AN ASSESSMENT OF THE COMPANION MODELLING APPROACH IN A CONTEXT OF NEGOTIATING WATER ALLOCATION STRATEGIES: THE CASE OF THE KAT RIVER VALLEY, EASTERN CAPE, SOUTH AFRICA.

A thesis submitted in fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Of

RHODES UNIVERSITY

By

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Preface

The research work described in this thesis was carried out at Rhodes University in the Department of Geography, Grahamstown campus from April 2005 to September 2007, under the supervision of Professor Kate Rowntree (Rhodes University, Department of Geography) and Dr Stefano Farolfi (CIRAD and CEEPA/University of Pretoria).

This thesis represents original work by the author and has not been submitted in any form to another university. Where use was made of the work of others it has been acknowledged in the text.

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"Kubo bonke OThixo akakho onjengaye kuba inceeba zakhe zim' ngonaphakade!"

My greatest thanks go to the man above, The Lord Almighty for through him everything is possible.

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Abstract

This Masters research took place in the Kat River Valley in the Eastern Cape, South Africa. The Kat River Valley is a semi-rural catchment that covers an area of approximately 1700km^2 and is characterized by a complicated history of dispossession and resettlement. Farming is the main activity that is practiced in the area. This includes the farming of citrus at a commercial scale, rangeland stock farming and small-scale vegetable farming. The economy of the catchment is enhanced mostly by commercial citrus farming, which consumes by far the largest amount of water in the river through irrigation. Water allocation is a burning issue among water users in the catchment and needs to be negotiated taking into consideration social, economic and environment impacts. The aim of this study is to describe, discuss and evaluate the Companion Modelling (ComMod) approach, which used a simulation model and a role-playing game related to the model in order to facilitate and develop negotiating skills as well as build capacity in decision-making amongst local stakeholders for water resource management in the Kat River Valley. The ComMod approach, developed by a group of Companion Modellers, is a community-based science approach that emerged in the 1990s. The ComMod approach is used in order to facilitate collective learning, negotiation and institutional innovation in dealing with resource management complexities faced by rural communities. Through ComMod, the model (KatAWARE) and its related role-playing game was developed by having the contact with local stakeholders. The information to feed the model and the role-playing game came from informal interviews, surveys, geographic information systems (GIS), workshops and focus groups. The use of workshops in the implementation of ComMod was a success. Results show that (1) new knowledge was acquired, which allowed stakeholders to have a broad understanding of a catchment system. (2) Awareness was created about complex systems and enabled stakeholders to see an individual action into to the broader system. (3) Strong interrelationships were fostered amongst different water users, which allowed stakeholders to share their view points. The ComMod process was however associated with a number of limitations, many of which resulted from the constraints that were imposed by the socio-economic background of the study area. Nevertheless, the outcome of the study shows that the ComMod process was useful in helping the Kat River Water

Users Association (KRWUA) stakeholders develop negotiating skills regarding water allocation strategies for the development of the Catchment Management Plan.

List of figures

List of Tables

List of Acronyms and Abbreviations

GIS	Geographic Information Systems
DWAF	Department of Water Affairs and Forestry
KRVP	Kat River Valley Project
KRWUA	Kat River Water Users Association
WUA	Water Users Association
IB	Irrigation Board
WRC	Water Research Commission
ComMod	Companion Modelling
RPG	Role-playing game
IEM	Integrated Environmental Management
NWA	National Water Act
IWR	Institute for Water Research
Km^2	Kilometer square
Mm^3	Million cubic meters
mm	Millimeter
mm/a	Millimeter per annum
CIRAD	Centre de cooperation Internationale en Recherché Agronomique pour le Développement
CMP	Catchment Management Plan

CONTENTS

CHAPTER ONE

BACKGROUND AND RATIONALE

1.1 Introduction

This study seeks to describe and discuss the Companion Modelling (ComMod) approach, which uses a simulation model and a role-playing game. The ComMod approach was applied in order to facilitate and develop negotiations for water resource management in the Kat River Catchment. Building capacity in decision-making amongst local participants has been also a component of ComMod. The ComMod approach was developed in the 1990s by a group of Companion Modellers Barreteau *et al.,* (2003) and uses simulation models and role-playing games for participatory management of natural resources. ComMod is employed within a context of participatory action research and has been applied for instance in Thailand, where sound water management has been challenged by the increase of agricultural commercialization (Barnaud *et al*., 2006).

In South Africa the ComMod approach had never been used before, and thus has been applied for the first time in the context of the Kat River Catchment. The call for the ComMod approach to be used in the Kat River Catchment came about on account of the need to implement a participatory process. This participatory process aimed to develop a negotiation-support tool, which would enable the Kat River Water Users Association to discuss future scenarios. In addition, this approach was used to relate possible water allocations between the different sectors, in the catchment, and the consequences, of these scenarios, in terms of economic, social and environmental outcomes. This has been as a result of the work by the Institute for Water Research (IWR) and Geography Department at Rhodes University, who through the Water Research Commission (WRC), initiated a project: “A stakeholder driven process to develop a Catchment Management Plan for the Kat River Catchment”, that facilitated a process of participatory water

resource management (Burt, 2005). This Master's study is a contribution to this parent project.

The WRC has close research attachments with many of the South African Institutions of Higher Learning. The WRC has also been providing funds on numerous occasions for research projects that have been carried out in the IWR and Geography Department at Rhodes University. One such project was a PhD by Ms Nicole Motteux, which looked at facilitating the effective participation of village communities in both (a) transformation of the Kat River Irrigation Boards into Kat River Water Users Association (b) the development of the Catchment Forum which is a body that provides the channel for village communities to have a say in the management of the catchment resource (Motteux, 2002). It is as a result of this research that water management with which I worked during this study institutions are found today in the Kat River Valley. According to Burt (2005), the Kat River Catchment area has been intensely researched for the past ten years, particularly through WRC funded research conducted by students and practitioners from Rhodes University.

As mentioned above, the parent project focused on the development of the Catchment Management Plan for the Kat River Catchment. Two structures were involved, including a science research team and a social team. The science research team was responsible for conducting scientific research work to determine the ecological Reserve; the team included geomorphologists, hydrologists, and ecologists that specialize in aquatic plants and animals. The social team was responsible for social aspects, namely: participation, representivity and capacity development of the Kat River Water Users Association regarding the research project. The ComMod approach implementation took place within the social context, therefore the social team were deeply involved in facilitating ComMod. I have been a member of the social team whilst doing this Master's study, because I was also asked to facilitate the ComMod approach. My role in the project was informed and guided by the terms of reference which will be given later in this chapter. The use of the ComMod approach in the Kat River Catchment started in April 2005 and ended in March 2007. This masters research, however, followed a two year study

programme, and therefore anything that happened after December 2006 is not included in this thesis.

The key element for the parent project involves the development of a Catchment Management Plan (CMP). While the core aim of this research is to develop a CMP, capacity building is required in order to meet the needs of diverse participants. Farolfi and Rowntree (2005) point out that participants in the Kat River Catchment are characterized by asymmetry of knowledge, different understanding, and varying needs that to some extent result in conflicting interests in their sharing of a water resource. With these conflicting interests it is difficult for local participants to participate in harmony towards developing a CMP. Therefore the ComMod approach has been used to create a platform where participants learn collectively, where conflicting interests will be voiced and, if possible, addressed. Rhodes researchers are involved in the ComMod project, working in close collaboration with an international organization, Cirad[1], some of whose researchers are based in the University of Pretoria. The key participants involved in the process are committee members of the Kat River Water Users Association.

This Chapter will outline why is there a need for the ComMod in the Kat River Catchment. In addition, a brief overview will be given of the Water Users Associations (WUAs), as local institutions as set by the National Water Act (NWA) of 1998 will be given. The relevance of ComMod to the Kat River Catchment will be illustrated. The terms of reference for this Master's study will be presented as well as aim, objectives and research questions.

1.2 Local Water Institutions

According to Dor *et al.* (2002), when the newly elected South African government came into power in 1994, past policies that favoured commoditization of resources were abolished. For instance, the National Water Act, Act 36 of 1998 (NWA, 1998) replaced the riparian Water Act of 1956 (Department of Water Affairs and Forestry, 2001).

[1] Cirad is the French agricultural research organization for international development. In South Africa it is based in and works in collaboration with the University of Pretoria focusing on applied modelling of relationships between societies and their environment whereby multi-agent systems and other modelling and simulation techniques are employed to investigate ways for integrated natural resource management.

Perkins and Wessels (2004) write that these past policies disregarded ecological and environmental impacts. Therefore, such policies needed to be amended. The African National Congress (ANC) elected government promulgated new laws including the National Water Act. From these laws a framework for the National Water Resource Strategy (NWRS) was set, in order to manage water resources in South Africa (NWA,1998).

The NWRS promotes institutional bodies such as the Water User Associations (WUAs) that are made up of individual water users who undertake local water related actions for their communal benefit (NWA, 1998). Participation of all participants to protect, use, develop, conserve, manage and control water resources is vital and forms a major component of decentralization[2] of water management. Before the WUA carries out its tasks, a plan is needed that will show how they aim to manage their catchment resources, in particular water. According to the NWA (1998), development of the plan must involve a great deal of stakeholder participation. This means participation by all segments of society, including those that have been historically disadvantaged and marginalized, for example women, rural communities and the poor.

However, stakeholder participation needs capacity development in order to ensure that participants participate fully and fairly. The WUA participants are a part of a society that is very diverse. Farolfi and Rowntree (2005) state that managing a common resource such as water is difficult because of different needs, different knowledge and understanding and different socio-political interests. A common goal will need to be negotiated by these participants. Thus the capacity to negotiate needs to be developed among participants so as to have agreed water allocation strategies drafted in the CMP. For this reason the ComMod approach has been selected for the Kat River Catchment in order to facilitate and develop negotiating skills among the Kat River Water Users Association members. ComMod is used in the context of action research, which requires a participatory process.

[2] Decentralization of water management involves taking away the role of regional offices in managing water by having local participants at catchment level managing it. This requires establishing water management institutions by ensuring that equity, sustainability and optimal use is achieved. Regional offices will be responsible for regulational and monitoring functions, whereas local institutions will be responsible for operational functions (NWA, 1998)

Within the ComMod approach, a model KatAWARE[3] was developed to enable members of the Kat River Water Users Association to discuss future development scenarios in relation to water allocations. The scenarios produced by KatAWARE were designed to simulate the possible outcomes between different users and to look at economic, social and environmental consequences of these outcomes (Farolfi and Rowntree, 2005).

