, with those quaternaries downstream of the transfer inlet having adequate water at all times, but those above (in the absence of significant new infrastructure or other changes) remaining in their current situation.

Groundwater:

- Groundwater is generally under-developed. Taking a low estimate of groundwater recharge as 2% of average annual rainfall suggests a reserve of 30Mm^3/annum. This compares with total current domestic demand of 9Mm^3/annum and the IBT of 25Mm^3/annum. While difficulties undoubtedly exist in developing groundwater in the complex geology of the catchment, the fact remains that this resource is under developed and under used. All additional supply to meet RDP minimum standards (and significantly increased service levels) could be provided by groundwater schemes.

3.5.2 Infrastructure

Domestic:

- Lack of access to domestic water supply is a combined institutional and infrastructural problem, not a resource one. The RDP minimum of 25 lpcd could be supplied to most communities by existing infrastructure if, the infrastructure functioned properly, transmission was efficient, and an effective rationing system could be enforced. None of these can be assumed to be likely, particularly the last. The communities that cannot currently receive their RDP minimum are those that are not linked to a bulk schemes, and/or do not have sufficient groundwater pumping capacity installed.
- At a community level, some boreholes have the capacity to supply much more than the communities demand, but this water cannot be used without local transfer infrastructure.
- With currently installed infrastructure, groundwater can supply about 50% of the total domestic demand. However, there are strong indications that it could eventually supply almost all of it – and to a high service level.
- While the IBT can provide sufficient water to meet all domestic needs, this will not happen unless new supply infrastructure is developed.

Agricultural:

- Because of the location of domestic intakes which are generally upstream of irrigation canals irrigation does not have any major impact on downstream domestic users

- Existing irrigation infrastructure is capable of (and does) completely interrupt river flows during low flow periods in lower stretches of the river. The new operating rules developed as part of the IBT require intake structures that take a percentage of flow rather than allowing the river to be run dry. The new structures have yet to be built, but it is expected that they will greatly improve the ability to meet the ER, regardless of the eventual completion of the IBT

3.5.3 Meeting demand and entitlements

Domestic: Existing domestic supply infrastructure in the catchment can supply on average over 100lpcd. However this figure disguises great disparities, with approximately 30% of the communities in the catchment having insufficient infrastructure to meet their RDP minimum standard of 25lpcd. In addition the quantity received by people is considerably less than theoretically installed capacity in many communities. With the IBT functioning, an improved service level based on a per capita supply of at least 100lpcd could be comfortably provided for, but only with matching extra investments in infrastructure to convey water to those communities that do not have access to bulk schemes. Importantly, the very high estimated cost for infrastructural development far exceeds the potential recovery (Mr. G. Deysel, BDM, pers. comm.). This situation lends support to the proposal for community-based groundwater schemes.

Agriculture: current irrigation demand cannot be met under drought conditions, although at other times it can. The extra water to be provided by the IBT is theoretically sufficient to meet current agricultural demand comfortably (but see the point above about infrastructure requirements).

In summary the RIDe analysis in the Sand catchment provides three major conclusions:

a) that failure to meet domestic needs is a supply (institutional and infrastructural) issue, rather than a resource problem
b) that increased service levels (up to 100lpcd) could be comfortably met if groundwater use was more widespread or irrigation use reduced, and
c) that the Injaka IBT will be critical to meeting current demand, and once installed and functioning at full capacity should ensure that existing IFRs are met most of the time

3.5.4 Recommendations and next steps

Several principal recommendations can be made based on the assessment:

Resource

- Groundwater availability should be mapped across the catchment. It is strongly recommended that rather than further extending the bulk supply network to the more distant communities in the eastern half of the catchment, a policy of groundwater based supply be examined. Bulk supply should be seen as a last, and worst-case, option.

Infrastructure

- Before more money is spent on new infrastructure a detailed survey should be made of existing infrastructure to determine what works, what doesn't, and most importantly why.

Demand and entitlement:

- An urgent assessment is needed within at least a representative sample of communities to determine actual levels of water use, as well as barriers to access.
- Also as a matter of urgency irrigation abstraction for large schemes should be metred. This is conversant with the most basic principals of good IWRM.
- No further licences to abstract surface water for irrigation should be given until the current situation is understood better; both in terms of water used, but also economic benefits.

