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**Supporting decision making on
rehabilitation and management transfer of
government smallholding irrigation
schemes: the SMILE approach**

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Working paper: 2002-17

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SUPPORTING DECISION MAKING ON REHABILITATION AND MANAGEMENT TRANSFER OF GOVERNMENT SMALLHOLDING IRRIGATION SCHEMES: THE SMILE APPROACH¹

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Introduction

Some of the key outcomes of the Earth Summit held in Rio in 1992 were the recommendations that water should be treated as an economic good, that water management should be decentralized, and that farmers and other stakeholders should play a more important role in water management (Keating, 1993). Such recommendations originated mostly from the new challenges and changing driving forces that the world's irrigation sector has been increasingly facing over the past three decades, that are competing demands for water, emerging environmental issues, persistent food insecurity and poverty, and financial difficulties. Many countries have embarked on a process to transfer the management of irrigation systems from government agencies to private sector local entities. Most professionals and operators are still unsure about what reforms should be adopted and how to design and implement them. This process, the so-called Irrigation Management Transfer (IMT), includes state withdrawal, promotion of the participation of water users, development of local management institutions, transfer of ownership and management, and so on. A number of successes as well as failures have been already reported and analysed (Vermillion, 1997; FAO, 2001). South Africa has just cautiously initiated IMT in government smallholding irrigation schemes located in former homeland areas. CIRAD and the University of Pretoria are carrying out a research programme which aims to assist decision-making on rehabilitation and management transfer of smallholding irrigation schemes to local management structures, then to pave the way for a sustainable management of these schemes on the longer run. The present paper aims to report back preliminary outcomes of the programme, which developed a modelling approach for assessing the economic viability of specific schemes of the Northern Province, earmarked for rehabilitation and transfer. The paper first describes the situation of smallholder irrigation schemes in SA, the current process of rehabilitation and transfer, and the numerous questions regarding sustainability and prospects of such schemes. The principles of the simulation approach are then presented. Finally, scenarios are tested on a case study scheme where a first simulation tool has been developed.

The plight of smallholding irrigation schemes in SA

At present, South Africa has an estimated 1.3 million ha of land under irrigation for both commercial and subsistence agriculture. Owing to history and past policies, different types of irrigation schemes have evolved in South Africa (Perret, 2001). Smallholding irrigation schemes (SIS) cover approximately 46000 to 47500 ha (Bembridge, 2000; NP-DAE, 2000) as former Bantustan schemes. SIS account for about 4% of irrigated areas in SA. It is estimated that half of them are located in the Northern Province (about 175 schemes represent 20000 to 22000 ha). It is also estimated that two thirds of South Africa's SIS have subsistence as a main purpose, and that 200000 to 230000 rural black people are dependant at least partially for a livelihood on such schemes. In spite of such a relatively small contribution, it is believed that those schemes could play an important role in rural development, since they can potentially provide food security, income and employment opportunities. In the Northern Province, it is acknowledged that most SIS are moribund and have been inactive for many years (NP-DAE, 2000; Bembridge, 2000). Several causes have been mentioned, i.e. infrastructure deficiencies emanating from inappropriate planning and design, and/or poor operational and management structures, both beneficiaries and government assigned extension officers lacking technical know-how and ability, absence of people involvement and participation, inadequate institutional structures, inappropriate land tenure arrangements, and a history of dependency (IWMI, 2001). In the Eastern Cape and Kwazulu-Natal, most schemes are also facing major infrastructural and institutional problems, along with local political power games that have characterized these schemes from the outset, and that hinder effective problem solving. Following the dismantlement of apartheid, management agencies were liquidated and government gradually withdrew from its past functions in SIS (services, technical advice and extension, training, marketing and financial support). Since the late 1990s, provincial governments have set up rehabilitation and management transfer programs throughout the country (ECRA, 2001; NP-DAE, 2000). The processes are however implemented very cautiously. For provincial departments, the underlying idea is undoubtedly to curtail the heavy financial burden of SIS, as most of them are not contributing to the commercial agriculture stream. On the other hand, departments would like to promote the emergence of small-scale commercial farmers, as well as the community subsistence function of the schemes (food security). These schemes were constructed with no consideration for operating costs or production economics. National and provincial governments might be tempted to transfer "uneconomical" schemes to users. All rehabilitation and reactivation efforts face the same dilemma, i.e. how can the social and economic aspects of SIS be reconciled?

A new water management policy

Since 1994, the South African Government has undertaken massive reforms aiming to address rural poverty and inequalities inherited from the past regime. Among other programs, it has adopted an ambitious new water legislation, which culminated in the acceptance of a new National Water Act (NWA, Act 36 of 1998). The Act provides an opportunity to re-think the paradigm underlying water management in South Africa and to develop new institutions. Among others, some new core concepts for water management are decentralization and water service cost recovery. New management entities (Catchment Management Agencies and Water Users' Associations) will be established at regional and local level respectively, emphasizing

a largely decentralized and participatory approach to water resource management. The direct implementation features of the Act are: State withdrawal from most former commitments, controls and financial support, decentralization and the transfer of power to local management and decision-making structures (CMAs and WUAs), water users' registration and licensing.