As stated earlier, the Kat River Water Users Association came about as a result of a PhD thesis by a Rhodes University student, Miss Nicole Motteux, who did her research study under the Department of Geography (Burt, 2005). Motteux's research took place at a time when transformation was beginning to take place in the South African water sector. The National Water Act (the NWA) had just been passed, which, amongst other things, promoted the decentralization of water management from regional offices to local institutions. As required by the Act, WUAs needed to be formed or existing irrigation boards needed to be transformed into WUAs (Motteux, 2001). As an irrigation board already existed in the Kat Valley, Motteux's research focused on transforming the existing irrigation board into the Kat River Water Users Association. Since the irrigation board comprised only large commercial citrus white farmers, there was a need to bring on board emerging citrus black farmers, black irrigation schemes and domestic users. The transformation of the Kat River Water Users Association became a participatory process, which was in line with the legislation and policy documentation. Motteux (2001) states that it created a forum where participants were allowed to take part, receive and share knowledge and be empowered about water related issues. The Kat River Catchment has therefore been characterized by complex socio-economic and socio-political issues, and these are important to understand as they surface in this research study.

1.3 What is a complex system?

The notion of Complex systems can be used to describe interactions between the effects of human beings and the natural habitat. According to Constanza ***et al***.(2006:2) "Systems are groups of interacting, interdependent parts linked together by exchanges of energy,

[3] KatAWARE is taken from the name AWARE, which means Action research and Watershed Analyses for Resource and Economic Sustainability. AWARE was a simulation model developed by Farolfi and Hassan (2003) for the Steelpoort basin. Some features of AWARE were adopted in the initial construction of KatAWARE, and this explains the origin of the name.

matter, and information. Complex systems are characterised by strong (usually nonlinear) interactions between the parts, complex feedback loops that make it difficult to distinguish cause from effect, and significant time and space lags, discontinuities, thresholds and limits. These characteristics all result in scientists' inability to simply add up or aggregate small-scale behavior to arrive at large-scale results. Ecological and economic systems both independently exhibit these characteristics of complex systems. When linked, ecological and economic systems are complex" Pahl-Wostl (2007) defines a complex system as having the following characteristics:

- It is multilevel and characterised by non-linear behaviour;
- Its actors have different perspectives and worldviews;
- The decision making process is very risky; and
- Management objectives may be interpreted differently by individual actors.

Complex systems are made up of imbalances, inadequacies and inequalities in living standards, education, access to information as well as access to resources. The world we live in is a good example of a complex system because there are imbalances between environmental, economic as well as social factors. These imbalances not only occur at global levels but at local scales as well as in catchments for instance. According to Pahl-Wostl (2007), integrated resource management attempts to provide services, prevent damage and maintain resources for future generations. In order for this to happen, we need to aim for a balance between social, economic and environmental factors. Often people's social, economic and environmental perspectives are in conflict with one another and this is what gives rise to complexity. Pahl-Wostl states that complexity results from human behaviour, and that human behaviour gives rise to problems which require collective learning in order to be managed and dealt with appropriately.

Integrated water resource management (IWRM) is complex and requires broad perspectives of social learning in order to function effectively. The characteristics of social learning in the IWRM context, according to Pahl-Wostl (2007), are that the people involved:

- Work together in problem solving;

- Reflect on personal decision making;
- Are aware of social linkages such as dependency and interaction; and
- Engage in collective learning and negotiated decision processes.

Lieblein *et al* (2000) write that action research and action learning provide dynamic learning environments that go beyond knowledge generation, to focus on problem solving, teamwork and flexibility in order to adapt rapidly. Lundqvist (2001) argues that efforts to deal with complexities should not be based on scientific knowledge only, and that local context is just as important to consider. Thus the participation of local stakeholders is vital in ensuring contextual understanding of a complex system. Local stakeholder at times might not be aware of complexities in their catchments and it becomes very crucial to assess this awareness. Therefore, processes like ComMod need to be evaluated in terms of knowledge and awareness generation among local stakeholders about the complexity of human/natural resources relations.

Complexity is also experienced within the biophysical environment and the way it is used/managed by people.

1.4 Biophysical factors that determine land and water availability

The Kat River Catchment has a total surface area of 1715 km^2. Figure 1.1 shows the location of the Kat River Catchment within South Africa and the Eastern Cape Province.

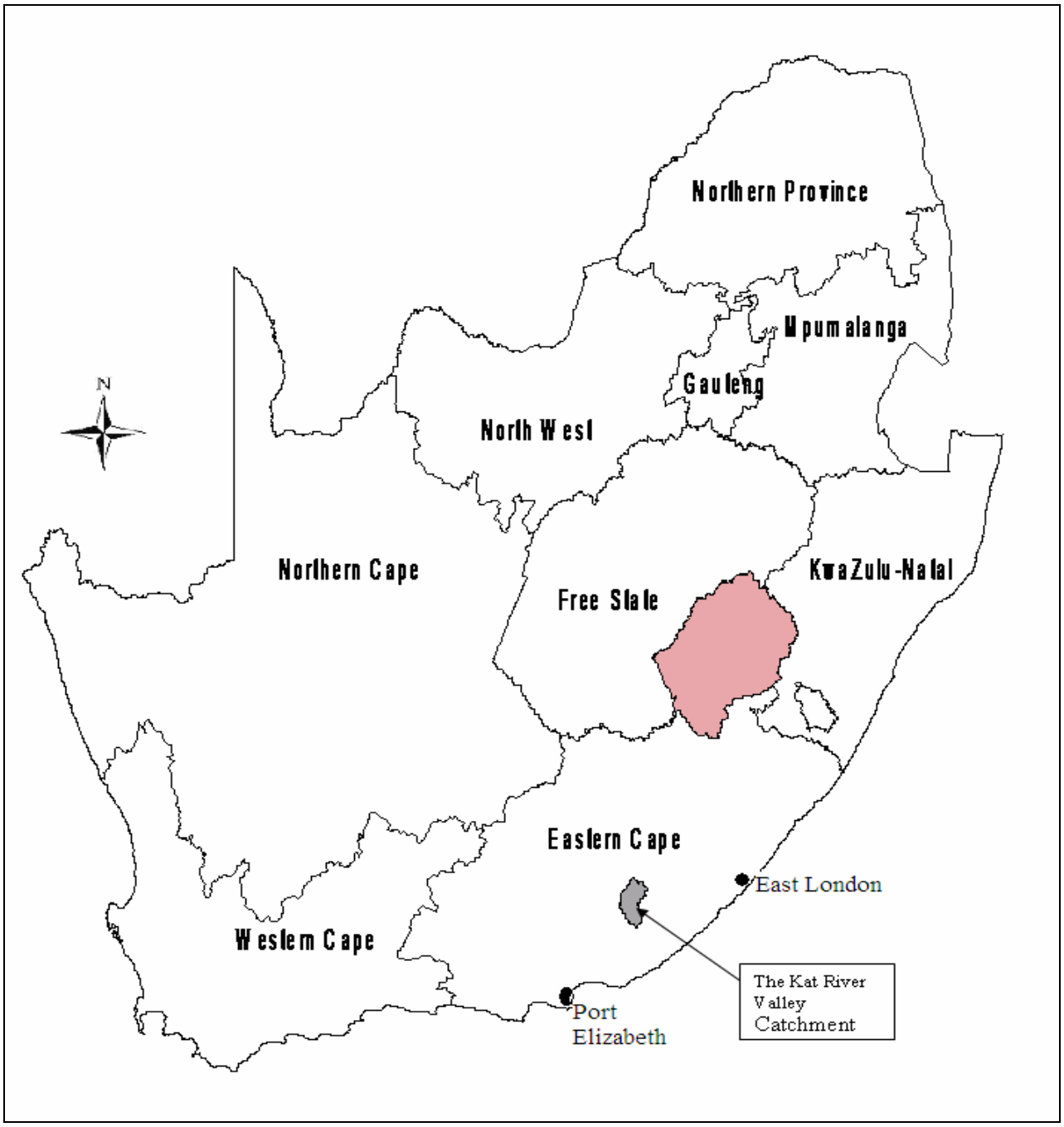


Figure 1.1: The Kat River Catchment within the Eastern Cape and within South Africa

The Kat River Catchment is made up of different land uses (refer to Figure 1.2). Vegetation consists largely of thicket and bushland. At higher altitudes the vegetation is made up of forestry and grassland. Landuse in the Kat River Valley is tabulated below:

Landuse in the Kat River Valley	
Landuse Type	**Measure**
Irrigation	18.7km^2
Dry land crops	36km^2
Afforestation	73.3km^2
Indigenous Forests	32.2km^2
Alien Vegetation	21.8km^2
Nature Reserves	19.2km^2
Urban and built up area	18.9km^2
Rough grazing	1494km^2

Of the 18.7 km^2 irrigation land 13.5 km^2 are citrus orchards and 7.4 km^2 is used by small scale farmers.

The mean annual precipitation is 668 mm/a and ranges from 800 mm in the upper catchment, whereas the lower catchment has 480 mm. The mean annual evaporation is 1580 mm/a. Natural mean annual runoff is 70mm (Farolfi and Jacobs, 2005). The climate is mild with summer temperatures ranging between 20 and 35 degrees Celsius, whereas in winter temperature range between freezing and 20 degrees Celsius (Motteux, 2001).