3.6. Main lessons learned using the RIDe approach in South Afirca

The use of the RIDe in the Sand had a focus on river and quaternary catchment level water resources and their ability to meet human and ecological requirements. As such it was different to its use in India (section 4) where it was used primarily at a village level. Nonetheless, we found it a useful conceptual approach to addressing issues in the Sand, and particularly the difficult issue of the Basic Human Needs and Ecological reserve. The simple (but crucial) insight made was that there is little benefit to identifying a catchment level BHNR based on population numbers, while ignoring the infrastructure needed to deliver it, has important implications in terms of recommending how the BHNR should be dealt with in future.

However, the RIDe work was not without weaknesses, due partly to lack of resources and partly to the fact that it was a new approach being developed during the work reported in this paper. Two particular weaknesses are worth mentioning

- The first is that, as mentioned above, the RIDe work in South Africa made insufficient effort to look at actual access to and use of water by communities. In most cases we were forced to use records of installed infrastructure for use, but as discussed this provides a rather overoptimistic picture. A RIDe assessment that ignores access and use must therefore be considered incomplete.
- The scope of the RIDe should be increased to look at water quality issues. There is already concern that low flow IFRs set for the drier months may be insufficient to ensure proper bio-remediation of waste water from some of the larger settlements.

4. USING THE RIDE FRAMEWORK FOR VILLAGE-LEVEL PLANNING TO IMPROVE WATER SUPPLIES IN SOUTHERN ANDHRA PRADESH, INDIA

4.1. Introduction

In recent years, there have been dramatic changes in the surface and sub-surface hydrology of the drought-prone areas of southern Andhra Pradesh primarily as a result of increased groundwater extraction for irrigation. Some seasonal rivers have become less dependable sources of water (e.g. the Pennar River); annual in-flows to tanks have reduced; domestic water supplies in many towns and villages are becoming increasingly unreliable; and, in general, the ability of livelihood systems to withstand the shock of drought has deteriorated. It is in this context of demand for water outstripping supply that the RIDe analytical framework was used as part of an action-research project to improve the domestic water supplies of four villages in Anantapur District, Andhra Pradesh.

4.2. Background

4.2.1 General context

The four villages are all located in the Kalyandurg Sub-district of Anantapur District in Andhra Pradesh (see Figure 1). These villages were selected because they were in a sub-district in which a larger survey of water points had recently taken place (Rama Mohan Rao *et al*, 2003) and, hence, it was known that all four villages had domestic water supply problems. Another consideration was the fact that three of the four villages were sites of ongoing watershed development activities. The names and demographic details of the pilot villages can be found in Table 1. The piloting of the RIDe framework started in these villages in October 2002. Although government-funded watershed development activities will continue, WHiRL-funded work in the four villages is scheduled to finish at the end of March 2004.

Village	**Population**	**Number of households**
Battuvani Palli	1186	162
Manirevu	1340	295
Obulapuram	630	116
Pathacheruvu	215	48

Table 3. Pilot village's demographic information

All four villages are located in a predominantly red soil (alfisol) area that is underlain by granites and gneisses. The hard-rock aquifers hold limited supplies of groundwater that are vital for both irrigated agriculture and domestic use. Mean annual rainfall is approximately 500 mm, however, there is considerable inter- and intra-annual rainfall variability and droughts and years of relatively high rainfall are common. The main land use in Kalyandurg is rainfed arable cropping with groundnut being the principal crop. Net irrigated and forested areas were estimated in 2001 to be 12% and 5% (Rama Mohan Rao *et al*, 2003). The principal irrigated crop is paddy rice.

4.2.2 Status of water resources

A water audit that was carried out in Kalyandurg during 2001 indicated that there had been a large increase in groundwater extraction during the previous 10-15 years (Rama Mohan Rao *et al*, 2003). As a result, groundwater levels had fallen and shallow wells had failed as deep borewells had been constructed and extraction from deep aquifers had become the norm. The water audit also indicated that surface water resources were close to being fully exploited in years with low or average rainfall. The large increase in agricultural water use was been prompted in part by a history of federal and state programmes that provided, for example, grants and subsidised loans for well construction, free or subsidised electricity for pumping water for irrigation and funds for the building water harvesting structures. Even the more innovative recent state programmes, such the *Neeru-Meeru* programme, have concentrated on funding supply-side activities on the premise that there are large untapped water reserves in drought-prone areas.