Water Users Associations (WUAs) potentially form the third tier of water management and will operate at local level. These WUAs are in effect co-operative associations of individual water users who wish to undertake water-related activities for their mutual benefit. The role of the WUA is to enable a community to pool financial and human resources in order to carry out more effectively water related activities. Irrigation management forms one of the key activities to be performed by WUAs (DWAF, 1999 & 2000). It is envisaged that a WUA would take over most irrigation management functions, i.e. water distribution rules, organising maintenance, collection of water supply charges and financial management, and possibly later, the management of investment, credit to farmers, marketing contracts, input supply, and so on.

Policy issues and questions on SIS

As described in previous sections, smallholding irrigation schemes of SA are currently facing privatisation, although some form of public-sector support may remain. Owing to current policies, and depending on the stakeholders' ability to adapt and react, the process is likely to eventually end up with two scenarios (although it may take some time, either way):

- continuous degradation (which is the current trend) then collapse; this means that a large majority of the remaining cultivated plots would be eventually rain-fed,
- or some form of sustainable self-management, which means that a large majority of plots would be cultivated and irrigated, and that the neighbouring communities would benefit from it.

This second scenario is being promoted by central and provincial governments, which aim to revitalise SIS through rehabilitation, and to curtail the financial burden of their maintenance and operation costs through a transfer of ownership and management. Most schemes are earmarked for rehabilitation and transfer to users' associations in the Northern Province and the Eastern Cape Province. Although both provinces have drawn plans (NP-DAE, 2000; ECRA, 2001), it remains difficult for decision-makers and operators to evaluate the potential for long-term sustainability, then to organise rehabilitation and transfer accordingly. All the above raises a series of questions, and demands investigation at different levels.

At Government level (policy making)

Which policies and measures should accompany the IMT process? (designing training programmes, level of rehabilitation, new waterworks and resource development, resource and waterworks-related pricing policy, land tenure reform, service and input supply, etc.). What is the current situation of the schemes earmarked for rehabilitation and transfer? Do these schemes have any prospects, any sustainable development potential? To which conditions? Is it possible to prioritise, i.e. to drive funds towards selected promising schemes? How to choose them? Is it realistic to transfer all costs incurred to the local management entities? In other terms, which costs may be covered by the farmers' contribution?

At WUA level (collective management of irrigation)

How can one help an emerging local institution to become a collective, representative and sustainable structure for negotiation, decision and management, in a changing and uncertain environment? Or in other terms, how can one implement the development of a local organisation, managing water distribution, maintenance and financial aspects? More specifically, how can the tariff structure take into account farmers' capacity and willingness to pay, as well as cost recovery requirements? How can the water pricing strategy and the water charging system take account of the different issues at stake, i.e. equity, poverty alleviation, resource conservation, economic viability?

At farmers' level (farming and cropping systems management)

What is the current situation in terms of cropping systems and, more generally, income-generating systems in the schemes? Are they compatible with a cost-recovery approach of the scheme's management? In other terms, are farmers capable to pay, are they willing to pay? What are the prospects and potential for changes and/or improvement in cropping systems?

The Smile approach

Overall objective

The overall objective of the approach is to accompany and support decisions and actions undertaken by development operators, in a process of rehabilitation and transfer of management to local entities.

A series of specific objectives consist of answering the questions listed in chapter 1.3. The Smile approach strives to go beyond mere observation or qualitative participatory methods, or general organisational principles, and to avoid complex systemic representations, although benefiting from those seminal works. Its objective is to facilitate decision-making and strategy development. Several frameworks and guidelines have been proposed for SIS assessment (Field et al., 1998; ARC, 1999; De Lange et al., 2000; Bembridge, 2000), although not having generated a common platform for data collection, processing, and then decision support.

Principles, theoretical background

A managerial perspective of irrigation schemes

A major prerequisite to a **self-management scenario** is the establishment of a sound local management entity (e.g. a WUA). Such process is not directly addressed through the Smile approach. However, the model includes management options and takes account of the management costs incurred, which may help making certain decisions at the outset (staff, management assets, etc.). Having a self-management perspective on SIS means acknowledging the following mode of operation:

- The **management entity** (WUA) provides irrigation water and related services to **farmers**.
- Such services **generate costs**: capital costs (provision for further refurbishment), maintenance and operation costs, and personnel-related costs.
- Partial or total **cost recovery** supposes that the management entity charges the farmers according to a system to be established (which involves defining a cost recovery strategy, choice of a water pricing method, choice of a base, determining fees, etc.).

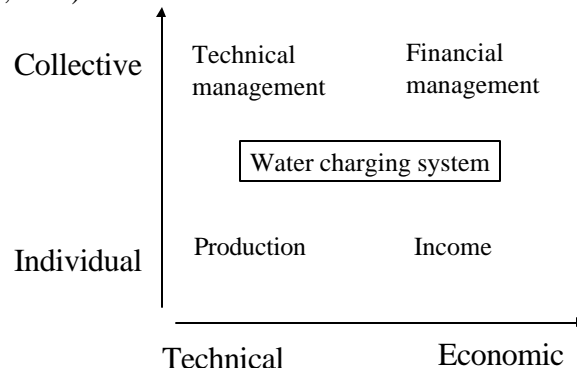
- The farmers tap into their **monetary resources** (generated by irrigated or rain-fed cropping systems, by off-farm income-earning systems) to pay these water service fees.
- It is a **client-supplier relationship**, although farmers indeed partake to the management entity. Public or private sector stakeholders may also contribute to strike the financial balance (through subsidies or sponsoring).

