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ACTION RESEARCH FOR THE DEVELOPMENT OF A NEGOTIATION SUPPORT TOOL TOWARDS DECENTRALISED WATER MANAGEMENT IN SOUTH AFRICA

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Abstract

In 1998 the South African government adopted water legislation that provides a new constitutional framework for water management. Economic efficiency, social equity, and environmental sustainability are the guiding criteria of the new South African water policy. Water management will be implemented through decentralised institutions (Catchment Management Agencies and Committees, Water Users Associations). These institutions will be in charge of local negotiations and the decision-making processes regarding resource allocation among stakeholders. The new water management institutions have the complex task of matching different and sometimes contradictory objectives in a socio-economic context characterized by inequalities, lack or asymmetry of information, and conflicting interests. Hence, a clear need for negotiation and decision support tools for these institutions is perceived. An action research project was initiated at the University of Pretoria in 2001. It has the main objective of supporting the sustainable establishment of decentralised water management institutions as negotiation and decision-making entities on water resource management at basin level. This paper describes and discusses the participatory approach, aimed at developing a negotiation support tool called Action-research and Watershed Analyses for Resource and Economic sustainability (AWARE). More precisely, the phases of development of the model in close collaboration with DWAF officers are analysed. These are part of a broader process that will involve all the water users at sub-basin level. The choice of involving different stakeholders at different stages of the process, and its possible consequences on the nature of the tool is discussed.

1 - Introduction

The new National Water Act of South Africa (NWA, 1998) promotes integrated and decentralised water resource management in a new institutional environment. The new act is radically different from previous water legislation, particularly with regards to water rights. Under the new NWA, water is considered a public resource. Only the right of use - and not ownership - is granted to users, through a license system for which they are required to pay. Another major feature of the NWA is decentralisation of water management through the establishment of catchment level water management institutions such as Catchment Management Agencies (CMAs) and Water Users' Associations (WUAs). Finally, protective measures have been introduced to secure water allocation for basic human needs and ecological and development purposes (the concept of the reserve) (Farolfi and Perret, 2002).

Social development, economic growth, ecological integrity and equal access to water remain key objectives of the new water resource management legislation. The above mentioned institutions are currently being established at regional and local level, emphasizing a largely decentralized and participatory approach to water resource management. Such radical

institutional changes however, require a long time horizon to implement. Therefore existing water rights will remain in place until the new water legislation is fully implemented.

The National Water Resource Strategy (NWRS) is the implementation strategy for the NWA. It provides the legal framework for the future management of water resources in South Africa (DWAF, 2002). The main objective of the NWRS is to match and balance water demand with water supply, in accordance with the sustainability, equity and efficiency objectives of the NWA.

The implementation of the Act and the NWRS raises many social questions and economic uncertainties, within a context of water scarcity, profusion of users and uses, backlogs and inequalities in infrastructure and water supply. In this context, it is believed that one of the key roles of CMAs is the regulation and control of water demand

The approach set up for this purpose, is the allocation of water use authorisations to users. A licensing process is therefore necessary. Issues and difficulties arising from this process include prioritising licensing between different uses and users, timing and methodology for the renewal of licenses and the potential impact of certain licensing strategies. In other words, there is a clear need for tools that can help the future decentralised water management institutions to accomplish their complex tasks.

In 2001 an action research project started under the co-leadership of the Centre for Environmental Economics and Policy in Africa (CEEPA) and the Centre of International Co-operation for Agronomic Research for Development (CIRAD)[1]. The overall objective of this research programme is to support the sustainable establishment of decentralised water management institutions (e.g. CMAs) as negotiation and decision-making entities on water resource management at basin level. Under this program, specific tools - aimed at facilitating the establishment of management rules and organising the negotiation process itself - have

[1] See details of the project at the web site: http://www.ceepa.co.za/cma.html

been tested and adapted. The programme also aims to provide specific tools to water management and policy agencies.

The purpose of this text is to illustrate the participatory action research approach adopted by the project, with particular emphasis on the development of a simulation model called AWARE (Action research and Watershed Analyses for Resource and Economic sustainability). The focus of this article is not on the structure of the tool, which is still under construction, but on the process of iterative construction of the model, in close collaboration with DWAF officers. It also looks at the prospective adoption of the model within pilot sessions to be held in the near future with water user representatives. Table 1 shows the phases of participatory development of AWARE and the actors involved in the process.