4.2.3 Domestic water supplies in Kalyandurg

In much of rural India, domestic water supplies are typically point sources – wells, or boreholes. As such, the link between demand and entitlement is closer than in the larger piped water systems found in South Africa. As part of the 2001 water audit (Rama Mohan Rao *et al*, 2003), rapid participatory assessments were made of status of the 438 domestic water points (hand pumps and public taps) in Kalyandurg Sub-district. The following factors were considered when classifying each water point as being *satisfactory* or as having a *problem*: functionality (i.e. no technical problems), distance to water point (i.e. less than 1.6 km), crowding (i.e. less than 250 people using the water point), adequacy of supply (i.e. 40 l available 365 days/year), peak summer availability (i.e. similar time and effort needed to collect water in peak summer), accessibility (i.e. no social exclusion), and water quality (i.e. acceptable from users' viewpoint). These factors and permissible limits are similar to those used by the Rajiv Gandhi National Drinking Water Mission.

The rather startling finding was that 51% of domestic water points in Kalyandurg were classified, by the users, as having a *problem*. In addition to showing the wide variety of problems faced by domestic water users, these figures compare starkly with official statistics which suggest that, at any one time, there are very few *problem* water points in these mandals. One reason for this is the fact that the official statistics concentrate almost entirely on "coverage" of villages with improved water supply systems and on whether or not a supply of 40 l can be provided. Also, the official statistics give little attention to problems of peak-summer water availability and the problems experienced by women particularly in queuing for water during these lean times.

The 2001 participatory assessment also indicated widespread social restrictions on access to domestic water sources. These restrictions took two main forms. Firstly, lower castes could not touch ('contaminate') open-well water, but could use public taps and hand pumps. Wherever scarcity forced villagers to use open wells as a source of domestic supply, lower castes brought their vessels to the well but could not draw water from it. They had to wait for upper caste villagers to fill their pots with water. Secondly, in many villages, separate hand pumps or public taps have been set up in parts of the village where the lower castes reside. When water was scarce and insufficient in the "upper caste" areas of the village, but available in the lower caste areas, upper caste villagers came to fill their vessels. The result being the lower caste families had to wait till the upper castes had taken their fill before collecting the remaining water from public taps or hand pumps installed by the government line department for their exclusive use.

4.2.4 Project interventions

Table 4 summarises the main differences between the approach taken by WHiRL as compared to more "traditional" watershed development or rural water supply projects. More discussion on these differences and related issues can be found in the WHiRL Project final report (WHiRL, 2004).

Watershed Development	Rural Water Supply	WHiRL Approach
• Little consideration given to protection of domestic supplies	• Source protection rarely involves consideration of overall pattern of water use and availability in whole watershed	• Regulating competition between domestic and agricultural users considered as an important part of source protection
• Planning starts with a very short "menu" options that are applied universally (i.e. watershed development is not problem focused)	• Planning of new sources of supply is not participatory nor are a wide range of options considered	• Planning is a participatory problem-focused procedure. Activities and/or interventions are matched with the problem and the local context
• Planning process tends to be rapid with little time for interactions and reflection (i.e. project management cycle is not used)	• Planning process tends to be rapid and non-participatory particularly during periods of drought or water shortage	• Planning process proceeds at a pace that is dictated primarily by the village and the communities in that village.
• Participatory surveying of water quality and quantity problems is not used as a starting point for identification of the causes of water-related problems	• Water quality surveys are not participatory and results of water analysis are not fed back to villagers	• Any surveys involve villagers and feedback to the village as a whole. Importance given to local and traditional knowledge.
• Equity issues that relate to inter-village, upstream-downstream and inter-generational equity are not considered	• Use of domestic water supplies for productive purposes (e.g. watering livestock, tea stalls etc) not considered.	• Wider equity issues are considered as is the importance of household-level use of water for productive purposes
• Awareness raising, institutional development and capacity building are rarely treated as a long-term processes requiring mediation and as much investment as physical works	• Water quality statistics are not cross-checked with the views and knowledge of villagers. Incidence of diseases such as dental and skeletal fluorosis are not used as indicators of water quality problems	• Strong emphasis placed on awareness raising and on cross-checking secondary information that does not agree with the facts on the ground
• Emphasis placed on increasing agricultural production	• Emphasis is put on meeting quantity norms. Less attention is given to other factors that reduce access to safe domestic water	• Priority given to meeting basic human needs even during years of drought

Comment [m1]: Is this the same thing as the other two?