In other words, a scheme can be seen as a firm with two interacting productive units, performing various functions in a given natural, institutional and economic environment (Rey, 1996; Le Gal, 2001). A number of flows take place between the different sub-systems: flows of water, money, labour, products, and information. On one hand, the collective management entity (supplier) “produces” water with certain characteristics (quantity, quality, costs, etc.). It has to perform two types of functions: a hydraulic function (water supply, operation and maintenance) and a financial function (cost recovery, water pricing and fees fixing, financial management).

On the other hand, individual farmers (clients) “transform” this water in products through their productive systems (irrigated cropping systems), then possibly in money if they market these products. Thus, farmers perform two types of functions: agricultural production (cropping system, irrigation systems at plot level) and commercialisation.

Smallholder families seldom rely solely on the production of an irrigated plot. It is common for irrigated plot holders to have rain-fed cropped areas, livestock, non-farm sources of income and so on (Merle et al. 2000). One should consider the whole income-earning system of smallholder irrigation farmers while reckoning their capacity and willingness to pay water fees. Water pricing and the water charging system form the key interface between farmers and the management entity (see figure 1). Defining crop production strategies, organising commercialisation, striking a balance between water supply and demand, developing a management information system, and the like, are also key subjects for both farmers and the WUA (Le Gal, 2001).

Figure 1. A conceptual framework for the management of irrigation schemes (adapted from Le Gal, 2001)



Action research

It is now acknowledged that mere technology generation and transfer, or market forces are not enough to bring about the necessary changes that have to occur in agricultural and resource-management systems faced with a quickly changing economic, legal and social environment. For such changes to occur, renewed

approaches require facilitation of collective learning and negotiated agreement (Jiggins & Roling, 1997). **Action-research** strives to play this facilitation role. As defined by Liu (1994), it combines:

- the convergence of a will for change and a research intention, which entails a two-fold objective, i.e. problem solving and knowledge generation (with local and generic scope),
- an ongoing long-term joint project between researchers, development operators and users,
- a common ethical framework negotiated and accepted by all stakeholders.

Several previous experiences show that projects inspired by action-research can efficiently support local development (Valleyrand, 1994; Perret & Legal, 1999). The tricky and essential point is to implement properly the participation of stakeholders, not only while collecting data but also during recurrent, interactive workshops (information sharing, discussions about scenarios, solutions seeking, etc.).

A recent trend in management-oriented researches is to proceed through direct intervention within the targeted organisations (Moisdon, 1997). **Intervention-research** means that the researcher is no longer an external observer, analysing managerial processes, then prescribing possible improvements in line with optimal solutions (such an approach refers to operational research). He/she is actually embarked in a common work with the individual and collective stakeholders. The prescription dimension takes part of an inner process in which control, strategy, piloting, ongoing learning are central.

Supporting decision making with models and scenario-testing tools

Human organisations (such as irrigation schemes) are complex systems, meaning that no simple representation can encompass or exhaust their scope, interactions, implications, issues, and dynamics. Furthermore, they evolve in uncertain environments (e.g. climate, markets, resource, etc.). **Complexity and uncertainty call for strategy**. Rather than striving to stick to a long pre-established trajectory, developing a strategy in complex and uncertain environment means developing a step-by-step approach, striving to foresee, adapt to, and benefit from any new issue, emerging situation or unexpected event, according to a broad guideline and several main objectives (Avenier, 1997). Besides, human organisations are not only constituted by individuals and assets, but also by **knowledge, rules and information** enabling monitoring and assessment of the activities performed, and orienting behaviours and choices. Very often, this information is combined to stand as a workable synopsis, in various forms such as indicators, worksheets, management boards, schedules, and production forecasts among others. These formalised representations of the organised activity are called **management tools** (Moisdon, 1997). Owing to the increasing complexity and dynamics of organisations, and to the increasing uncertainty of their economic environment, management tools no longer seek optimal solutions and one-way prescriptions or recipes, but rather favour **information, learning processes, adaptability, discussion, collective awareness**, and so on.

Such an instrumental approach aims to support and accompany the knowledge and exploration of reality. Its main objective is to help a group of stakeholders sharing a common representation, making decision and developing an adaptative strategy on the process they are involved in, and anticipate the possible evolution. As such, developing a management tool represents an intervention into the organisation, as the structure of the model is based on dynamic links with the conceptual representation of

the organisation and the rules structuring intervention. Developing management tools goes along with developing the organisation itself, and its strategy (Moisdon, 1997), which may prove crucial in the context of the establishment of WUAs as local management entities. Modelling then running simulations may fuel discussion and make people interact, challenge hasty judgements and support sound decisions, raise new questions, and foresee issues and problems.