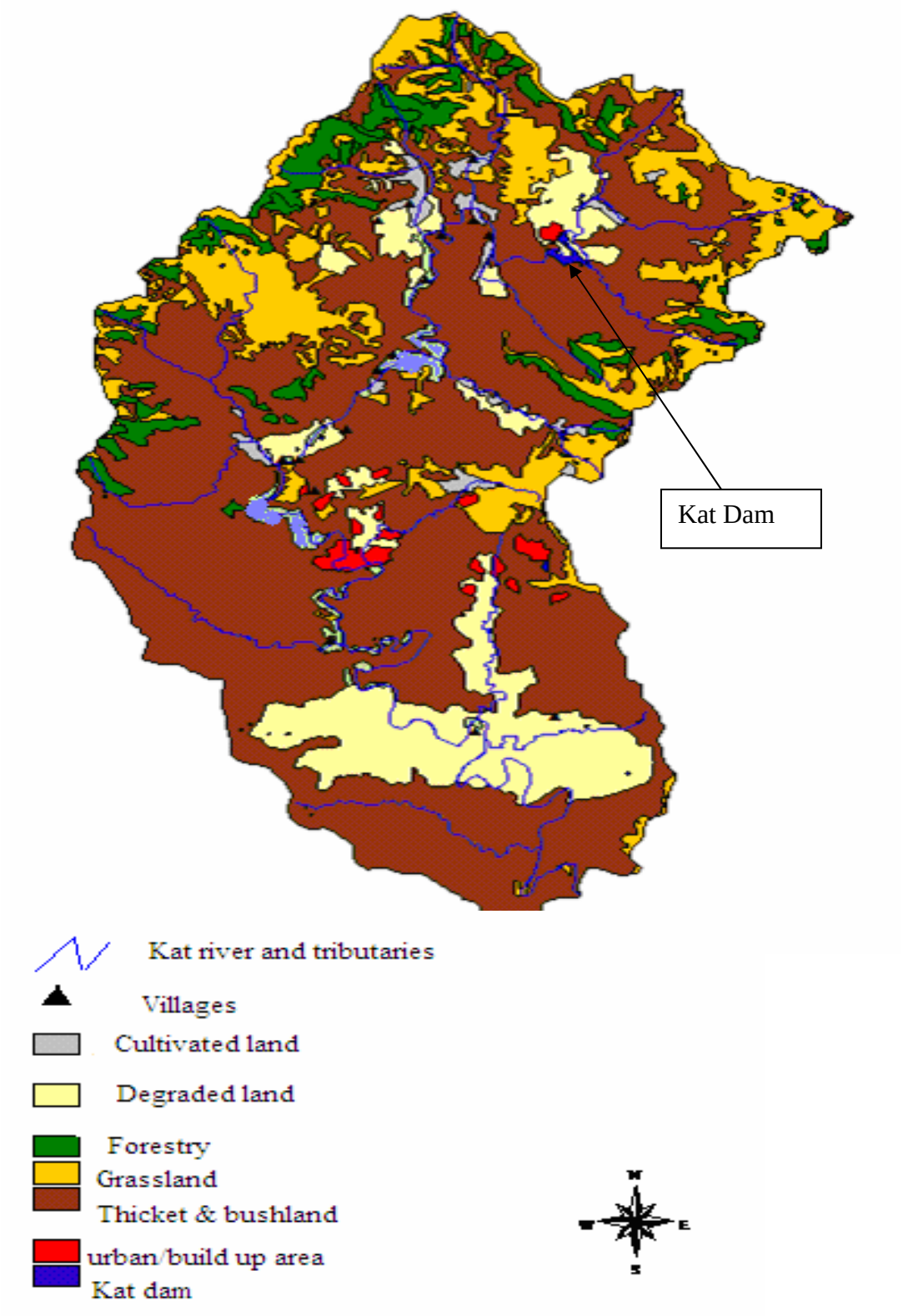


Figure 1.2: Land use in the Kat River Catchment

According to Motteux (2001) the Kat Dam was commissioned in 1970 for irrigation purposes. The Kat Dam has a storage capacity of 24.9 Mm^3, however there has been a gradual decrease due to siltation. The Dam has natural inflows of 22.3 Mm^3, with monthly water releases estimated to be 10.04 Mm^3 for irrigation uses, 1.72 Mm^3 for domestic uses and 4.36 Mm^3 for river losses.

1.5 Socio-economic and socio-political factors in the Kat River Catchment

According to McMaster (2002), farming is the main activity that is carried out in the catchment. Commercial citrus farming is practiced in the middle and lower Kat; rangeland stock farming becomes more important in the lower Kat. There is a population of approximately 26 000 in the catchment who suffer from high unemployment rates. Seymour and Balfour are semi-urban areas found in the upper catchment and they are characterized by economic stagnation (Fox, 2005; Mujkanovic, 2005; Edgren, 2005).

As a result of a complicated history of dispossession and resettlement Mlilo (2005), different areas of the catchment are characterized today by very different levels of development. For instance, the upper and middle sections of the catchment, both falling under what was previously known as the Ciskei[4], are populated by small scale farmers producing annual crops with limited resources. Emerging farmers producing citrus on farms that were previously owned by the Bantustan administration also live in these portions of the catchment. In the lower portion of the catchment, which was part of the Republic of South Africa during the apartheid era, large scale commercial farmers produce citrus.

One of the burning issues that exist in the upper Kat today is the uncertainty about land tenure. This is a consequence of the non-implementation of the land reform that was voted by the South African government and that should restitute and redistribute land rights to African farmers who were dispossessed during the apartheid era. This

[4] Ciskei is a name that was given by the apartheid government with an intension to categorize the area as a Bantu homeland where only the black people resided. Such homelands were overcrowded and poor resourced and therefore had an increasing poverty rates, poor education, poor infrastructure, poor services provision and experiences economic burden because they could not sustain themselves (Burt, 2005)

uncertainty is one of the factors hindering the farmers from making valuable progresses in terms of investments and productivity improvements. To face this problem, however, Mlilo (2005) describes how some of these farmers have grouped together into cooperatives to make it easier to buy equipment, secure inputs and improve their marketing strategies.

In the middle and lower catchment are found the white-owned citrus orchards, which consume by far the largest amount of water in the river through irrigation. According to Mujkanovic (2005;), Edgren (2005;) and Mlilo (2005) citrus irrigators achieve high levels of production, employing a labour force of up to 200 people in the whole area depending on the season.

There is no doubt that initiatives such as ComMod, aiming at promoting water resource management in the Kat River Catchment, have to face the above stated complicated history and complex situation of the area. The Kat river represents a complex system where many components (socio-economics, political and environmental) are interrelated and produce combined effects that cannot be analysed through mono-disciplinary approaches such as the economic studies or the ecological ones. A multidisciplinary approach is therefore required in order to take into consideration the complex interrelations among various components of the system as well as their dynamic nature.

1.6 Why is ComMod used in the Kat?

The Kat River Water Users Associations is at a stage where it needs to implement water allocations to different users (Burt, 2005). As a result of inequalities, asymmetry of information and varying interests brought about by the area's history, the use of decision-support tools might be helpful. This is the reason why the ComMod approach was introduced by Dr Stefano Farolfi[5] in the Kat River catchment. According to Barreteau ***et al.*** (2003), ComMod is a participatory process designed to enhance participants' participation in natural resource management by raising awareness about complex

[5] Dr Stefano Farolfi is an environmental economist and my co-supervisor in this master project. He is a researcher at Cirad. He successfully developed the AWARE computer model for Steelpoort Basin; as a result he was asked by WRC to develop KatAWARE as part of the WRC funded project in the Kat valley.

systems. Farolfi and Bonté (2005) state that the use of ComMod seeks to make participants learn about each other, be aware of the complexities that exist in catchment settings, learn to conduct participatory decision-making where all citizens of the catchment are considered and lastly learn about managing natural resources for the benefit of both humans and the environment. The KatAWARE model and its related role-playing game developed through ComMod explore scenarios, where water allocation strategies are negotiated by participants (Farolfi and Rowntree, 2005). This participatory nature of ComMod links with action research where "learning by doing" (Liu, 1996) or "social learning" (Roling, 1996; Allen, 2000) is strongly encouraged.

Participation in action research takes place in the form of spiral cycles, involving planning, action and reflection throughout the entire process. Action research projects are therefore comprised of numerous spiral cycles where different stages of planning, action and reflection occur (see Chapter Three). Similar to action research, ComMod makes use of iterative processes, where there is continuous back and forth interaction between field work, modelling and simulation. As a result of an iterative process the model is modified at each cycle with improved information of a complex area. This process facilitates participants to progressively explore dynamic actions, capacity is also developed to understand complex issues, negotiating techniques are gained and lastly decision-making conditions are learned (Farolfi and Rowntree, 2005).

1.7 Who are the research actors? Who are the WUA actors?

My role in this research had been outlined by the terms of reference developed by Farolfi, Rowntree and the funders, the WRC.

Terms of Reference

To facilitate the negotiation process within the local WUA, two information vehicles and negotiation support tools will be implemented and adapted to the local context: a simulation model called AWARE and a role-playing game derived from the model. A participatory and companion modelling approach will be followed to develop these tools, which implies a co-development of the model and the role-playing game with the local participants. There is good opportunity to develop the model in association with a GIS platform.

Duration of contract:

From April 2005 to March 2008

Place:

Rhodes University

Tasks to be performed:

** Thorough bibliographic survey and review of ComMod as an approach and method for managing consensus-seeking processes and multi-stakeholder groups in the water sector;*

** Collection of primary and secondary data to calibrate to the local context the simulation model and the role-playing game;*

** Organisation of and active participation (co-animation) in the meetings with local participants for the development of negotiation support tools;*

** Contribution to the development of the model and the role-playing game, participating actively also in the implementation of the computerized tools;*

**Follow-up of the relations with local participants, and contribution to the preparation of the progress reports during the implementation of the project;*

** Follow-up and coordination, under appropriate supervision, of the process of participatory modelling and negotiation support with local participants; and*

** Contribute to the preparation of the assessment reports on the use of the implemented tools to facilitate the process of negotiation regarding water management in the Kat.*

The above mentioned tasks were performed as required, with the exception of the modelling component, which was carried out by the Cirad Team. There was an addition to the tasks, which came during the course of the project. This new task required me to conduct the evaluation of the ComMod approach as part of the Agriculture et Developpement Durable[6] (ADD) project, further details of which can be found in Chapter Four.

The social team was tasked to work on the parent WRC project. However, since the parent project is an umbrella for the ComMod implementing project, the team automatically became a research actor in the ComMod research project. I became a social team member because my tasks complemented those of the team. The social team comprised of the following members:

- a practitioner who has expertise in social related projects, Miss Jane Burt;
- a facilitator and mediator of Xhosa and English languages, Mr Monde Ntshudu
- a parent project administrator, Miss Helen Fox; and

[6] ADD stands for Agriculture et Developpement Durable (Agriculture and Sustainable Development). The ADD project comprises of a team of researchers who are responsible for implementing the ComMod approach in different countries of the world.