Table 4 Summary of main differences between the approaches of the WHiRL project and "traditional" watershed development and rural water supply programmes

4.3. Use of the RIDe Framework

4.3.1 Project management cycle

The project management cycle that was used to guide WHiRL project activities in the four pilot villages is presented in Figure 7. As the project management cycle was designed to be interactive and process-based, activities in each village proceeded at a pace that was dictated primarily by village-level factors. The RIDe framework was used throughout the planning cycle, however, it was found to be most beneficial during the "option identification" phase. Figure 7 highlights details of the main steps and interactions that took place during this phase. At each of these steps, discussions were structured so that issues relating to water resources, infrastructure and demand/entitlement were considered explicitly either as separate entities or as part of the overall management system. For example, **Table 5** lists the main issues that were identified as problems affecting domestic and productive water supplies and considered during the "problem analysis & issue identification" step.

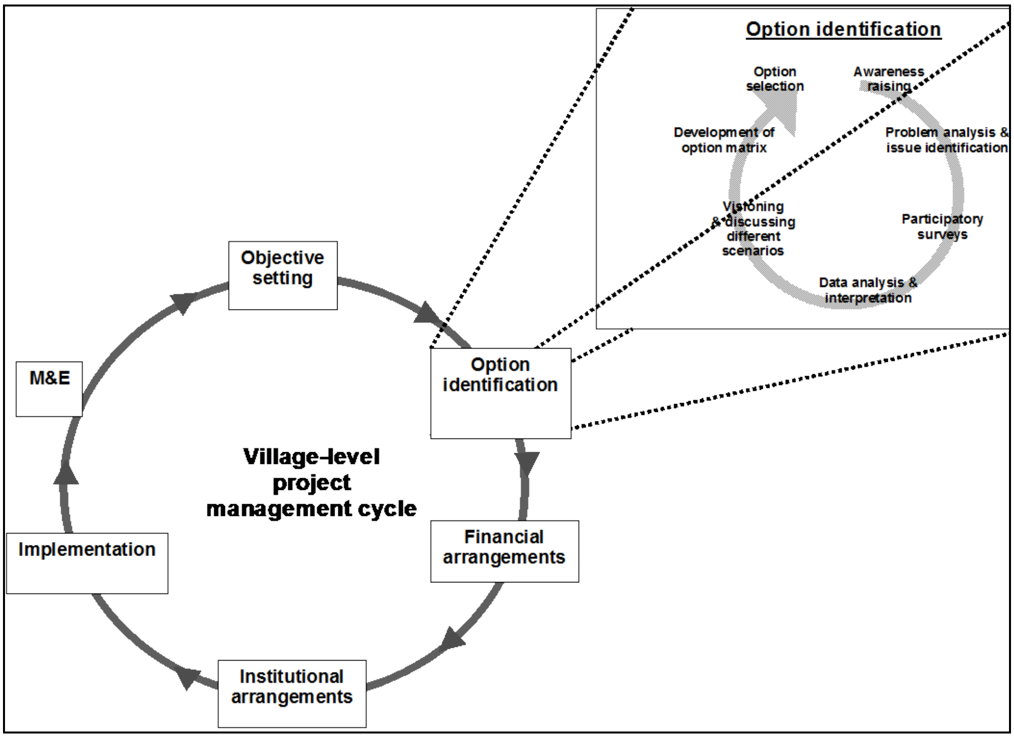

Figure 7 WHiRL project management cycle

Resources	Infrastructure	Demand/Entitlement
• Declining groundwater levels • Tank inflows declining • Recurrent meteorological drought • Fluoride and other water quality problems	• Poor O&M of RWS infrastructure • Power supply problems • Limited domestic water storage • Well failure due to competition for groundwater • Competitive deepening of wells	• Caste restrictions on domestic water access • Demand for safe domestic water not met • Demand not met for irrigation water • Demand not met for water for small-scale productive uses • Land and water disputes with neighbouring villages • F related health problems • Big increase in 2020 demand anticipated

Table 5. Issues identified using a RIDe framework during "problem analysis & issue identification"

4.3.2 Participatory surveys

Participatory surveys were organised to provide “technical” information on the causes of some of the water-related problems. Surveys included assessment of the condition of tanks (reservoirs), the impact of new water harvesting structures on tank in-flows and availability and access to “runoff water” in relevant tank catchment areas. Participatory surveys were also carried out on: fluoride concentration of domestic water sources and a representative sample of irrigation wells and the condition of water supply infrastructure.

All four pilot villages have tanks that were constructed more than 50 years ago to store water that, historically, has been used for a wide range of uses. Battuvani Palli and Manirevu are both located in headwater catchment areas and each village has one large tank. Pathacheruvu and Obulapuram also have village tanks but as they are not located in headwater catchments, there are other villages and tanks located in the catchment areas of their tanks. In recent years, all the tanks have been converted into percolation tanks (i.e. they are no longer used to supply “irrigation” water directly to downstream irrigation schemes) and large numbers of large water harvesting structures have been constructed in the tank catchment areas.