Practical features

A three stages approach

The approach implies three phases:

- Data collection, which includes field visits, farmers' and operators' interviews, literature review on infrastructures (e.g. pre-rehabilitation reports), crops, farming systems, markets, local institutions, and so on. Information is required on the socio-economic and technical circumstances at household level
- Data processing and model development; future developments will benefit from the existing model (Smile) which may be adapted to other situations rather than actually be redeveloped. The model evaluates both the costs incurred by scheme management, and the possible components of cost recovery in a context of management by a water users' association. Prior to model development, it is necessary to develop a typology of farmers' strategies and practices (see below)
- Running the model on a scenario-testing basis, evaluating the impact of certain measures or decisions, or certain farmers' strategies on agricultural and production features, land allocation, costs and cost recovery, economic indicators, equity- and sustainability-related indicators. This supposes interactions with experts and local stakeholders

The need for accurate data

The more accurate and reliable the data, the better the modelling and simulation development. In spite of the numerous reports that have been written on most schemes earmarked for rehabilitation and transfer, it proved very difficult to gather the necessary information for modelling then simulation purposes. This called for multiple contributions and partnerships with knowledgeable experts, and proved crucial in choosing the case study schemes: Dingleydale - New Forest (DD-NF). Concerning infrastructure, most data are usually lacking since the schemes were managed by former independent homeland authorities and have only been recently re-transferred to the South African authorities. In DD-NF, recent studies have been undertaken prior to rehabilitation and offer very accurate and reliable data (AWARD, 1999; ARC-LNR, 1999b). Concerning the communities and their farming practices, studies have been undertaken on some case studies, but often focusing on certain issues such as gender or productivity for example. For this study, economic data were of major importance. In DD-NF, most economic data were made available via two complementary surveys both undertaken in 2000 on the farming households: a quick pre-feasibility survey based on a large sample (200 households) undertaken by Loxton Venn & Associate (Mitchell, 2000) and a more comprehensive survey done by CIRAD, based on a similar sample size (Merle et al., 2000). Data on the whole communities would have been very helpful, but were not available. Concerning management entities and their strategies, DD-NF offered, once again, a good

compromise. It doesn't have a WUA yet, but as a pilot project, a transitional development steering committee has been established.

Multi-disciplinarity and partnership

The approach requires interest and commitment by a number of individuals and institutions. Partnership and multi-disciplinarity have been established and sustained during the course of the project. Engineers, agronomists, extension officers, economists, development operators, farmers, decision and policy makers were first involved mostly on an individual and informal basis during the two first phases as listed above. Then some key experts and stakeholders have been involved in an informal and flexible, yet very efficient, steering committee for the last phases. Members of the Agricultural Research Council, Department of Water Affairs and Forestry, International Water Management Institute, Water Research Commission, Provincial Departments of Agriculture, consulting agencies (Loxton Venn & Associates) have been involved at different stages.

Diversity of strategies: the need for a typology of farmers

A strategy may be defined as the combination of processes (plans, decisions and acts) that an individual or a group of individuals (a firm, a family, etc.) develop purposively, and which aim at changing/transforming their social, economic and/or physical environment. Such processes combine resources and/or techniques and/or knowledge and know-how (Olivier de Sardan, 1995). Farmers develop strategies as responses to a changing and uncertain environment, in order for them to duplicate/reach/transform a given life style that corresponds to an objective, as groups and/or as individuals. The crops, crop management sequences, cropping systems, animals and animal production systems, farming systems, off-farm activities, and so on, that the farmers combine and mobilise reflect such strategies (Yung, 1998). Within an irrigation scheme, diverse strategies may develop, depending on each household's history, composition, objectives, and so on. On the one hand, it is impossible to take account of each and every household's characteristics; on the other, it is irrelevant to consider the scheme homogeneous; hence a typology that groups households with similar strategies and characteristics, with regard to a given objective. For example, Lamacq (1997) built up farm typologies according to action models, aiming at modelling water demand. Merle et al. (2000) developed a typology of households in Dingleydale-New Forest scheme in South Africa, mostly according to their social and micro-economic traits, and to their production and marketing styles. Such a typology has been simplified and re-focussed on production/marketing styles (because of their importance in a self management perspective), then used for modelling purposes in the case study.

Developing the model: conceptual framework

The approach as a whole takes root in the above principles. The model's conceptual framework takes into considerations the economic aspects of scheme's management, and addresses some technical indicators in order to check that scenarios are realistic (e.g. water resource availability). Further technical details and calculations about the model may be found in Perret and Touchain (2002).

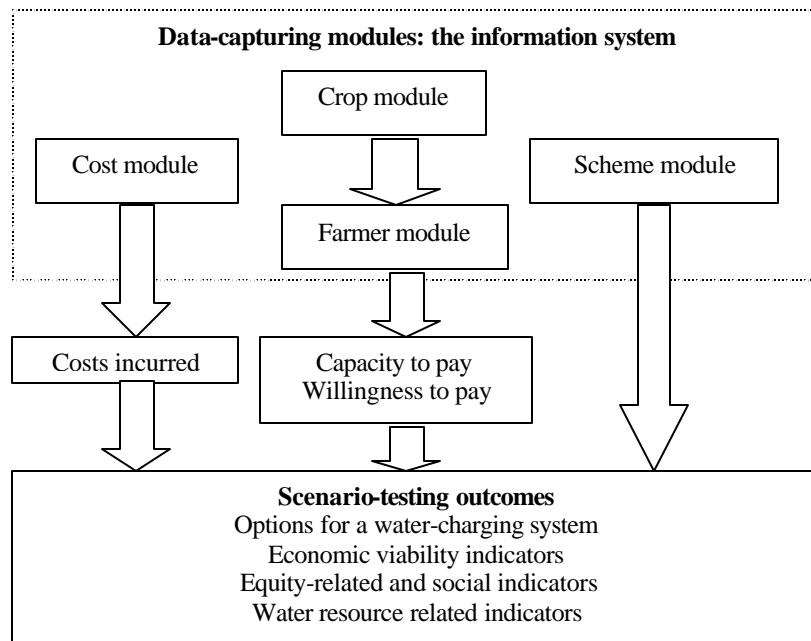
Four input modules form the basis of the information system, as interfaces for data capturing by the user (see figure 2). Each cost-generating item is listed in the "cost" module. This module generates output variables that reckon the costs incurred by the scheme and its management (i.e. capital costs, maintenance costs, operation costs,