- International post-grad students (Masters and PhD) who came from different countries and became part of the project for a maximum of a year, because their research studies were related to integrated water resource management.

The Cirad team, responsible for the ComMod process, was comprised of the following members:

- Mr Bruno Bonté who specializes in multi-agent simulation models; he helped develop the model KatAWARE;
- Dr Jean Pierre Muller who specializes in developing simulation models and role-playing games; and
- Dr Stefano Farolfi who has expertise in ComMod and also specializes in developing simulation models and role-playing games.

Other important research actors that contributed significantly to the ComMod project were;

- Professor Kate Rowntree, who is the leader of the parent project; and
- Miss Sharon Birkholz, who is the coordinator for the parent project.

The WUA actors are comprised of local participants who are members of the WUA representing their water use sectors. The WUA consist of the following members (see Chapter Four for details);

- Three large scale citrus farmers
- Three small scale vegetable farmers
- Five domestic water users
- Nkonkobe municipality member
- Department of Water Affairs and Forestry (DWAF) regional office member.

Both the ComMod implementing project and the large project were still ongoing as this thesis was written. As mentioned above, because my Masters research tasks complemented the tasks I had as a social team member, I had to develop an exit strategy so as to allow the commencement of the thesis write up, though I still continued with my tasks as a social team member. My Master's research work ended with the ADD project ComMod evaluations and anything that occurred after my exiting in December 2006 has not been included in this thesis.

1.8 Research aim, objectives and research questions.

The aim of the study was to describe and evaluate the ComMod approach applied in the Kat River Catchment for building capacity and knowledge and negotiating water allocation strategies. The process was based on the co-development and application of two main tools, namely the model KatAWARE and the related role-playing game.

In achieving the above aim the following objectives were pursued;

- To review the complex literature that influenced the development of ComMod. This literature ranges from Post-normal science, to Constructivism, up to Action research;
- To describe and document the ComMod process as it was implemented in the Kat River Catchment;
- To contribute information obtained through workshops, surveys, secondary data, interviews and Geographic Information Systems (GIS) to the KatAWARE model;
- To evaluate the ComMod process using personal reflections, team reflections and evaluations, including the ADD evaluation; and
- To provide recommendations for the possible future applications of ComMod in other similar contexts.

The research questions that guided this study were as follows;

- Has KatAWARE followed the ComMod approach?
- Has the ComMod approach led to any change within the WUA members in respect of knowledge, particularly on a) complexity and b) interrelation among different elements of the system.
- Has the ComMod approach been relevant for the process of building the capacity of the Kat WUA to conduct negotiations leading to the preparation of the Catchment Management Plan?

1.9 Thesis Outline

This thesis is divided into five chapters. Chapter One has provided a general background (Introduction) to the research, set the study into context, given the problem statement and

the rationale of the study. The aim, objectives and research questions were also given. Chapter Two provides the theoretical framework, describes the tools and approaches as well as research paradigms that were used in the study. Chapter Three describes in detail the ComMod approach in the context of action research as has been carried out in the Kat catchment. Chapter Four focuses on evaluating the ComMod approach as well as analysis of data. Chapter Five concludes and provides some recommendations.

CHAPTER TWO

THEORETICAL FRAMEWORK

2.1 Introduction

This chapter presents the theoretical underpinnings on which the study is based. As the ComMod approach is an example of community-based science, a brief overview of community-based science approaches using some examples from various countries are given. The theory behind the ComMod approach is presented. Tools that are constructed during the ComMod process are also presented. Lastly, the action research process that parallels the ComMod approach will be explained.

2.2. Global overview of community-based science approaches

According to Kelly *et al.* (2005), community-based science approaches are designed for building the capacity of local communities, thus allowing them to manage biophysical, economic and social systems. Community-based science approaches draw from various overlapping theories, including: participatory research, collaborative research, social learning, community-based Natural Resource Management, community engagement, community development, capacity building, empowerment, power, systems orientation, modelling, evaluation of participatory research and, lastly, participatory evaluation. The focus of community-based science approaches is, in summary (Kelly *et al.*, 2005:6):

- "Participatory processes for local or regional engagement;
- Economic, social and environmental impact assessment;
- Evaluation of participatory research;
- Developing and implementing local or regional plans;
- Modelling behavior, resource dynamics and resilience; and
- Integrative science for local or regional change."

Even though community-based science approaches have been in use since the 1970s, Kelly *et al* (2005) say that there is no systematic review to document the success and lessons of these approaches. A summary of four case studies that use different examples of community-base approaches is given below.

The first case study from Australia uses a sustainability science approach that follows a holistic and integrated systems methodology designed for institutional and personal transformation. The term sustainability science is described by Blackstock *et al* (2007:727) "as the integration and application of knowledge about natural and social systems, considering long term uncertain and non-linear relationships." Here capacity is developed to undertake participatory and collaborative environmental decision-making. The key element is information provision, which allow participants to undergo a learning process designed to increase their understanding of complex systems (Blackstock *et al*., 2007). However, Blackstock *et al* (2007) add that there is uncertainty about whether participation within sustainability science is achieved in practice.

The second example of a community-based science approach uses participatory GIS and has been used in Brazil. According to Bacic *et al* (2005) spatial information was used to influence negotiations and decision-making of local participants regarding a water pollution problem caused by intensive pig farming. Synoptic satellite image and orthophoto collections were used in conjunction with the spatially explicit dynamic pollution model. The model allowed participants to explore the effects of collective understanding, perceptions and analysis of shared environmental problems. As a result participants were able to identify problem areas on the images, whilst engaging in discussions and making collective decisions in order to find solutions to their pollution problem (Bacic *et al*., 2005). This case shows that visual presentations of complex issues as modeled scenarios in GIS can be used to promote understanding of complexities among participants. Also stakeholder interaction and collaboration is important in order to use information that has been generated effectively through modeled scenarios (Bacic *et al*., 2005). Even here, there are drawbacks. For example, if insufficient time is given to allow participants to explore further ideas, then participatory GIS is not conducive to collaborative decision-making. In addition, spatial information needs to be relevant to participants so that they can identify themselves with the process (Bacic *et al*., 2005).

The third example of community-based science approach comes from Vietnam. Scott *et al*. (2006) highlight their experiences while conducting participatory research in Vietnam

between 1997 to 2001. According to Scott *et al* (2006), community-based research projects in Vietnam have been in progress since the early 1990s. However, during the past few years the research culture has taken a position focusing on tangible outcomes. Scott *et al*. (2006) described a number of areas of difficulty that they experienced as: entry, access, gender, political issues and lastly research has been made a commodity thereby conducted for enhancing the market economy. They write that an outsider conducting research in Vietnam needs to have links with one of the academic institutions in the country, which in turn would provide them with contacts for information. This implies a preference for a top-down system. Also questionnaires, surveys and mapping are preferred by academic institutions in Vietnam over participatory research methods. These research methods used in Vietnam disregard local knowledge. As a result researched communities in Vietnam do not experience shared learning, exchange of ideas and advancement of knowledge that is often brought about by participatory research initiatives. Therefore, in the case of Vietnam, community-based science approaches often become unsuccessful (Scott *et al*., 2006).

The ComMod approach is also one of the community-based science approaches; it emerged in the 1990s. ComMod has been used to facilitate collective learning, negotiation and institutional innovation in dealing with resource management complexities faced by rural communities. ComMod was applied for instance in Thailand, where sound water management has been challenged by the increase of agricultural commercialization. According to Barnaud *et al* (2006), ComMod was used to facilitate the decision making process for participants, getting them to agree on new rules for the management of limited water resources. Through ComMod, a multi-agent simulation model and a role-playing game were constructed and used to explore possible scenarios. This allowed multiple participants to be aware of the complex system of which they are part. ComMod stimulated collective learning amongst participants. Also, participants started to work together through negotiations, thereby changing the existing dysfunctional water management system. As a result, a Watershed Management Committee was established in which multiple participants exercised their right to collectively make decisions in the management of their water resource (Barnaud *et al*.,

2006). Even though in this case ComMod was useful for attaining institutional innovation, certain difficulties were associated with the process. These difficulties included the coordination of the process. Barnaud *et al* (2006) also indicate that a bottom-up dialogue amongst multiple participants proved to be a failure.

The above mentioned case studies highlight that collective learning, negotiating and collective decision-making are among the few non-tangible skills gained by communities in community-based science approach projects. As these benefits are non-tangible, often communities see them as being not important. In addition, what emerges is that while community-based science approach projects are becoming popular with researchers worldwide, there are constraints that are associated with them. These include lack of transparency, ambiguity, questions as to who is driving the project, who benefits and how. Such limitations may hinder the projects from attaining valuable outcomes and yielding the useful results that would help rural communities to better manage their natural resources.

This Master's study uses ComMod among community-based science approaches mentioned above. The key research element has been to evaluate the impacts of the ComMod approach on Kat River Water User Association participants.

2.3 The Companion Modelling approach

According to Farolfi and Rowntree (2005), ComMod involves the use of tools such as a simulation model and role-playing games in order to build the capacity of multiple participants. Such tools are used at catchment level by participants in order to understand and form their own negotiation process and, in addition, decide on decision-making means for their catchment. The ComMod's key principle that guides its functioning according to the ComMod Charter 1.1 (ComMod Research Team, 2004) is as follows. Throughout the process of developing the model there must be a continuous interaction and information exchange between researchers and local participants through workshops, surveys, interviews and focus groups. Through this continuous interaction participants are given an opportunity to validate or refute the assumptions made by the model. Farolfi and Rowntree (2005) write that the effect of ComMod is to allow participants to share

representations and simulations, taking into account possible decisions and actions within their environment. Viewpoints that do not reflect the reality of participants are eliminated and viewpoints that do reflect the reality of participants are incorporated in the latest amended version of the model.

The implementation of ComMod requires that both the model and role-playing game be co-developed by the research team together with the local participants as illustrated in the ComMod cycle Figure 2.1.