Participatory surveys carried out in each village, measured the storage capacity and specific catchment areas of all water harvesting structures that were located along drainage lines. Using 20 years of daily rainfall data, the volume of water harvested by each structure and the potential impact on downstream flows was calculated using a simple MS-Excel based bucket-type model. Runoff was estimated using the SCS method (Samra *et al*, 1996). The results of this analysis agreed well with local knowledge. The outputs from this survey also provided information for discussion of the impact of the new water harvesting structures on the utility of the village tanks and on groundwater recharge in the locality of wells that supply domestic water to the villages.

High levels of fluoride in domestic water have emerged as a major health problem in Kalyandurg in recent years. Symptoms include: skeletal deformities, stunted growth, aching joints, brittle bones and discolouration of teeth. Participatory surveys were carried out using a pocket colorimeter (Hach, USA). The findings of these surveys were shared immediately and, as with the runoff analysis and findings, this relatively specialised information was combined with local knowledge in the next steps of “option identification”.

Finally, an attempt was made to carry out an MS-Excel based village-level water audit for each village. These audits were structured in the same way as the Sand River RIDe analysis reported in the previous section. This was not successful even though the approach used procedures for village-level water balance estimation that are recommended by the Government of Andhra Pradesh. The main problem was that reliable information on groundwater levels and aquifer characteristics were not available and, hence, it was impossible to have any real confidence in the water balance figures that were produced.

4.3.3 Visioning

In reality visioning and awareness raising were continuous iterative processes rather than discrete steps suggested by Figure 2. Many different approaches were taken to awareness raising (e.g. exposure visits, handouts, practical demonstrations, a video) and visioning discussions often involved mediated activities that could be better classed as awareness raising. Discussions during the visioning process took place in formal and informal meetings at the household, street and village levels, led to the identification. **Table 6** is a summary of some of the options that were identified.

Resources	Infrastructure	Demand/Entitlement
• Improve ground and surface water management so as to improve sustainability of domestic water supply and equity of access to water for productive purposes • Reduce F concentrations by improving recharge to and/or reducing extraction from aquifers that are sources of domestic supply	• Develop alternative domestic supply sources • Establish institutions to manage/protect domestic supply infrastructure • Promote installation of gates in water harvesting structures to enable better management of run-off • Promote water harvesting in village to provide source of water for small-scale productive use • Develop resolutions for improving tank inflows • Pilot the use of simple household-level techniques for reducing F concentration of drinking water	• Ensure demand for safe domestic water met for all members of community • Improve tank inflows during low rainfall years. Thereby improving tank utility for livestock watering, bathing, washings and cultural activities • Reduce risk of well failure as a result of competitive well deepening • Improve access of the poor to water for small-scale productive purposes

Table 6. Summary of options identified during the visioning process

4.3.4 Option Matrix and option selection

Table 7 is a summary of the option matrix that was produced during the Battuvani Palli option selection process. The full option matrix for this village has more options and more detail, and it evolved over time as discussion and reflection led to different variations being proposed. The advantage of using this RIDe-based option matrix was that it ensured that the feasibility of each option was discussed in a structured and systematic manner. This meant that options were discarded that, say in the case of Options 2 and 5, were unacceptable in societal terms even though they were technically feasible. In the end, the consensus was reached in Battuvani Palli to make Option 1 their preferred option but then to switch to Option 2 if the new borewell on Temple Land had fluoride content that was above permissible limits.

Option	Stock	Infrastructure	Demand / Entitlement
1. Borewell on Temple Land	Expected high yield and high F conc.	Feasible but 2 km of piping required	No societal problems as not private land
2. Borewell in area of low F concentration on border with Duradakunta	Expected high yield and low F conc.	Feasible but 5 km of piping required	Unacceptable – land ownership is disputed
3. Borewell on Temple Land. If high F conc., exchange with farmer	Expected reasonable yield and low F conc.	Feasible but 2 km of piping required	Acceptable but complicated both legally and politically
4. Shallow borewell along nala to south-west of village and near to water harvesting	High risk that F conc. will be high and yield insufficient	Low infrastructure costs	Not societal problems
5. Village-level treatment of current village water supply to reduce F conc.	Current source has high yield and high F conc.	Technically feasible to install treatment plant	Unacceptable because running costs too high
6. Household treatment of current village water supply to reduce F conc.	Current source has high yield and high F conc.	Feasible to use filters, Nalgonda treatment etc	Unacceptable because running costs too high

Table 7. Summary of the Battuvani Palli option matrix

4.4. Principal conclusions and lessons learned from usign RIDe framework in India

Programmes aimed at integrating rural water supply and watershed development require decision-makers at all levels to take a holistic approach to identifying both causes and solutions to water-related problems. It is also generally accepted that the active participation of stakeholders is crucial to successful identification of the causes of and solutions to water-related problems. One aim of the WHiRL Project, which was responsible for implementing the pilot studies reported here, was to develop innovative and practical methodologies that could be used to improve and protect water supplies used to meet basic human needs.