personnel costs). Such information answer the question as to how much does it cost to operate the scheme in a sustainable manner (regardless of who is going to pay for it). Each potentially income-generating and/or irrigated crop is listed with its technical and economic features (e.g. management style, cropping calendar, water demand, yield, production and marketing costs) in the “crop” module. This module generates micro-economic output variables (e.g. gross and net margin par ha, and per m³) that allow comparative evaluation of crops in terms of profitability, land productivity, and water productivity.

A “farmer” module captures the different farmers’ types, with their cropping systems (combination of crops that have been documented in the crop module), average farm size, percentage of scheme’s size, willingness to pay for irrigation water services. This module generates type-related output variables (e.g. aggregated income per type, crop calendar) and scheme-related output variables (e.g. number of farmers, aggregated water demand) when combined with the “scheme” module. A “scheme” module lists the scheme’s characteristics (e.g. size, rainfall and resource-availability patterns, tariff structure). This module is combined with the “farmer” and “cost” modules, and generates output variables on water pricing, tariff, cost recovery rate, contribution per type. This allows answering the question as to who may pay, and how much, for water services. It also generates some social and equity-related indicators, and resource-related indicators (e.g. total number of farmers, area per type, number of farmers per type, type net income, scheme total net income, total water consumption, overall weekly water balance).

The initial inputs (real data) form the base scenario. Additional scenarios may be tested through the capture of non-real / prospective data, especially when the given scheme has not yet been rehabilitated or transferred (e.g. alternative crops and cropping systems, emerging farmers’ types, changes in scheme’s management patterns, options for a charging system, new infrastructures, and so on).

Figure 2. The model’s conceptual framework



A first simulation tool

Dingleydale-New Forest as a case study

A simulation tool has been developed (Perret & Touchain, 2001), based on such a conceptual framework, and from data collected in the Dingleydale - New Forest irrigation scheme. This scheme was chosen as a case study. It is one of the pilot projects in the Northern Province through the Water care Program (i.e. a scheme earmarked for rehabilitation then transfer by the Provincial Department of Agriculture). With 1600 ha under flood irrigation, it is the largest scheme of the Northern Province. It is actually composed of two schemes sharing parts of their infrastructure and used by different communities. Merle et al. (2000) showed that the scheme is typical, and displays a number of traits that are common to other SIS:

- a large majority of non-farming plot occupiers,
- a diversity of practices and performance among irrigation farmers, yet generally little productive and subsistence-oriented,
- a simple conception of infrastructures (dam and canals, operating under gravity), yet deteriorating,
- a lack of support services, a weak agri-business environment, and missing markets,
- water allocation and water availability problems, especially in winter.

Although in a virtual state of collapse, this scheme appears to be in a better shape than other schemes in the country, with a 30% land use ratio and a diversity of crops being grown apart from grain maize. Also, the scheme is well documented.

Principles

Moisdon (1997) listed a number of characteristics that are deemed indispensable to enable a management and decision-making support tool to reach its goals; it should be:

- Simple: the tools must be user-friendly, easy to use and to understand, yet with a sound compromise between accuracy and simplicity,
- Flexible and fragile: the tool should not be fixed but should be revised and adapted overtime, according to the users' requirements; the tool may evolve, or even be discarded, according to new circumstances or rising questions; such a short life cycle is important to sustain interest, focus and participation around a common problem-solving purpose,
- Interactive and discussible: in the context of intervention research, it is important that the process of development itself create a multilateral dynamic of retroaction and revision of choices; scenarios will neither be ranked or rated; the tool is not prescribing, but rather facilitating discussion, investigating possibilities, then supporting decision; the outputs form a range of indicators,
- Decentralised: the tool should be made available and used at different levels of decision.

Following these principles and the conceptual model, it was decided to develop a prototype of a tool on a spreadsheet software (Microsoft Excel™).

Main features

The prototype follows the principles of the conceptual model, although with some alterations: it does not consider weekly crop calendars but just cropping seasons (winter vs. summer crops), neither it considers water balance at crop, type or scheme

levels. Owing to the spreadsheet platform's characteristics and limitations, the tool is made of 3 types of spreadsheets, all belonging to a single:

- 3 input/output boards, namely "farmer", "cost" and "charging system" boards, whereby data are captured, then output variables, indicators and graphs are reported;
- 3 calculation sheets, whereby calculations are made for each of these boards;
- 2 data-storage sheets, whereby background information on infrastructures and crops are captured and stored.