	Phase	Actors involved
Phases illustrated in the article	Gathering information, identifying a study area, collecting secondary data	Researchers, DWAF officers, experts, consultants, water user representatives
	Construction of the prototype	Researchers
	Development of the model, validation of the legal framework and rules of implementation of the water law, new secondary data, accreditation by DWAF	Researchers, DWAF officers, experts, consultants
Phases in preparation	Adoption of the model in pilot sessions with local water user representatives, further modifications of the tool, validation by stakeholders	Researchers, DWAF officers, experts, consultants, water user representatives
	Adoption by DWAF of the modified model as a CMA's negotiation support tool	DWAF officers, water users representatives

Tab. 1 – Phases of participatory construction and adoption of AWARE

The first three phases have been covered to date, the last two phases are expected to be implemented by 2004.

After a short description of the aims and main activities of the project, an illustration of the applied concepts and methods of action research will be given. Then, the iterative and participatory process followed to date for the construction of AWARE is described, and the prospective adoption of the model in negotiation sessions is illustrated. Examples of model

outputs are then briefly presented to illustrate the potential of AWARE as a tool for facilitating discussions among stakeholders.

2 - The participatory action research approach

In order to deal with the questions formulated above, the project "*Tools and methodologies for the sustainable establishment of decentralised water management institutions in South Africa"* jointly implemented by CEEPA and CIRAD, adopted a multi-disciplinary approach, specifically with regards to the theory of systems (Le Moigne, 1995; Limburg *et al*. 2002). Following this approach the project was initiated by means of the following activities (tab. 1):

- Gathering information about the current water availability and demand, with emphasis on current water management practices and rules, the issues facing users, their current and prospective representation, their negotiation behaviour and framework, and finally the functions that are likely to be performed by management institutions;
- Formalising and first discussing these functions, rules, practices and information with DWAF officers, experts and consultants and making this data available through the construction and use of a simple prototype model[2]. This point is crucial, as sharing information in a transparent and formalised manner is regarded as the first step towards effective resource management.

At present, the research project aims to complete the development of a prototype model based on the gathered knowledge of water management rules. Once validated by DWAF officers, the model will be adopted as a negotiation support tool in pilot sessions with representatives of various water users at sub-basin level (CMA's geographical area of responsibility). During these sessions, the model will be used to run simulations and discuss the resulting scenarios of water management. The sessions will include tests of new rules, tests of the impact of certain

[2] Modelling started in the early stages of the project. A simple prototype (see next paragraph) was set up, allowing report-back and validation by DWAF officers and experts about the principles and rules of its operation. Advanced versions of the prototype were developed thereafter.

events, tests of the impact of certain individual or collective management patterns, tests of alternative organisation patterns, etc.

The model will be amended based on discussions and remarks raised in these sessions with water users.

The first pilot session is planned for 2004 in the Kat River, a sub-basin located in the Eastern Cape Province. AWARE will be used as a negotiation support tool within a project to develop methods for the cooperative establishment of a catchment management strategy. The session will incorporate inputs from various stakeholders, government agencies and specialists.

AWARE was conceived as a negotiation support tool in response to a specific need emanating from water management institutions. The "social demand" was therefore overall institutional. AWARE simulates the socio-economic and environmental consequences of the adoption of different water allocation strategies. It is therefore a tool that can be used to represent the local water management institution's behaviour. A clear and specific knowledge of the rules and practices governing the implementation of the NWA was a crucial pre-requisite for the development of the model. For these reasons, the construction of the prototype and the first development of AWARE took place in collaboration with DWAF officers, who are experts in terms of legislation, rules and implementation of water policy according to defined priorities. They were also able to provide a considerable amount of data and information for the parameterization of the simulation tool. Finally, CMAs will emanate directly from DWAF.

The preference to consult public officers first had unavoidable consequences on the nature of the developed model, particularly on the characteristics of the outcomes, which reflect DWAF's needs. The accessibility of the outcomes to ordinary water users will be tested during the pilot sessions at sub-basin level. Local stakeholders' needs and criticisms in terms

of model outcomes and reality representations, will be the priorities for the future developments of AWARE. This process is likely to be conducive to the stakeholders' validation and acceptance of the tool.

In other words, the version of AWARE that will be used for the pilot sessions with water users will have received a first validation by DWAF (a process of accreditation is underway), but does not represent the final product of the action research project. The final product will be validated by water user representatives during the negotiation pilot sessions. Two possibilities are envisaged at this stage: a) a unique version that can be easily adapted to each sub-basin through a change of parameters; or b) several versions, one for each sub-basin.