The experience of piloting the RIDe framework in India is that it helps facilitate successful local-level implementation of integrated water resource management particularly when used as part of a project management cycle that is also geared to integrated and participatory decision making. Feedback from the WHiRL field team, which comprised a community organiser and a natural resources specialist, was that the RIDe framework helped to ensure that discussions were systematic and problem-focused. They also believed that the RIDe framework helped to structure discussions such that confusion over symptoms and causes of water related problems was minimised. The process led to the selection of options that had local ownership and that were tailored to the social and physical context in which they were to be implemented.

Although the piloting of the RIDe framework in India has focused on decision-making at the village level, district-level NGO and government line department staff have been involved and every effort has been made to pilot procedures that can be replicated and scaled up. Given the success of the work to date, it is suggested that the next step is to pilot the use of the RIDe framework at a larger scale with greater involvement of sub-district and district level staff. Although institutional difficulties can be anticipated as a result of, say, line department remits and resistance to change, these should not be insurmountable not least because recent Government of Andhra Pradesh legislation (i.e. the Water Land and Trees Act) calls for more integrated approaches to land and water management. It is also recommended that the RIDe framework be used by NGOs as a practical tool to ensure that their own watershed development planning recognises domestic water needs and that rural water supply planning considers the water demands of other sectors.

5. INITIAL LESSONS FROM IMPLEMENTING RIDE

The RIDe framework emerged from the real needs of action research in India and South Africa that was focused on addressing water resource management problems associated with domestic water supply in rural areas. As such it is based in the practicalities of trying to apply IWRM principles to local level water resource development and management. This section of the paper summarises the lessons learned from the application of RIDe in these two different contexts, and draws some generic lessons to provide guidelines for other users who wish to apply or further develop the RIDe framework.

RIDe can be used with different entry points and at different scales. The entry point (whether resources, infrastructure, or users) should be driven by the nature of the problem being considered, and this will also influence the scale of analysis. In South Africa, a water resources entry point was adopted at a river catchment scale, and the problem revolved around ensuring that catchment resources were adequate to meet needs under different development scenarios. In India, the entry point was users' demands and entitlements (and ensuring that these could be met); with the main focus being the need to meet domestic water requirements at the village-level. This latter case also illustrates how different scales may need to be considered in an assessment, from the localised basement aquifers when looking at groundwater, to the much larger catchment areas of tanks/reservoirs that harvest surface water and recharge wells located nearby.

RIDe makes explicit the implications on water resources of using large scale infrastructure to supply user requirements. Because of the nature of large supply systems (irrigation, domestic, industrial) it is often difficult to effectively ration water once it has entered the system, due the large number of individual users who's behaviour would need to be modified. If a domestic water supply system is designed to bring 200lpcd to 1,000,000 people 200 km away, it is unrealistic to assume that it will be possible to require the utility manager to halve the intake because of drought, or the need to meet international requirements downstream. Infrastructure, and particularly infrastructure for domestic supply and high value industry, imposes its own political and economic reality on water resources.

An iterative and phased RIDe approach is useful. While described in the two case studies as a largely linear process, RIDe, like other holistic planning approaches, is highly iterative. Initial problem analysis is often nothing more than brainstorming, and is in turn used to identify key stakeholders and information sources, followed by initial secondary data collection, quality control and analysis. This in turn serves to highlight new problems and information gaps. We found that RIDe based analysis is best carried out in two principal phases: Phase 1, data collection, quality control and reconciliation (water resource assessment) and Phase 2, analysis, scenario testing and presentation of results.

Pragmatic data collection is critical. In general there is lots of information available on an area, and this should be gathered, and where necessary ground-truthed. It is not unusual to find big discrepancies between the secondary information that is held by different stakeholders. Involving these stakeholders in reconciling and, where necessary, correcting information is a crucial step if consensus is to be reached. It is also important to be pragmatic and flexible in collection and use of information based on principals of optimal ignorance and maximum imprecision. There is always a limit to how much data is required, and the quality of the data needed. Box 2 gives a brief overview of the kind of information that may be available and useful to collect.