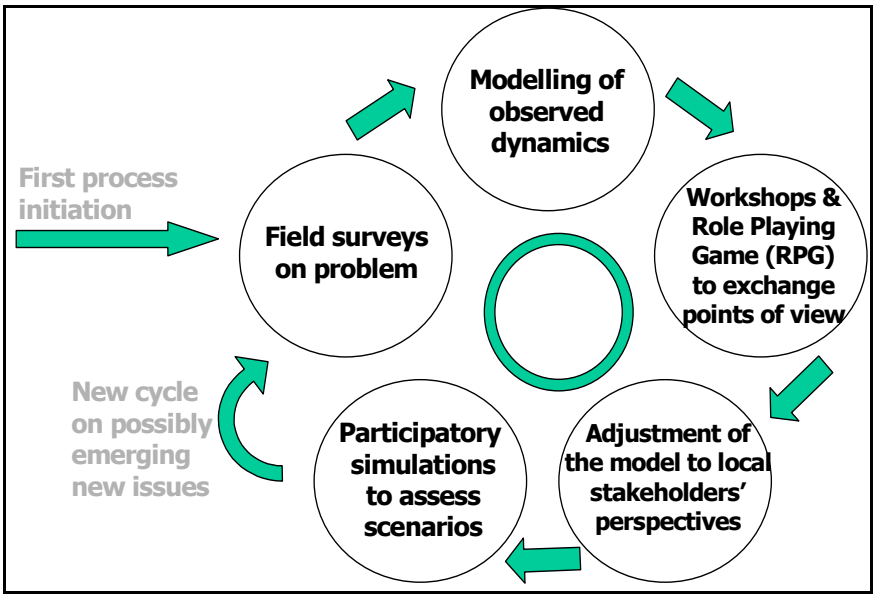


Figure 2.1: The ComMod Cycle,
Source: (Farolfi and Rowntree, 2005)

The ComMod cycle shows the continuous and repetitive feedback between theory and the real world. A number of cycles are created, where through all the cycles there is an improved correlation between the simulation, research path and decision-making process. Within the ComMod cycle, viewpoints of participants are taken into consideration, which might have otherwise been perceived as illogical and unrealistic. Participants get a chance to question any new element within each cycle that is introduced. During the iterative process, the understanding of both the participants and the research team is improved as both parties engage with each other. Through this process different types of dialogues occur, leading to a strong participatory modelling process. According to the

ComMod Charter 1.1 (ComMod Research Team, 2004) (2005), each iteration leads to shared decisions, participants develop the capacity to share information, exchange viewpoints and acquire knowledge.

As the ComMod approach is designed for improving participants' knowledge about a complex system, assessing the impact of the ComMod approach on participants' knowledge, perceptions and practices is necessary. According to Jones ***et al*** (submitted) a valuation framework was developed in 2006 by a group of researchers that use ComMod approach in participatory research projects worldwide. Jones ***et al*** (submitted) writes that the ComMod evaluations aim to look at what works, why it works and how it could work better. When evaluating a context-based project, getting feedback from participants by asking the following questions is very important (Jones ***et al***., submitted), namely:

- To what extent did the participatory procedures which included models and role-playing games produce desired outcomes?
- Did the use of models promote commitment and empowerment to the participants?
- Did the process lead to consensus or rather to a mapping out of different positions and interests? and
- Was the use of models helpful in the production of new knowledge?

In order to understand the feedback that is obtained from such questions, a strong knowledge and understanding of the local context is required. Jones ***et al*** (submitted) states that there are various types of learning from various participants that occur during the ComMod process. All these learnings need to be captured when doing the evaluation. Some partial conclusions of the ComMod evaluation are presented in Chapter Four. Given that the ComMod approach is used within a participatory action research context it becomes crucial to understand the process and implications of action research.

2.4. Action Research

Action research, according to Ramos (2006), is an explicit process that involves reflecting on the way people live their lives, hence their day to day experiences. It entails a participatory process where knowledge is co-created while integrating perspectives of

multiple participants. Action research is designed for providing a learning, empowering and capacitating experience to participants. The three key components of an action research process constitute planning, action and reflection as illustrated in Figure 2.2.

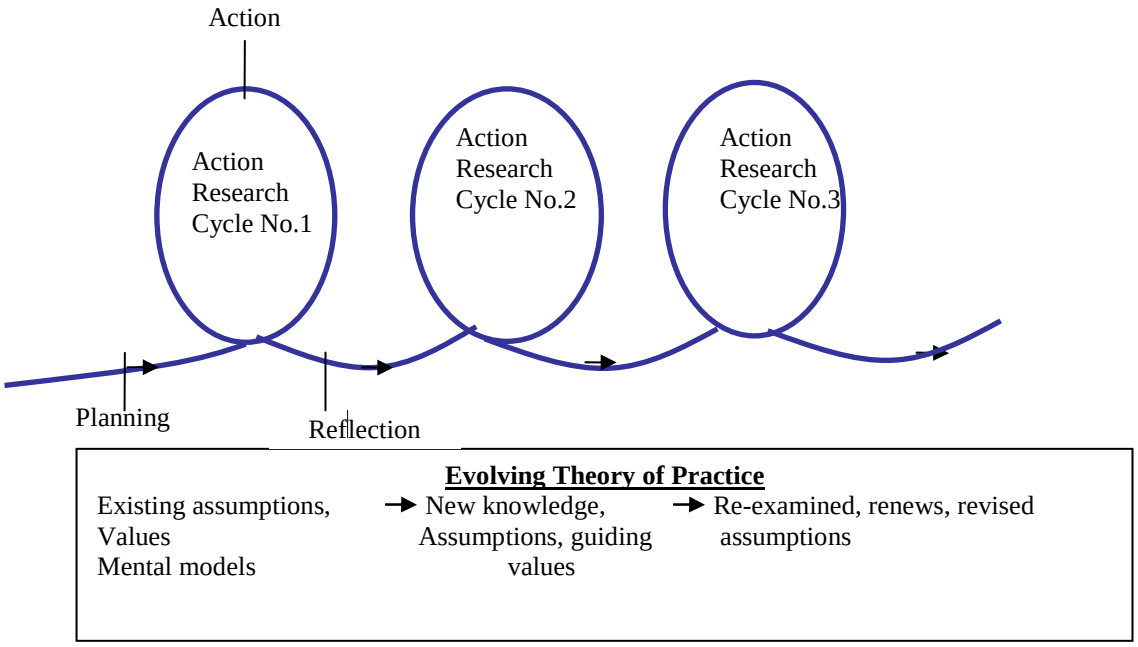


Figure 2.2: Action research spiral cycle.
Source: (Farolfi, 2004).

In the action research spiral cycle, the planning phase is where all the preparations occur; this includes pre-meetings and capacity development sessions. The next phase, the action phase, is where implementation takes place. Usually the action takes place in a workshop; here stakeholder involvement is essential. The last phase is the reflection phase. In this phase everybody that was involved in the action is required to reflect on what happened. In this phase interviews, questionnaires and focus groups can be used. Throughout the process of action research the reflection phase is the most important phase because it is where successes and failures of the process are revealed. According to Fishman (1997), action research is the process that is designed to influence social change through collaborative participatory action, thereby helping communities to assess and interpret their social problems. Lindqvist *et al* (1996) write that there is a gap that exists between

scientific theory and social needs. Therefore they see the programs of action research as having been designed to bridge the existing gap.

Lewin (1946) explains that the concept of action research emerged in the 1940s. At that time the focus was on participatory learning, human emancipation and cyclic iteration. Ramos (2002) writes that recently the focus is on participation, social change, engagement in knowledge creation, systems thinking, holistic complexity, future visions, democracy, social innovation, ongoing probing of assumptions and reinterpretation of the system under study. Therefore both Ramos and Lewin agree on the fact that participation and societal learning are the key motives for action research programs. According to Liu (1996), learning by doing is important in an action research process. This means that participants learn new information while sharing their existing knowledge through interacting with other participants. Participation is, according to List (2006), vital in action research and takes place following the spiral cycle. List (2006) states that participation needs to be encouraged in democratic societies as it gives an opportunity for public involvement. List (2006) highlights the process of cycling and the transfer of knowledge between cycles as two essential elements of the spiral cycle, which, according to Ramos (2006), helps in solving complex issues. Janhoff and Weisbord (2006) point to a drawback of an action research process in that it is very time consuming and often takes months or years to implement. However they suggest that the most effective activity a researcher or a consultant can undertake is to create opportunities for local communities to do what they are ready to do.

Similar to ComMod, action research involves a high level of participation whereby learning and change enhance each other. In both ComMod and action research, development of scenarios is crucial for learning purposes and it is where participants' thinking is enhanced and broadened. The use of an iterative process by both ComMod and action research ensures that the research process is explicit, there is increased community involvement, communities are able to freely engage in information exchange and are able to be influential in decision-making. Therefore through the use of iterative and spiral cyclic processes, both ComMod and action research are designed to help solve

complex issues; this is a complement to the theoretical framework that underpins ComMod and also action research.

2.5. Theoretical Framework that underpins ComMod

2.5.1. Post-normal science

ComMod draws its philosophical underpinnings from the paradigm of post-normal science. The paradigm of post-normal science is, according to Funtowicz and Ravetz (1991), most appropriate for managing complex issues which are related to both science and society. According to Van de Kerkhof and Leroy (2000), a new image and a new understanding of science and its societal role was required by social-environmental issues; post-normal science emerged in order to fulfill this need. It allows processes of discussion, while at the same time participants are empowered to engage in negotiations. Thus participation and involvement of social policy are of great importance and form a major part of the paradigm (Funtowicz and Ravetz, 1991; 1994). Van de Kerkhof and Leroy (2000) argue that society does not fully understand environmental problems, and show how post-normal science can reduce environmental problems from complex science-related issues into simpler social-related issues that are more manageable.

Funtowicz and Ravetz (1994:199) state that there are various uncertainties in ecological problems which require "a more cautious approach in quantitative arguments than has hitherto been fashionable". Barreteau (2003) states that Post-normal science also creates a link between science and society where certainty and predictability are enforced. According to Ravetz (2004:352) "The great lesson of post-normal science is that the quality of results does not depend on the elimination of uncertainty. Rather, the skilled management of uncertainty, along with the recognition that some decisions are at stake, is the key quality". According to Munda (2004), post-normal science is also used by policy makers to reach out to interest groups in order to come up with explicit and holistic ways of solving policy problems and ensure informed decision-making.