The model has the final aim of providing an operational tool for CMAs, but it is also part of an approach based on action research, which represents in itself a discussion and learning process. This process is limited, in this article, to DWAF officers and researchers. Future steps of the project will open the dialogue to water user representatives. It seems nevertheless useful to report DWAF officers' reactions and contributions that prompted researchers to modify the prototype and to develop improved versions of the model. Moreover, it is relevant to point out the discussions raised at the numerous sessions where the model was presented. These discussions stimulated debate among officers on the implementation of the NWA at local level. For each public officer involved, working on the structure of the model meant the re-consideration of the potential effects of the adoption of water allocation strategies. Each participant had to defend his own position against the criticisms of other officers.

As in every action research programme, the concept of *learning by doing* (Liu, 1994) is fundamental. It recognises that people learn through the active adaptation of their existing knowledge in response to their interactions with other people and their environment. As the dynamics of a social system are often more apparent in times of change, learning and change can enhance each other (Röling, 1994; Allen, 2000). During the development of the model, the "doing" phase consisted of verifying the rules and practices of the implementation of the

NWA, as well as the parameters introduced by researchers and discussions of the scenarios run. The "learning" phase emerged from the discussions among officers and the consequent push to re-consider the potential consequences of the adoption of water allocation strategies on socio-economic and environmental indicators.

Action research approaches can be associated with Post-Normal Science illustrated by Funtowicz and Ravetz (1994), and Funtowicz *et al*. (1999). Post-Normal Science differs from the positivist paradigm in the sense that it focuses on those aspects of problem-solving that tend to be neglected in traditional processes of scientific practice: uncertainty and value loading. It provides a coherent explanation of the need for greater participation in science-policy process (Funtowicz *et al.* 1999). The development of AWARE, and particularly the phases covering the adoption of the tool in pilot sessions with local water user representatives, will play a crucial role in facilitating this participation.

Given the nature of social systems, it is impossible to fully design the detail of action research in advance. The approach also does not lend itself to rigorous implementation and requires a considerable degree of flexibility. The research design is emergent, meaning it develops progressively and is influenced by the events that take place during the project and by the progressive analyses that are made (Dick and Dalmau, 1999; Allen, 2000). Accordingly, the choice of modelling and formalising tools to represent reality is crucial. Multi-agent simulations (MAS) and system dynamics models (SDM) allow for relative flexibility in method design, because their methods, portions of the model, and codes can easily be modified according to the adaptive process of participatory research.

The use of repeated cycles enables action researchers and their partners to reach an appropriate conclusion (figure 1). It is equivalent to what some authors call the "hermeneutic spiral" (Gummesson, 1991).