The RIDe framework is applicable to both large and small studies. The RIDe concept is equally valuable for an afternoon's work gathering information from a few reports, or a multi-million investment in primary data collection. Making an assessment of the relative value in terms of improved decision making versus the cost in terms of extra data collection is an important part of a RIDe or any other water resource assessment.

Box 2 Key issues in information collection for a RIDe based analysis

- **Demand (and entitlements)**
  - Identification of all uses and users within an identifiable community or other recognised administrative unit, of their representative structures and organisations, and of roles and responsibilities in ensuring that requirements are met.
  - Assessment of water requirements: current and future; quality and quantity, for each group of users. Requirements may vary throughout the year, and the importance which users allocate to water for different uses may vary.
  - Information on the degree to which requirements are being met (user satisfaction), and barriers to access. It is important that the information collected be qualitative (dealing with users' perceptions) as well as quantitative, and that it be disaggregated to look for differences in access based on wealth, gender, caste or other social distinctions.
  - Information should be collected both from representative agencies, but also directly from users. This is particularly critical for qualitative information and information regarding accessibility and equity.
- **Infrastructure:**
  - Identification and quantification of the capacity of all different water supply systems providing water to a user group and/or, of the system demand of all infrastructure drawing water from a resource unit.
  - Information on infrastructure can be collected from relevant agencies (irrigation, domestic water supply etc), and should include information on the roles, responsibilities and effectiveness of the agencies themselves.
- **Resource:**
  - Identification and quantification of the availability (current and future) of water resources surface and ground; quantity and quality; naturally occurring and impounded within the area(s) of interest. This information needs to be temporally and spatially disaggregated to a scale that is relevant to the supply infrastructure.
  - Information should also be colleted on existing or planned future allocations of water resources including amount, assurance, and the user or infrastructure manager to which the allocation is made.
  - As for Users and Infrastructure, identification of the main stakeholder institutions involved in water resource management (allocation, licensing, etc.) and their effectiveness is important.
  - Information on stocks can come from a variety of sources, ranging from observed historical flows to the outputs of complex models. While the environment is characterised as a user in the RIDe approach, information on, and responsibility for meeting, environmental requirements often rests with the same institutions in charge of water resource management.

Analysis may include an element of modelling. As described in the South African case study, both simple spreadsheet and more complex supply and demand modelling was used. Models can be very useful in examining the implications of current trends and management decisions on achieving a vision. Visioning and scenario development are themselves powerful tools for stakeholder involvement, although it is outside the scope of this paper to consider them in more detail.

Considered presentation of results according to the target audience. An important element in using RIDe as a process support tool is to ensure that outputs are provided in a simple to understand visual format. Information and data can be presented as reports, charts, or perhaps most powerfully as maps generated in a GIS.

6. CONCLUSIONS OF EXPERIENCE TO DATE USING RIDE

- RIDe is a useful approach to targeting water resource assessments as part of holistic, participatory, and problem focussed planning for water resource and water supply development. RIDe is not a radical departure from existing approaches, but rather a useful addition – particularly to water resource assessments which are given more structure, and become more systematic. As such it provides an important tool in helping to counter criticisms of IWRM as being too vague and lacking in a clear problem focus.

- RIDe is an analytical framework, and as such is a guide for problem, stakeholder, information and tool selection. It is not a specific set of activities. It can (and should) be implemented at different levels of resolution, with different stakeholders, and different information resolution depending on both the decisions to be taken and the stakeholders involved. A RIDe framework is as useful in a village meeting, where it helps participants differentiate between symptoms and causes of water-related problems, as it is in guiding a catchment level water resource assessment.

- By creating a framework that explicitly acknowledges infrastructure as the link between water supply and water resource management within a single conceptual framework, RIDe helps to provide critical insights into how water resources and water users interact.

- RIDe provides a framework for assembling and analysing water-related information in a way that concentrates effort and resources on analysis of causes of problems as opposed to symptoms. By definition, integrated water resources management requires that attention be given to the natural, engineering, environmental and societal aspects of water management systems, hence without a structure for assembling and analysing information, it is very easy to become completely swamped in information.

- RIDe has emerged from ongoing work in South Africa and India. It was largely conceptualised after the fact, based on lessons learned and an analysis of what did and did not work. It now needs to be further tested in new environments, to be refined and further operationalised.