However, according to Ramos-Martin (2003), measurable standards to assess the impact of post-normal science in policy processes are not yet in place. Even though that is so,

Van der Sluijs (2002) point out that recently approaches have been developed where computer models are used to assess complexities in an integrated manner. This is why ComMod, with its use of computer models, can draw from post-normal science in order to tackle uncertainties. Walker *et al.* (2002) state that there are large uncertainties within complex systems. They can be categorized into three levels, according to Tacconi (1998):

- technical level: where standard routines such as statistical methods could be employed;
- methodological level: where values and personal judgments are disputed and where high level skills are mostly required; and
- epistemological level: where irremediable uncertainty is involved, not only ignorance but ignorance of one's ignorance.

Out of these categories, ComMod mainly uses the methodological level which relies on facilitation by skilled individuals. This involves to a large extent the participation of those affected and interested in the issue at hand. Collaboration between socio-economic, socio-political and scientific problems that the society faces is promoted. In addition, a dialogue is created through the bottom-up approach. Through this, knowledge is produced and shared. Thereby, according to Ravetz (1997), divergent visions and perspectives of participants involved are made explicit. Participatory processes in post-normal science require great trust between research practitioners and the research community (Kay *et al.* 1999; Luks 1999; Tognetti 1999 and Van der Sluijs 2002).

It is not suprising, then, that post-normal science is being used to try to understand complex water resource issues, as it is a paradigm designed for complexities. With the existing strong competition among water users in this study, which requires appropriate water allocation strategies without compromising environmental and socio-economic needs, post-normal science has the ability to allow for interactive water management. As post-normal science is still very new, the drawbacks of its approach are not yet apparent. This therefore places a huge challenge on whoever is going to use this paradigm. However, currently, it seems like the most promising paradigm to interlink science and society-related issues.

Parallel to post-normal science is constructivism. Even though there is an obvious difference in the two paradigms they do to a large extent compliment each other. Both use participatory process. According to Funtowicz and Ravetz (1991) post-normal science focuses on the importance of dealing with uncertain realities where there are high levels of competition. Constructivism, according to Rovai (2004), focuses on social cognition where uncertain realities are dealt with through shared learning, collaboration and reflection. Participatory processes are also an important component here.

2.6 The tools that ComMod uses.

Natural resource management, according to Barreteau ***et al*** (2001) and Barreteau (2003), provide a context that encourages the use of simulation models and role-playing games as learning tools in order to better the processes of decision-making for local communities. Models within ComMod are often developed using a GIS format in view of the fact that GIS is a tool that is able to spatially represent the reality of participants. According to McCall (2003), the GIS is designed for mapping local knowledge, thereby giving a voice to the local communities. In addition, it is used for its ability to store, analyse and display spatial data. ComMod principles, which entail the process of learning and change through the use of repeated cycles, are used in the construction of simulation models and role-playing games (Farolfi, 2004). This forms an iterative action research approach and is implemented in different stages of the model and role-playing game construction. Farolfi (2004) writes that the use of GIS allows the model and role-playing game to represent information on both spatial and temporal scales and also gives the model topologic background.

The construction of a model requires the participation of actors to participate in all the phases of the process. The role-playing game, which mirrors the computer model, aims to enhance stakeholder education and negotiation. The role-playing game is used by researchers to collect further information from participants, which could not be obtained during a computer model. According to Barreteau (2003), the role-playing game is designed to facilitate stakeholder interaction by positioning the participants in a given situation in such a way that they can discuss reality without being directly implicated in it. The negotiation process in the game prompts participants to work with their own

opinions and viewpoints in order to allow their group to build consensus. In addition Castella *et al* (2005) write that role-playing games allow for the main obstacles to data collection that are often encountered in questionnaires, open discussions or participatory appraisals to be conquered.

The development of the model KatAWARE and its related role-playing game was drawn from the principles of ComMod. The next chapter (Chapter Three) will detail the steps through which the KatAWARE was constructed.

2.7 Conclusion

In this chapter a view of the epistemological bases of the ComMod approach was presented. It has been shown how the participatory research approach is influencing the operational and applied research activities in the field. Constraints to participatory research projects have been briefly indicated. Even though such constraints exist, transparency needs to be achieved in management of resources. Bottom-up approaches where local communities become involved represent ways of achieving this transparency and enhancing shared information and capacity development, as well as empowerment among participants. The theoretical underpinnings of ComMod as illustrated in this chapter focus on repeated sharing of knowledge between experts and non-experts. Even though learning is socially constructed by the world to which the learner is exposed, it is vital that people's worlds be integrated in order to achieve constructive decision-making. This chapter has mentioned the tools that have been developed to facilitate stakeholder decision-making and negotiation support processes. However the use of such tools must be context-based in the sense that local participants should understand how to interpret information that comes from the use of such tools. In this thesis the development of the KatAWARE model and its related role-playing game within the context of the ComMod approach is described and discussed in Chapter Three. An evaluation of how the participants engaged with the process, as well as with the tool, is discussed in Chapter Four.

CHAPTER THREE

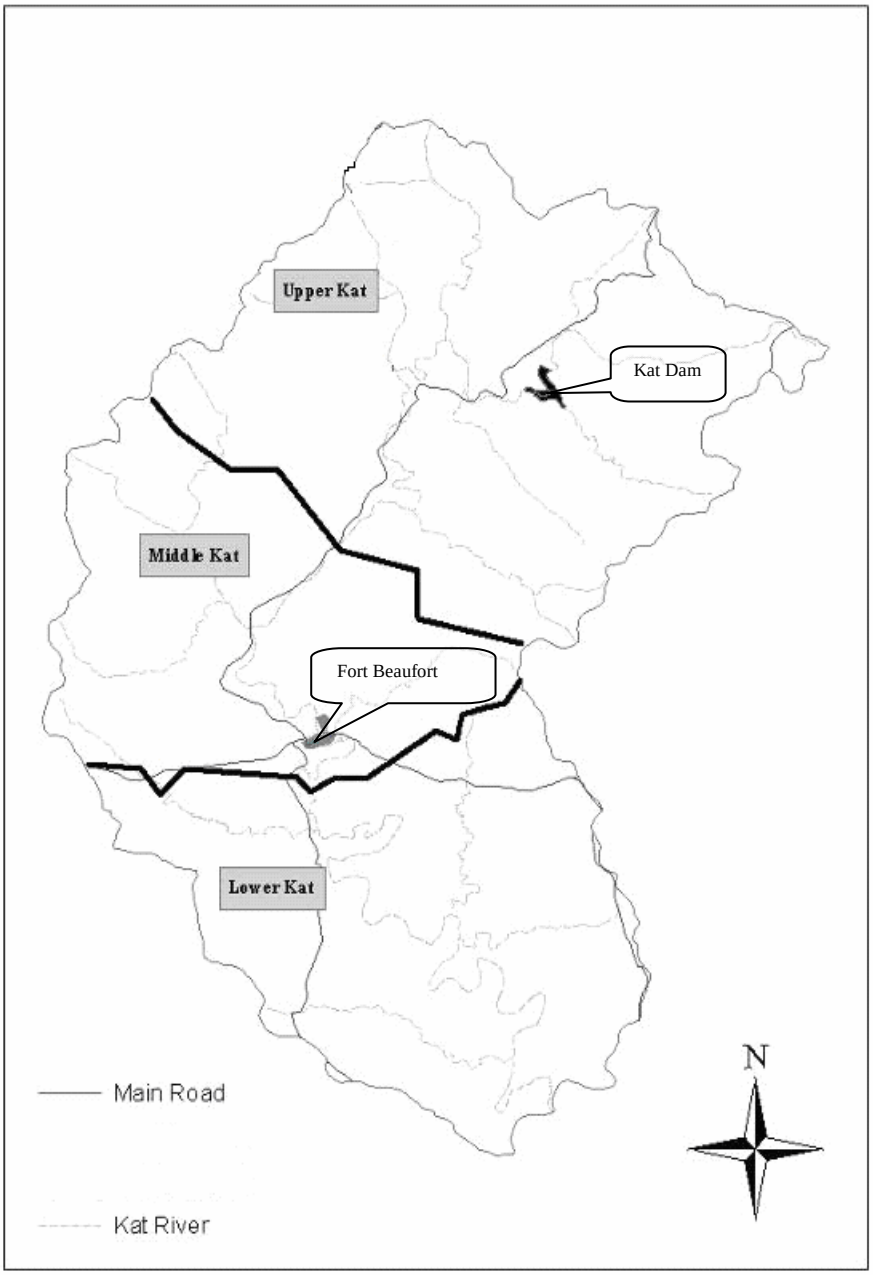
THE COMPANION MODELLING PROCESS IN THE KAT RIVER CATCHMENT

3.1 Introduction

This chapter seeks to describe in detail the process of ComMod as was implemented in the Kat River Catchment. The main actors that were presented in Chapter One are reintroduced with particular reference to the KRWUA members who represent the main participants. The visual features of the tools that ComMod uses are demonstrated. And lastly the spiral cycles following the way they occurred in the Kat River Catchment are presented.

3.2. The Kat River Water Uses Association members.

The main participants that were part of the ComMod process were the committee members of the Kat River Water User Association. This committee represented the KRWUA, which consists of all water users in the catchment, and gave a small group to work with. Figure 3.1 illustrates where they are located in the Kat River Catchment. The Kat River Water Users Association members, though they reside in the same catchment, have different backgrounds, needs and aspirations. For example the livelihoods of small scale farmers are totally different to those of large scale farmers. This background is illustrated in more detail in Figure 3.2. The background of participants had a great impact on the way they responded to the ComMod process, hence their understanding, relation and perception of ComMod tools.



Upper Kat:
Two small scale farmer representatives
Three domestic users representatives

Middle Kat:
One small scale farmer representative
Two large scale farmer representatives
One domestic users representative
Two municipal representatives

Lower Kat:
One domestic users representative
One large scale farmer representative

Figure 3.1: The Kat River Water Users Association members and their locations in the Kat River Catchment.