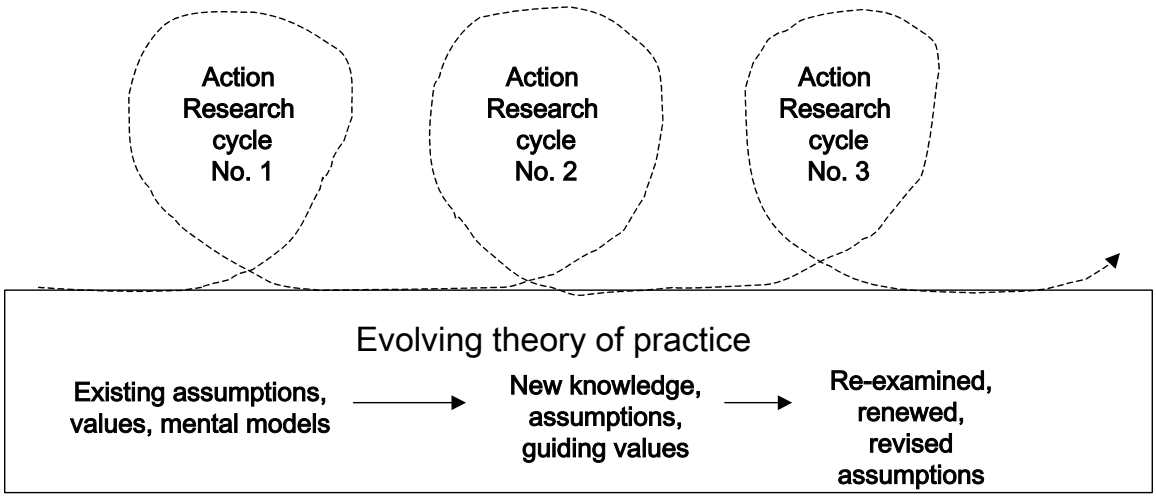

Fig. 1 – The iterative nature of action research *(Allen, 2000)*

But learning, which often shakes current beliefs and habits in individuals and organisations, is seldom embraced with ease and enthusiasm, even though there is a growing recognition of the need for change (Argyris *et al*, 1985). In fact, the first response to any inquiry into a mismatch between intention and outcome, is likely to be the search for another strategy that will satisfy the *governing variables*, and leave the *belief systems and values* which the individual or organisation is trying to maintain intact. Take the example of the deterioration of the water resource at basin level. If the CMA (or department in charge of that basin) views the problem only in terms of allocation strategy (compulsory licensing), it will adopt a new action strategy leading to different prioritisation of entitlements and consequently, different distribution of water. In such a case, where new strategies are used to support the same governing variable, this is called single loop learning. However, another possibility is to change the governing variables themselves (Bunning, 1994). For instance, rather than try a new allocation strategy, the water management agency may choose to initiate a more open form of inquiry. The associate action strategy might then be to look at how the reserve can be modified, or how to increase the water availability through investments like dams, or finally whether or not to facilitate the trade of water rights among users. In this case, the process requires the involvement of appropriate stakeholder groups in a more collaborative approach, discussing and, if necessary changing, the governing variables. These cases are called

double-loop learning, and involve more fundamental shifts in people's belief systems and values. (fig. 2).

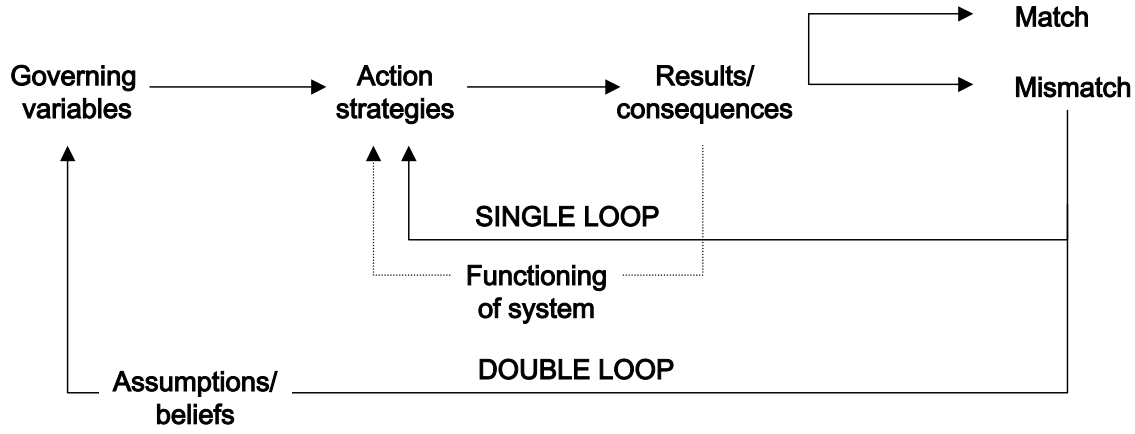

Fig. 2 – Single and double-loop learning *(Allen, 2000 adapted from: Argyris et al., 1985)*

Double-loop learning in the development phase of AWARE with DWAF officers, consisted of the discussions that took place during working sessions with the research team. These discussions challenged decision makers to re-consider their assumptions (and the axioms contained in the NWA) on water allocation strategies in light of the potential consequences shown by the scenarios.

But the whole project is aimed at fostering a process of double loop learning at the level of sub-basin, where CMAs have the main task of promoting negotiation and discussion among water users. These discussions will lead to a participatory process of water allocation that will emerge from the concerns of all groups. The adopted water allocation strategy will therefore result from the combination of DWAF directives on the one hand and the interests of water users on the other.

At CMA level, a single-loop learning scheme would correspond to a decision-making process that excludes stakeholders concerns, or that does not allocate them sufficient influence to modify the governing variables, represented by the set of allocation strategies prescribed by DWAF.

Conversely, a double-loop learning scheme would allow the results of negotiations to have an impact on the definition of allocation strategies, but also on the CMA's general water management policy.

AWARE, in facilitating the discussions that take place among all the stakeholders, will play an important role in favouring this double-loop learning scheme by CMAs. It will contribute to build-up a decision making process that is more flexible and sensitive to local needs.