An additional sheet displays the summarised output of a simulation for printing or demo purposes. The user may keep record of any scenario and its outcome, just through file saving. Such a first attempt proved easy to develop, to use and to adapt, although with several limitations:

- The user must be familiar with Excel.
- The different input areas are open and unprotected, allowing mistakes. If running simulations is easy, capturing background data remains awkward.
- There is a lack of an actual database attached to the model.
- If certain modules become bigger, some calculations will be limited or impossible.
- Finally, the model has a limited genericity and cannot be applied to every situation without major updating and adaptation.

Running simulations

Principles

A scenario -testing approach basically refers to a comparative approach whereby the user attempts to see how changes in certain inputs affect outputs and indicators. Thus, the approach lies much on two important principles:

- A base scenario should be defined, reflecting a management and water charging system being applied to the current situation. The most realistic and likely features of a water charging system and of a local management entity are chosen according to information collected.
- A number of realistic alternative scenarios should be defined. They include changes that are very likely to occur and/or that are likely to affect much output indicators.

The definition of scenarios must be done in close partnership with a number of stakeholders and experts.

It is also advisable not to test a scenario that includes too many changes at once, since it may become impossible to identify their individual weigh and impact. Changes may be combined afterwards, when each individual impact is well known.

Examples in the case study scheme

A base scenario

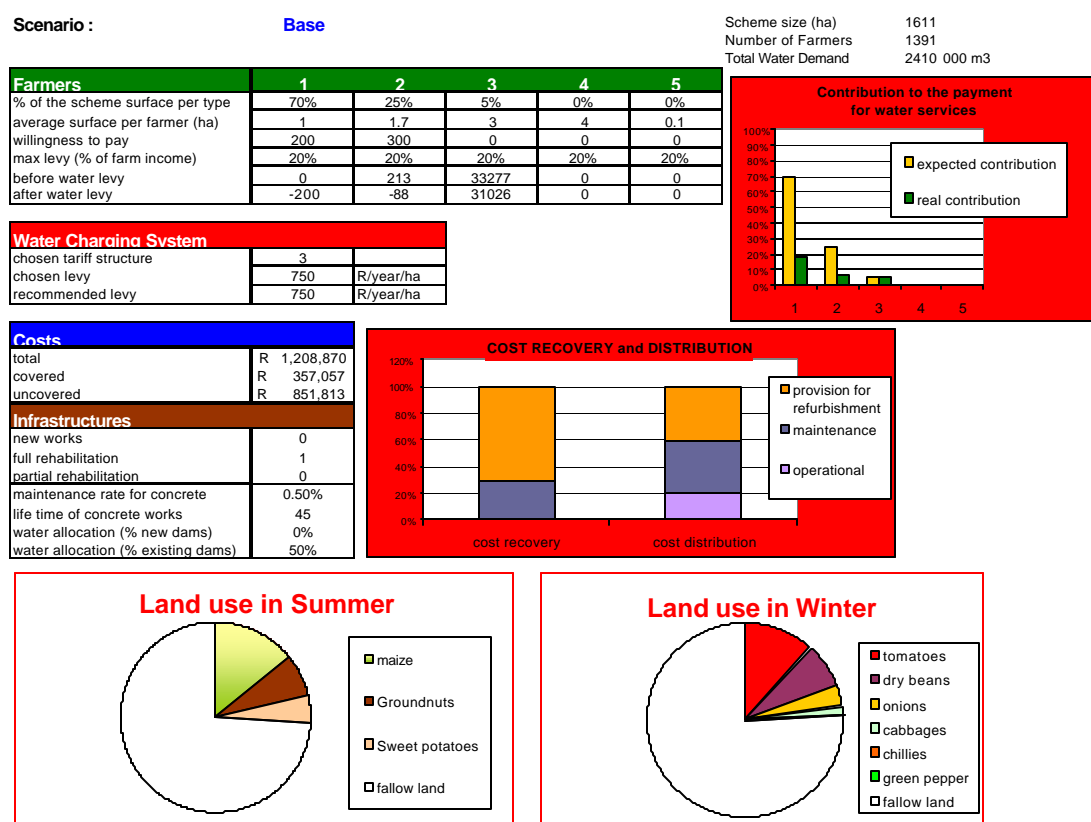
The base scenario data feeds a first simulation that provides a number of output variables, graphs and indicators, as shown displayed in figure 3. The base scenario may be summed up as shown in table 1. The outcome highlights that the current farmers' strategies and cropping systems do not make it possible to cover the costs. Less than 25% of the total cost is recovered (R 357 000 over R 1 208 000).

Table 1. Base scenario

Modules	Current situation	Hypotheses on non-existing
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		components
Cost	Existing infrastructures once rehabilitated	Full rehabilitation option but no new waterworks. Basic management assets and personnel that are deemed necessary
Crop	Existing crops with their current features (gross and net margins, yields, etc.)	
Farmer	Existing types (non farming land occupiers, subsistence farmers, transition farmers), with their existing features (farm size, crop combinations, net income, willingness to pay, etc.)	
Scheme	Current size	Basic tariff structure (per ha)

Figure 3. Synoptic board with the results from a base-scenario simulation



A “partial rehabilitation” scenario

At the time of the study, the rehabilitation strategy and means were still discussed. It appeared interesting to test a “partial rehabilitation” scenario, whereby concrete furrows for secondary conveyance are refurbished instead of being replaced by pipes in the “full rehabilitation” scenario. The total cost then raises to over R 1 600 000, mostly because of the much heavier maintenance costs incurred.