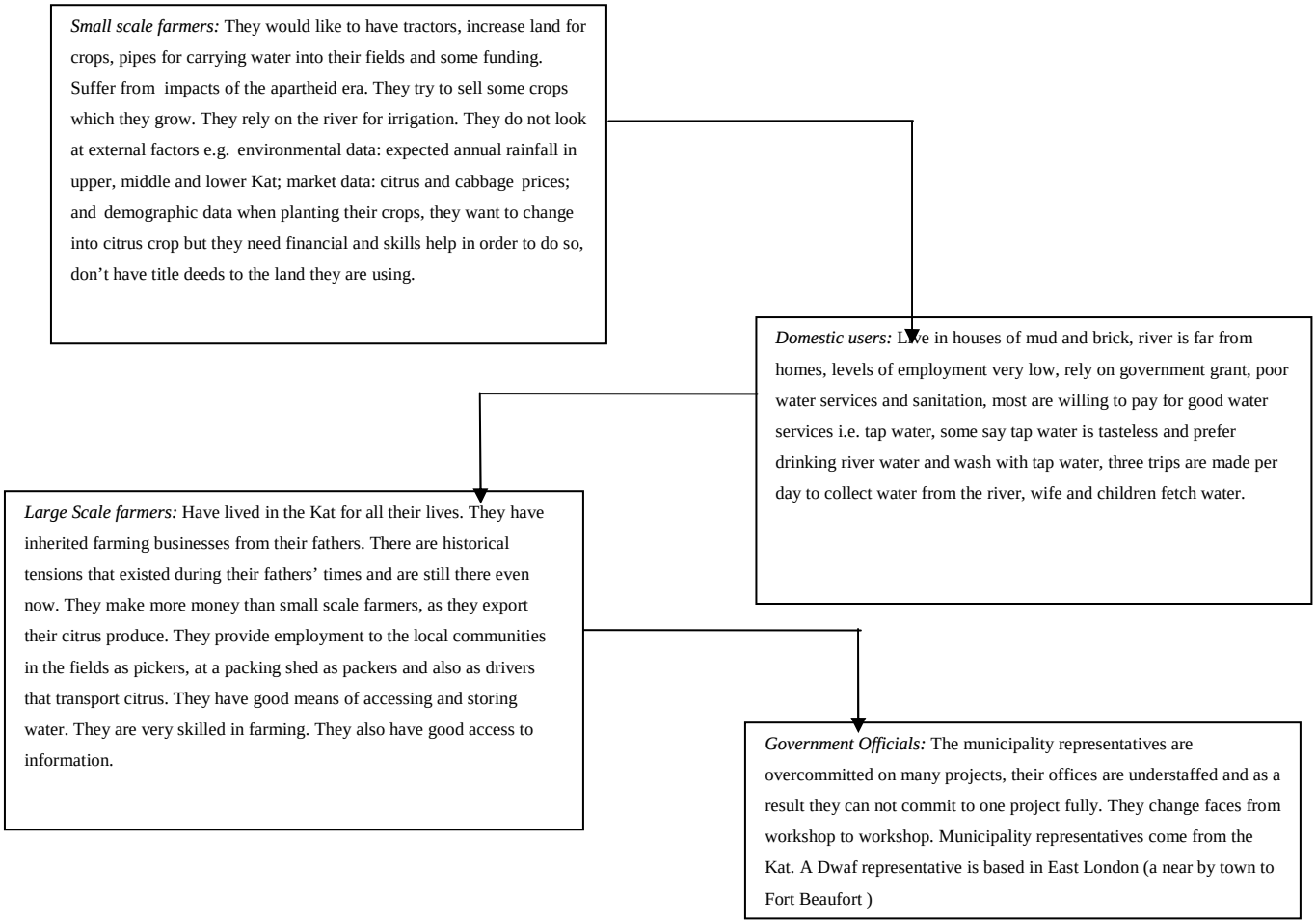


Figure 3.2: The background of the Kat River Water Users Association members.

3.3 The Companion Modelling Tools

The ComMod tools that were developed in the Kat River Catchment comprise the simulation Model KatAWARE and its related role-playing game. These tools were developed specifically for the Kat by the Cirad Team in collaboration with the Rhodes research team who worked together with the KRWUA in order to feed the tools with information for the Kat River Catchment. The simulation interface of the model is shown in Figure 3.3. It has been developed using the GIS spatial representation. By using a

visual representation participants were better able to understand the spatial variability of water availability. Participants were also able to place themselves within the catchment.
The model KatAWARE was built using the "CORMAS" (Common Pool Resources and Multi Agent Simulation) modelling platform. More information on CORMAS and the way it is applied can be obtained on the Cormas website (http://cormas.cirad.fr/). The inputs that make up the model comprise agents *(the villager and the farmer)*, topologic background *(the voting area, the upstream and downstream sub-catchment)*, objects *(citrus fields or cabbage fields)* and time scheduling *(years and months)* (Farolfi and Bonté, 2006). The kind of data that the model uses include; water demand *(yearly and monthly)*, water supply *(yearly and monthly)*, method of water supply *(tap, river or dam)*, catchment water availability *(yearly and monthly)*, mean annual runoff, number of citrus orchards, employment opportunities produced by citrus farming, number of labour working at citrus orchards, labour income, proportion of dwellers collecting water directly from the river, proportion that have taps, number of people in household relying on water, willingness of dwellers to pay for tap water to mention a few.

The visual outputs of the model comprise of the following:

- The graphs: show water availability and water consumption in different areas of the Kat River Catchment. They also show the yearly yield of water flowing out of the catchment.
- The legend: show where on the map the different participants are located and on the map this is shown by different symbols.
- The year window: show the number of years that the simulation has been run.
- The percentage of yield used: show where in the Kat River catchment is there water stress. The blue shows areas of minimum water stress and the blank shows areas of maximum water stress.
- The month window: show the months of the year

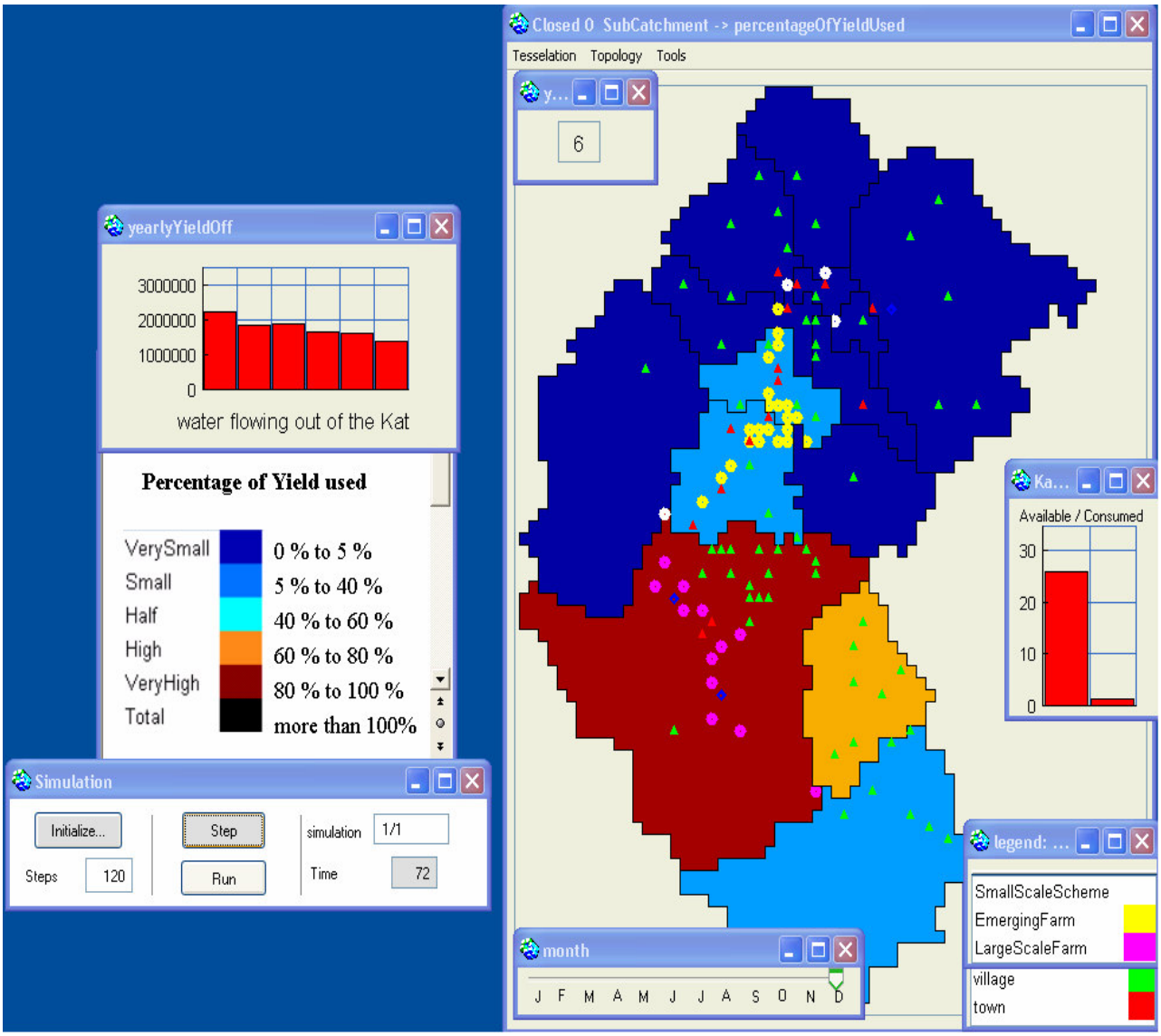


Figure 3.3: Simulation interface of KatAWARE. (Source: Farolfi and Bonté , 2006)

The above simulation interface of KatAWARE (Figure 3.3) can be interpreted as in the following example. In the month of December of year six, there is more water stress in the middle Kat compared to the upper and lower Kat. However there is more water available in the Kat Dam, simultaneously less water flowing out of the catchment.

Another important output was the line graphs. These proved especially confusing to participants. One example is shown in figure 3.4.