Finally, as a negotiation-support tool, AWARE aims at sensitising and empowering local water users, particularly those that have less access to information and lower negotiation capacity (like the smallholding farmers, and the rural communities). In fact, a stringent problem that CMAs will have to face when discussing water allocation in rural South Africa, is the huge difference in terms of economic weight, and consequently negotiation capacity among sectors (Farolfi and Perret, 2002).

3 - Model evolution and present features

AWARE aims at investigating the economic efficiency, environmental sustainability and social desirability of some of the water management strategies that CMAs could potentially use. Although actual decentralised water management processes are unfolding and developing progressively, AWARE looks at situations whereby once established, CMAs would handle the licensing processes. It is a prospective simulation-oriented tool representing the perspectives and behaviour of public agencies and individual water users. The Steelpoort sub basin of the Olifants river catchment, shared between the Provinces of Limpopo and Mpumalanga was selected as study area because of its complete representation of the major sectors of water use as well as the availability of data.

This section describes the different stages of development of AWARE to date according to the iterative action research approach.

The model was originally conceived as a multi-agent system (MAS) (Bousquet *et al*. 1998). The most recent version of AWARE is a simulation model constructed in a programming language specifically designed for system dynamics modelling (SDM) (Richmond, 2001).

After a short review of MAS and SDM, the main features of AWARE's different versions are shown and the inputs from DWAF officers that motivated the revision of the terminology and aspects of the model are detailed.

MAS in its simplest form consists of models of individuals. These individuals are often superimposed on an automated environment and are capable of observing their environment, analysing what they observe and of modifying their behaviour accordingly (Ferber, 1995).

"Agent-based modelling takes a bottom-up approach to generating data comparable to that observable in the real system" (Deadman, 1999). This bottom-up approach consists of defining methods that correspond to the behaviour of individuals, which are a part of the real world system analysed. These methods do not specify the overall behaviour of the simulations, which instead emerges as a result of the actions and interactions of the individual agents (Deadman, 1999).

MAS assist the understanding of how global patterns in societies or economies emerge from individual behaviour (e.g. Epstein and Axtell, 1996). It has also been applied in economic studies of natural resource management in order to analyse possible processes of change (Bousquet *et al*., 1999; Deadman, 1999; Rouchier *et al*., 2000; Farolfi *et al*. , 2002).

SDM is a powerful methodology and computer simulation modelling technique for framing, understanding, and discussing complex issues and problems (Radzicki, 1997). SDM, though not as powerful as multi-agents systems in exploring agent behaviour and interactions, allows easier dynamic representations and long-term scenario-oriented simulations (Costanza and Gottlieb, 1998), predicting the outcomes of policy decisions. Where long term studies or experimental manipulations are not possible, (as in the case of the analysis of CMA water

allocation strategy outcomes over a period of several decades), representative models can help to fill in knowledge gaps (Costanza *et al.*, 1993).

The prototype (version 0)

According to the iterative and participatory approach illustrated above, a prototype of the model was first realised. It was based on a simplified representation of the Steelpoort watershed.

Water entitlements are allocated and issued by the CMA every 5 years, according to the objectives of social equity, environmental sustainability, and economic efficiency emphasised in the National Water Act. Environmental objectives are contained in the preservation of the ecological reserve. After giving first priority to this water destination, the CMA can decide how to allocate the remaining available resource among the economic sectors, according to the critical objective of improving the economic efficiency of water use for greater social benefits (Hassan, 2003). The sectors include irrigation boards, smallholders, forestry companies, industries and mines. When licenses are to be issued, every water user will send an estimate of its water demand to the CMA. If the available water, with the exclusion of the ecological reserve, is more than the total requirements of all users, each user will receive an entitlement for the amount of water it has requested. If the water demanded is more than the volume to be licensed, the CMA allocates water according to one of the following four strategies[3]:

1.) *No prioritisation*. All users receive licenses for a percentage of the amount of water that they have requested. This percentage is the same for all users and depends on the overall available resource.

[3] This process of prioritisation corresponds to *Compulsory Licensing* as indicated in the NWA (Chapter 4, part 8).

2.) *Urban and rural domestic uses* are issued with licenses first. The rest of the users share the remaining unlicensed water proportionately, so that all users receive licenses for an equivalent percentage of what they have requested.

3.) *Smallholders, irrigation boards, and rural domestic uses* are given priority. Thereafter, as in strategy 2.