A “land use and maize productivity” scenario

Low yields and partial land use cause low productivity at scheme and community level, and also generate low income at farmers’ level, which in turn make impossible for them to pay back water services.

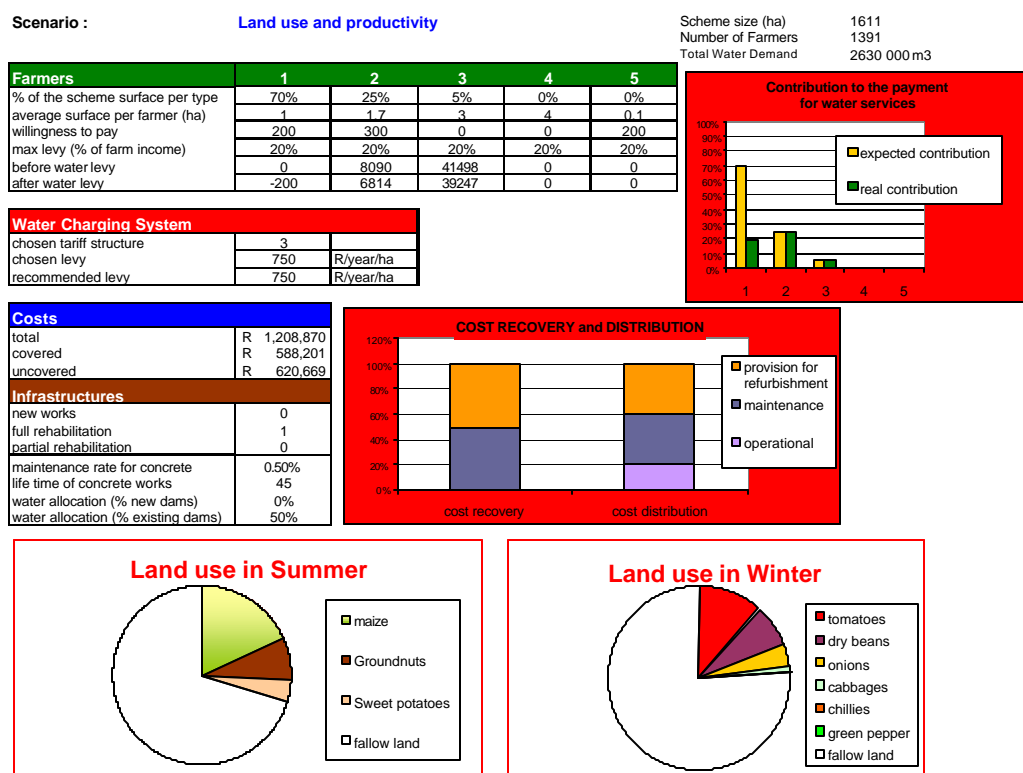
A “land use and productivity” scenario may be tested. It considers the same types of farmers, but assumes that after training sessions on maize production techniques, on-farm experimentations and demonstration plots, and the like, the two farming types (subsistence farmers and transition farmers) have intensified maize production, thus increased their yields, and their land use in winter (see table 2). Such scenario supposes also better access and support to farmers in terms of input / output markets, and possibly credit.

The results show a slight increase in land use in winter. However, the major outcome is the improved cost recovery ratio, since subsistence farmers start making some money out of maize production and can pay back water services (see figure 4). Such a scenario presupposes the necessary integration/combination of interventions (training + input/output markets + credit, etc.).

Table 2. Changes between the base scenario and a “land use and maize productivity” scenario
(percentages indicate the proportion of the type area covered with maize with a given management style in winter)

Scenario	Subsistence farmers	Transition farmers
Base (current situation)	Low yield (1t/ha): 50%	Average yield, partly harvested in green (3t/ha): 30%
Land use and maize productivity	Low yield (1t/ha): 10% Average yield (3t/ha): 20% Average yield, partly harvested in green (3t/ha): 20% High yield, partly harvested in green (7t/ha): 15%	Average yield, partly harvested in green (3t/ha): 20% High yield, partly harvested in green (7t/ha): 20%

Figure 4. Synoptic board with the results from a “land use and maize productivity” scenario