7. REFERENCES

Davies, B.R., and Day, J.A., 1998. *Vanishing Waters.* Cape Town: UCT Press

Davies, B.R., J.H. O'Keeffe and C.D. Snaddon. 1995. *River and stream ecosystems in South Africa: predictably unpredictable*. Pp. 537-599. In: C.E. Cushing, K.W. Cummins and G.W. Minshal. Eds. River and Stream Ecosystems. Elsevier

DWAF. 1990. *Water resources planning of the Sabie river catchment, study of development potential and management of the water resources,* Department of Water Affairs Directorate Project Planning, Pretoria

DWAF. 1998. *Final Workshop Report: Sabie -Sand IFR*. Aan de Vliet. Department of Water Affairs and Forestry, Pretoria

DWAF. 2002a *National Water Resources Strategy*. Proposed First Edition. August 2002., Department of Water Affairs and Forestry, Pretoria

DWAF. 2002b. *Sabie River Catchment, Operating rules and decision support models for management of the surface water resources*, First draft June 2002, Department of Water Affairs and Forestry, Pretoria

FAO, AQUASTAT South Africa [online]
http://www.fao.org/ag/agl/aglw/aquastat/countries/south_africa/index.stm

GWP. 2000. *Integrated water resources management: TAC Background Papers No. 4*, GWP, Stockholm Available at http://www.gwpforum.org/gwp/library/TACNO4.PDF

GWP. 2004. *Toolbox: Integrated Water Resources Management*. [online] Available at http://www.gwpforum.org

Meays, L.W., (Ed.).1996. *Water Resources Handbook* (International Edition). McGraw-Hill

Midgely, D.C., Pitman, W.V., Middleton, B.J., 1994, Surface water resources of South Aifrca 1990, Users Manual', WRC report no. 298/1/94, Water Research Commission, Pretoria, South Africa

Moriarty, P., Butterworth, J. and Batchelor, C. 2004. *Integrated Water Resources Management and the domestic water supply and sanitation sub-sector*. Thematic Overview Paper [online] forthcoming at www.irc.nl

Oxford Scientific Software (2003) http://www.oxscisoft.com/aquator/index.htm

Pike, A., R. Schulze, S. Lorentz, F. Ballim, V. Taylor and B. Howe. 1997. *Simulation of streamflows and sediment yields in the Sand and Sabie Catchments: Report to the KNP Rivers Research Programme*. Dept. of Agricultural Engineering, University of Natal.

Pollard, S. R, Perez de Mendiguren, J. C, Joubert, A, Shackleton, C. M, Walker, P, Poulter, T, and White, M. (1998) *Save the Sand: Phase I feasibility study : The development of a proposal for a catchment plan for the Sand River Catchment*, Department of Water Affairs and Forestry, Department of Agriculture and Land Affairs.

Pollard., S, Moriarty, P.B., Butterworth, J.A., Batchelor, C.H., Taylor, C.H. (2002) *Water resource management for rural water supply: implementing the Basic Human needs Reserve and licensing in the Sand River Catchment, South Africa*, WHiRL Working Paper 6, NRI, UK (available at http://www.nri.org/whirl)

Rama Mohan Rao, M.S., Batchelor, C.H., James, A.J., Nagaraja R., Seeley, J. & Butterworth J.A. (Eds.) 2003. *Andhra Pradesh Rural Livelihoods Programme Water Audit:* Andhra Pradesh Rural Livelihoods Project, CRD, Hyderabad, India

Republic of South Africa. *The National Water Act, Act 36 of 1998*. The Department of Water Affairs & Forestry. Government Gazette 19182, Government Printer, Pretoria.

Samra, J.S., Sharda, V.N. and Sikka, A.K. 1996. *Water Harvesting and Recycling: Indian experiences*. CSWCRTI, Dehradun, India.

Scanlon, J., Cassar, A., & Nemes, N. 2003. *Water as a human right?* Paper presented at the 7th International Conference on Environmental Law, Sao Paulo, Brazil, 2-5 June, 2003 [online] Available at http://www.iucn.org/themes/law/pdfdocuments/WW-Rev%202%20-%202nd%20June.pdf

Smits, S., Pollard, S., du Toit, S., Butterworth, J., Moriarty, P. 2002. *Modelling scenarios for water resources management in the Sand River Catchment, South Africa,* HIRL Project Working Paper 8, NRI, UK Available at http://www.nri.org/whirl

World Bank (2003) *Water Resources Sector Strategy – strategic directions for World Bank Engagement*, World Bank, Washington DC, USA. Available at www.worldbank.org