4.) *Mines and industries* are given priority for water licensing. Thereafter, as in strategy 2.

Each type of user is charged a sector-dependent price per unit of water for which it receives entitlements. These entitlements are used to calculate the annual income for the CMA. In order to estimate the actual annual volume of water received by users, a periodic fluctuation around the mean annual runoff, representative of the South African climate, was used.

Each user makes an annual assessment of the amount of water it receives. User satisfaction is determined by the allocated amount of water as a share of the requested amount. If the water quota is less than satisfactory, a complaint of water shortage is sent to the CMA.

Version 1

The prototype was presented and discussed during the workshop "Water Management Policy, Tools and Institutions in SA: Learning from the French experience of the Agences de l'eau", held at the university of Pretoria in October 2002. Officers from DWAF and from a French water agency, as well as researchers from several research institutions attended the workshop. From the discussions and work groups, several amendments were introduced to the prototype version of AWARE. The animated discussions that took place during the workshop emphasized the different positions within DWAF regarding the implementation of the NWA and the role of CMAs. Some modifications to the model were agreed upon at the end of the workshop. These mainly centered on the terminology used and the strategies introduced in the model. The importance of the "social component" of the reserve,

represented by basic human needs[4], was pointed out. "Version 1" developed during the workshop, included the following modifications:

The term *ecological reserve* was changed into *reserve*, to include basic human needs, representing the social component of the reserve. The terms *quota* and *license* were changed to *entitlement* in line with the terminology used in the NWA.

The process of allocation of water entitlements was revised: each simulated user applies for a water entitlement (and pays an application fee). Applications are then evaluated by the CMA, water entitlements are issued up to the volume of water applied for, and finally users pay sector dependent tariffs per cubic meter of water for which they have received an entitlement.

The reserve was made dynamic and can now fluctuate with water availability.

All new water allocation strategies preserve the reserve, thereby assuring the supply of basic human needs and domestic uses.

Finally, a method for considering different water demand growth (or decrease) rates for all types of users was introduced into the model. This has enabled the use of statistical forecasts to create long-term scenarios simulating different socio-economic dynamics.

Version 2

During the mentioned workshop, DWAF officers suggested that the scenarios produced by AWARE should show the impact of the different water allocation strategies on socio-economic indicators such as the gross geographic product and the number of formal employment opportunities. These parameters were introduced in "version 2" of the model, which was presented to DWAF during the "Presentation and discussion of the AWARE approach" meeting held in February 2003.

[4] Defined in chapter 3, part 3, of the National Water Act as an amount of water corresponding to 25 l/person/day (NWA, 1998).

On this occasion, other improvements were proposed and discussed. All these changes were aimed at reflecting the terms and rules contained in the NWA and the NWRS, in order to make AWARE a tool with the ability to interpret the impacts of DWAF policy implementation on socio-economic and environmental indicators at watershed level.

According to the NWRS, the water available in the watershed was substituted by a constant amount called *yield*. This amount corresponds to the usable water (about 25% of the natural mean annual runoff) plus the annual return flow from irrigation, urban uses, mining and bulk industrial activities (NWRS, 2002).

The concept of *assurance of supply* for different users was also introduced. A 90% assurance of supply means that in ten years out of a hundred, some level of failure to supply will occur, where not all of the water needed will be available. AWARE can calculate different levels of assurance of supply for different categories of users and within the same category, or attribute the same assurance of supply to all users (98% according to DWAF, 2002, p. 6).

Financial aspects regarding the management expenditures of CMAs were furthermore introduced in AWARE. These costs, when reconciled with the income resulting from user charges calculated by the model, enabled the analysis of the economic sustainability of decentralised water management institutions.

Version 3

In view of the adoption of AWARE as a negotiation support tool, DWAF officers pointed out some areas of possible improvement in the MAS version of the tool. These included difficulties in modifying the structure of the model with a change in strategy, and the low speed of simulations. Using the multi-agent system, the research team embarked therefore in the process of construction of a version of AWARE in a programming language specifically designed for system dynamics modelling-SDM (Richmond, 2001). In AWARE's SDM version, CMA allocation strategies determine the reconciliation between yield and demand

for water over a 25 year period. As in the MAS "version 2", this version simulates the state of the ecological reserve during the analysed period and calculates a number of socio-economic indicators in function of the water allocation strategy adopted.