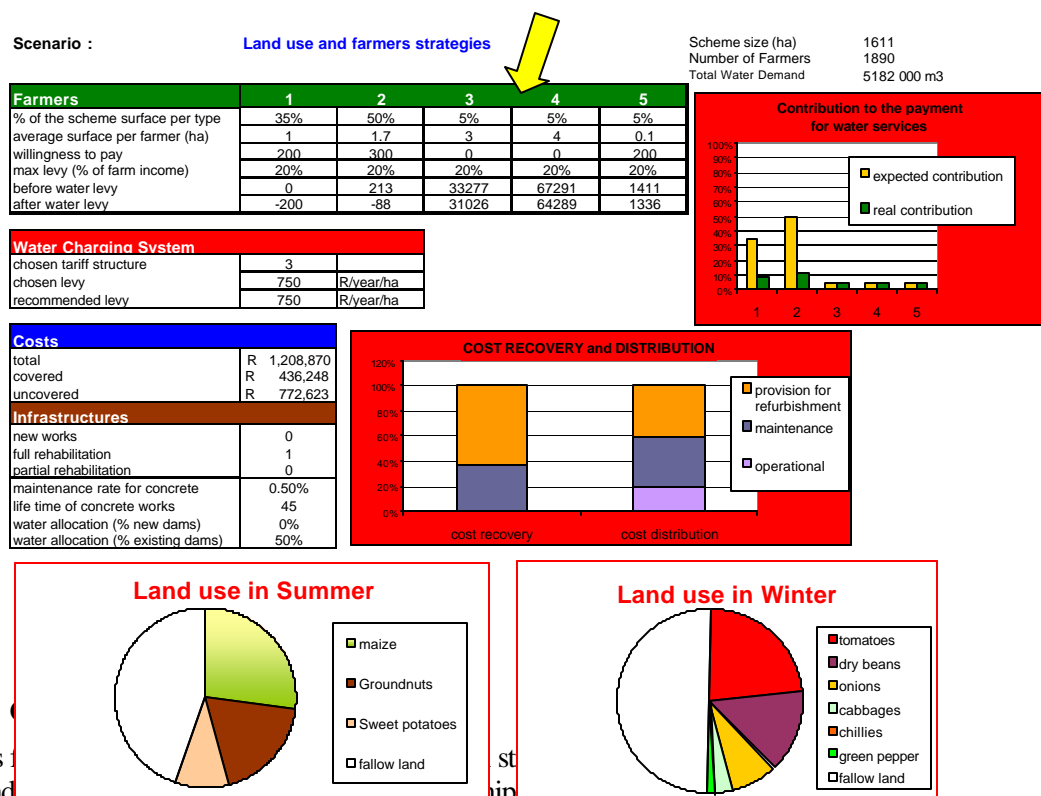
A “land arrangements” scenario

It is clear that the overwhelming proportion of non-farming plot occupiers is a major cause for poor economic viability of the scheme. It has been observed that unclear land rights and poor information prevent farmers from developing innovative inner arrangements (sale, renting, lending, leasing, or swapping arrangements, permanently or temporarily, etc.) (Merle et al., 2000; Lahiff, 1999). Alternative scenarios may be developed on such bases.

As an example, a “land use arrangements” scenario may be imagined. It processes the same data than the base scenario except for farmers’ types. Non-farming plot occupiers cover only 35% instead of 70%. The land has been redeployed towards subsistence farmers. There is a shift towards commercialisation strategies (type 4) and also the creation of a number of food plots (see figure 5).

Figure 5 shows the outcome of the simulation, which highlights a significant improvement in land use and production, yet with much higher water consumption. Cost recovery is slightly improved. Above all, land use rearrangements and the creation of small food plots have an impact on social issues (more women involved in food plots), equity (more families benefiting from the scheme) and food security (increased production). The number of farmers, thus families, involved in the scheme is about 1400 in the base scenario (current situation). It reaches more than 1800 in that example.

Figure 5. Synoptic board with the results from a “land rights arrangements” scenario (the arrow spots the changes from the base scenario)



approach is adequately addressed, documented, implemented and discussed, and (2) the principles of self-management, autonomy and economic viability must be acknowledged among all stakeholders.

The modelling approach as such makes it possible to share a common representation on the subject, to gather information in a homogenous and exhaustive manner, and to develop further simulation tools, and reach genericity. A first pilot tools has been developed, based on case study data, and scenarios have been tested. The results from the case study scheme are likely to echo much broader among SIS in South Africa:

- the current situation cannot lead to sustainability, since costs are hardly covered;

- total costs can hardly be reduced, since the bulk lays on capital and maintenance costs (however, a partial rehabilitation may prove more costly in the long run than a total one);
- the current biggest problem is the majority of non-farming plot occupiers, with low capacity and willingness to pay water fees;
- low land productivity also strongly limits farmers' income and capacity to pay back water services;
- even slight changes can significantly improve the situation (i.e. reduction of the proportion of non-farming occupiers, shift from mere subsistence towards more commercial farming, increased cropping and improved cropping systems, etc.)

A number of recommendations measures and decisions may be drawn from such simulations. Operators and decision makers should especially address inner land tenure/access arrangements, farmers' training, access to markets and services. An inescapable prerequisite to sustainable management is the establishment of a sound local managing organisation, which cost is included in the model. Also, public and private sectors should consider intervention on the financial balance of the schemes, in order to achieve long-term economic viability (in the form of subsidies or sponsorship on capital costs, accompanying programmes, and the like). Although requiring accurate and reliable background data, the methodology shows huge potential for decision-making support and for investigation on sound management pathways.

The approach is not completed yet. Further developments are currently taking place, with two major interactive orientations:

- Addressing other situations (other schemes of the Northern, Eastern Cape and Kwazulu-Natal Provinces), within which the team is willing to apply the Smile approach, trying and answer strategic questions on the sustainability of schemes earmarked for rehabilitation and transfer. Such situations are also likely to feed back the conceptual framework.
- Developing the tool as such (a software), aiming to ultimately provide an investigation and decision-making tool to scheme managers, consultants and stakeholders.

Our wish is that the partnership that has been established, and proved efficient and successful so far goes on, for us to assist a successful transfer, then a sustainable management of smallholding irrigation schemes in SA.

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