A complex ecological-economic system like the one represented by water management at watershed level, can be dynamically illustrated through this type of modelling. The impact of policy decisions on environmental, social, and economic indicators can be shown.

This version of the model also investigates water allocation strategies under market clearing conditions (Farolfi and Hassan, 2003).

DWAF has an official accreditation panel that assesses decision making and negotiation support tools. AWARE was recently submitted to this panel. The present version is most probably the one that will be adopted in the pilot sessions in the Kat River, where its acceptance by water user representatives will be tested. Stakeholder remarks and criticisms will be considered for future versions of AWARE in an iterative process similar to the one already adopted with DWAF officers. Only the version validated by local stakeholders can be adopted by CMAs.

Table 2 summarises the ongoing process of progressive modification of the AWARE model, according to the participatory research programme established with DWAF officers.

	Prototype	*Version 1*	*Version 2*	*Version 3*
Demand from DWAF	To build-up a negotiation support tool for CMAs	To emphasize basic human needs To define terminology	To introduce socio-economic indicators To introduce CMAs' costs and revenues To make the yield a constant	To simplify the model structure To make simulations simpler and faster
Simulation platform	Multi-agent	Multi-agent	Multi-agent	System dynamics modelling
Strategies	1 - No priority 2 - Priority to urban and rural domestic uses 3 - Priority to smallholders, irrigation boards and rural domestic uses 4 - Priority to mines and industries	First priority to urban and rural domestic uses, then priority to: 1 - Mines 2 - Mines and industries 3 - Irrigation boards 4 - Smallholders	Idem	Idem, reintroducing the "No priority scenario"
Reserve	Ecological Reserve	Basic human needs included	Idem	Idem
Calculation of Reserve	Constant	Reserve fluctuating with water availability	Introduction of classes and 2 level per class: Maintenance and Drought	Constant
Socio-economic indicators	NO	NO	YES	YES
Water Available	% of runoff (fluctuating)	% of runoff (fluctuating)	Yield	Yield
Assurance of supply	NO	NO	YES	YES
Water prices per sector according to water demand	NO	NO	NO	YES
Costs/Revenues	Charges from users	Charges from users	Charges from users and CMA's operating and Investment costs	Idem

Table 2 – Summary of the evolution of the AWARE model

4 - Simulations

Figure 3 comes from the last version (3) of AWARE (Farolfi and Hassan, 2003) and illustrates a 25-year simulation relating to the Steelpoort sub-basin of the Olifants River. The state of the ecological reserve and some socio-economic performance criteria such as GGP and employment can be observed within the analysed period, in function of the water allocation strategy adopted by the CMA as well as the annual increase/decrease rate of users. Data came from DWAF (2002) and Urban-Econ (2000).

To obtain the scenario illustrated in this section, the following annual sectoral growth/decrease rates were introduced: mining and industry grow at 5%, commercial agriculture declines by 1%, smallholder farming increases at 1% and domestic use grows at 4% and 2% in urban and rural areas, respectively.

Under the assumptions of fixed water supply and the structure and scenarios of changes in water demand over time, the current negative water balance (deficit) of -34 million m^3 in Steelpoort will reach -60 million m^3 by year 25. In this situation, the CMA must implement a process of compulsory licensing. This implies adopting one of the strategies of water allocation illustrated in part 3. AWARE simulates the socio-economic and environmental outcomes during the analysed period according to the adopted strategy. Because the objectives of environmental sustainability (preservation of the ecological reserve) and social equity (satisfaction of domestic needs) are set as priorities in the simulated strategies, it is interesting to understand the effects of the various strategies on economic efficiency.

Figure 3 shows the impact of a strategy giving highest priority to mines and industries (after preservation of the ecological reserve and domestic uses).

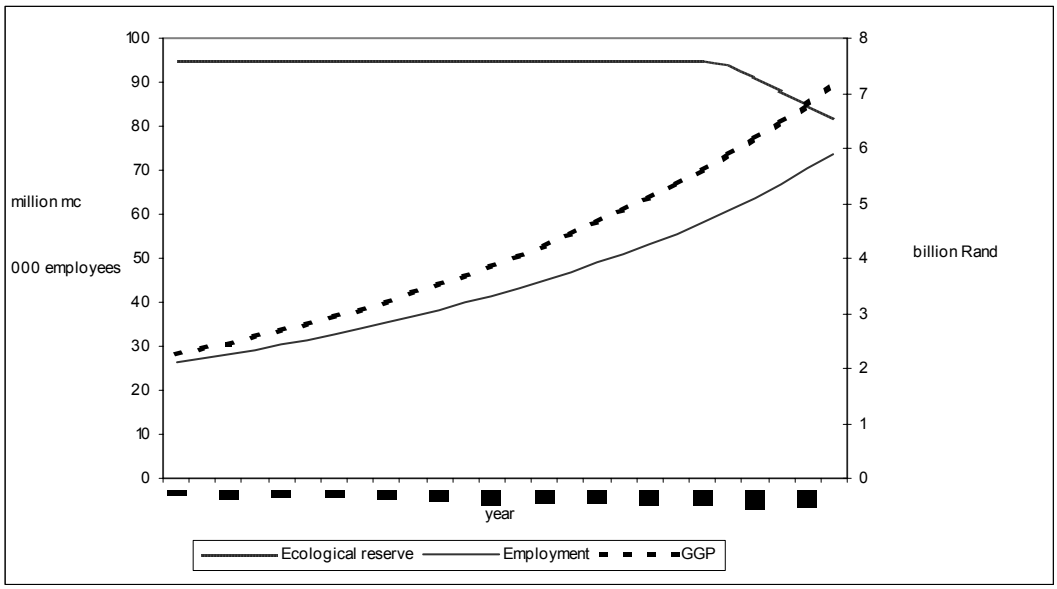

Figure 3 – Allocating water to mines, industries, and domestic users first: impacts on the Steelpoort sub-basin GGP, formal employment, and on the ecological reserve

At year 0, it is possible to observe the high economic efficiency of this strategy (GGP = 2.24 billion Rand; 26,300 formal employees). The simulated development of the prioritised sectors results in an even better performance over time. At year 20, however, it starts imposing on the ecological reserve.

If a higher user charge is applied to the mining sector and to industry (from 0.0215 to 0.04 R/m^3), the portion of the reserved consumed is much smaller, and only appears at year 24. Although the adoption of economic instruments by DWAF results in reduced economic performance (lower GGP and formal employment), it preserves the reserve.

The endless range of dynamic scenarios that can be obtained by modifying the increase/decrease rates of the relevant sectors and the user charges/subsidies, allows investigating the effects of the different strategies that CMAs can adopt. This feature represents the main advantage of this scenario-oriented negotiation support tool.

Some considerations on the limits and simplifications of the scenarios as produced by the model can be found in: Farolfi and Hassan, 2003.

5 - Conclusion

The implementation of the South African NWA involves a decentralised approach, emphasising the role of local institutions, like the nearly established CMAs, for the democratic and participatory allocation of water resources to different users.

In this context, negotiation support tools like AWARE can play a crucial role in facilitating the processes of decision-making on strategies of water allocation, and for the accompanying discussions among the stakeholders once CMAs are established.

An operational version of AWARE, validated not only by DWAF officers, but also by water user representatives through pilot negotiation sessions, is expected to be available by the end of 2005, when the first CMAs (particularly the one of the Olifants basin, which is the study area of our analysis) will be operational. The process of accreditation of the model by DWAF is presently underway.

This article focussed on some phases of the participatory action research approach being adopted within the project in close collaboration with DWAF officers and experts. These

covered the construction of a prototype and its development. The adoption phase of the model in pilot basins, testing its capacity to facilitate negotiations among water users, is expected to take place in 2004. These sessions will lead to further changes in the model, taking into account the concerns of all stakeholders involved in the process of water allocation management at catchment level.

The iterative construction of AWARE is a process of learning by doing. Researchers obtain information that is translated into methods of the model. This makes a realistic representation of basin water management under different strategies increasingly possible. On the other hand, decision-makers benefit from the process since their practices and rules are discussed in detail. Apart from facilitating frequent and open debate, the meetings between DWAF officers and researchers on the evolution of AWARE were also an opportunity to discuss water management action strategies and related governing variables.

At the same time, the process allowed researchers and DWAF officers to move towards a model that effectively and satisfactorily represents the studied reality. This in itself is a partial validation of the tool.

The final validation of the model will take place during negotiation sessions involving representatives of all water users in a sub-basin.

The adoption of AWARE in pilot sessions first, and then as a negotiation support tool by CMAs is likely to help decentralised institutions to implement participatory water management strategies at local level, instead of top-down oriented policies of water allocation. According to the terminology employed, this process is conducive of a shift from single to double loop learning in the CMA's decision-making. From an action research perspective, this will represent the most significant achievement of the project.

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