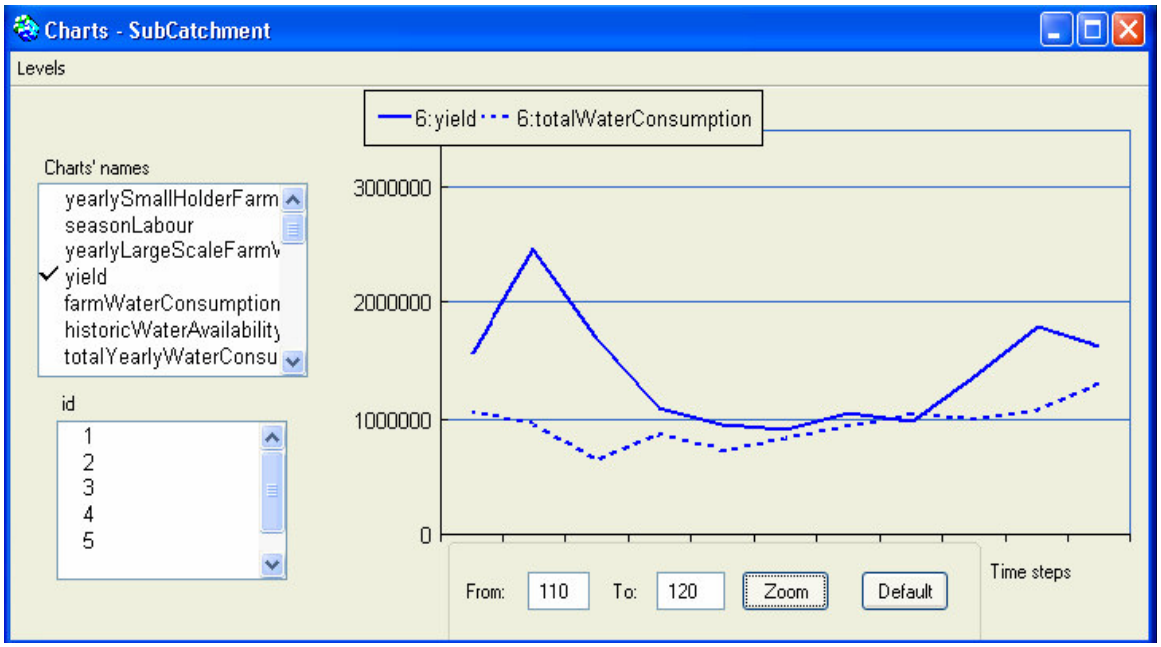


Figure 3.4: Sub-catchment Q94F: water demand and water supply at year 10 (January to December) (m3) (Source: Farolfi and Bonté ,2006)

From the graph one can identify the months when water demand for citrus was high relative to the water supply (yield). The situation that is represented in Figure 3.4 is stressful to the environment and aquatic life as it shows that water demand cannot be met if the ecological Reserve is to be respected. DWAF (2001) defines the ecological Reserve as the quantity and quality of water that is required in a basin in order to protect aquatic ecosystems thereby ensuring ecologically sustainable development and use of the relevant water resource.

According to Farolfi and Bonté (2006), all information and data that was available for the construction of KatAWARE model was assembled and used for the role-playing game. A systematic structure of the Kat River Catchment is represented in the role-playing game in Figure 3.5. The role-playing game presented an explicit reality and players were real participants, who confronted environmental and socio-economic parameters in as real situation as possible. Also, the role-playing game was designed to be user friendly to the participants.

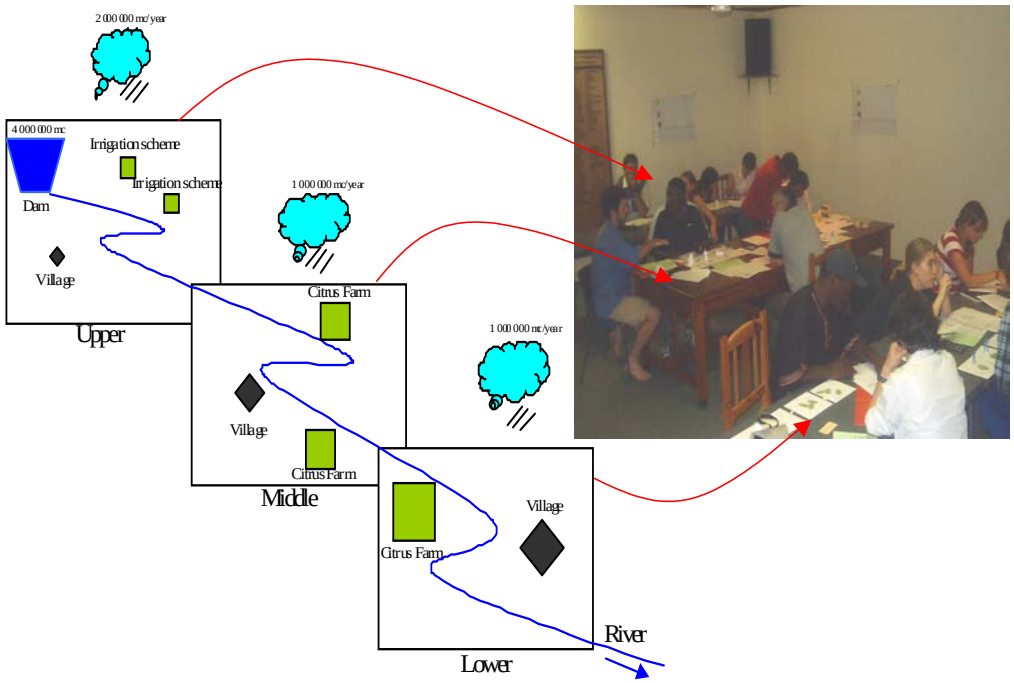


Figure 3.5: The "playground" in KatAWARE role-playing game: schematised catchment and its translation into a role-playing game session (Source: Farolfi and Bonté , 2006)

The game setting consisted of three sub-catchments (upper sub-catchment, middle sub-catchment and lower sub-catchment). The upper sub-catchment comprised a dam, two or three smallholder irrigation schemes and a village manager. The middle sub-catchment comprised two citrus farms and a village manager. The lower sub-catchment comprised a citrus farm and a village manager. Also included in the game were posters that indicated external factors and dam management as presented in Figure 3.6.

Figure 3.6: Middle sub-catchment with two citrus farms (each farm with hectares of land, labour, citrus trees, decision sheet and capital) and one village manager (with blocks showing the percentages of water for people using communal taps, indwelling taps and river water, a village manager also had a decision sheet as well as capital). In addition posters indicating dam storage, natural runoff, domestic consumption, irrigation consumption, surface cabbage, surface citrus, population and annual flow.

The figure shows visual outputs of the model which comprised the following:

- Decision sheets
- Cabbage and citrus trees
- Labour
- Farming land or irrigation surface
- Blocks to indicate the percentage of water allocated by the village manager to various domestic water users, namely: those that depend on the river, those with communal taps and those with household taps.
- Two new posters with external factors; these factors included environmental data: annual rainfall foreseen in upper sub-catchment, middle sub-catchment and lower sub-catchment; market data: citrus and cabbage prices; and demographic data: population in the three villages of the catchment.

A total of five ComMod workshops fell within the scope of this Master's research. The details are given in the following session, which illustrate the cycles of action research.

3.4 The cycles of action research.

Data was collected from secondary sources and primary surveys. These data were used to develop the KatAWARE model. Additional data was obtained through workshops; this data was then fed back into the model so that it better represented the reality of the participants. Further details of data collection are given below. In Chapter two, action research has been explained to be an explicit process that involves reflecting the lived experience of people's lives through a participatory process. Action research therefore allows participants to be empowered and capacitated about their surroundings. Action research has three key components, namely planning, action and reflection. The planning phase entails preparation, this include pre-meetings and capacity development sessions. The action phase is where the implementation as well as data collection takes place. This is usually in a workshop. Reflection is the last phase of the action research cycle where all the participants are allowed to reflect on what happened during the two initial phases. In this phase interviews, focus groups and questionnaires can be used.

In this study one of the key elements was to implement the ComMod process as laid down in Chapter Two (refer to Chapter Two for procedures of implementing ComMod). The development and construction of the KatAWARE model and role-playing game was carried out following ComMod procedures of continuous interaction and information exchange by researchers and the KRWUA participants. This iterative process was used in collecting data that fed directly into the construction of the model and the role-playing game. The spiral cycles that ComMod uses allowed data collection to occur in different methods such as workshops, surveys, interviews and focus groups. The manner in which the ComMod approach was followed is shown in different phases of the spiral. Each spiral consists of the three phases, namely: planning, action and reflection (see Figure 2.2, Chapter Two) and all of these phases were used in gathering different kinds of information in using different methods (see Tables 3.1 to 3.5 for details). Throughout the implementation of the ComMod process there are several interlinked spiral cycles that

show collaboration and co-development of the ComMod tools by researchers and participants throughout this study. A total of five ComMod iterative cycles were followed. Each cycle corresponds with a detailed table which illustrate the cycle number, date, activity, participants and focus synopsis.
Cycle One started in October 2004 and ended in June 2005. This is where most planning and capacity development for the ComMod process took place. This planning involved introducing the ComMod process and the ComMod tools to Rhodes researchers and KRWUA participants. Also collection of primary and secondary data for populating the model as well as preparation of the first ComMod workshop was conducted in this cycle.

Cycle Two started in July 2005 and ended in October 2005. The planning here involved further primary data collection in a form of a survey and was going to be used in the further construction of the KatAWARE model. Farolfi and Abrams (2005) write that secondary data did not provide adequate insights on issues related to water consumption per sector's units as well as prices and willingness to pay by the different water users. As a result primary data was collected as additional information to secondary data. The survey was conducted by myself and a Martha (a Belgian research student) on water use practices that occur in the Kat River Catchment involving the domestic water users, small irrigation schemes and large scale farmers (for questionnaire see appendix two).

Cycle Three started in June 2005 and ended in November 2005. Planning in this cycle involved using the information that was obtained from using the computer model KatAWARE in ComMod workshops one and two to construct the role-playing game. The third ComMod workshop was held where the game was played by KRWUA participants using various scenarios in order to develop and enhance negotiation and decision-making skills. Reflections of the ComMod process in particular the role-playing game were obtained from participants and the research team.

Cycle Four started in November 2005 and ended in August 2006. Planning in this cycle involved further developing the role-playing game using the information that was collected ComMod workshop three. The fourth ComMod workshop took place where the

game was played by participants in order to collect more information that would help them to choose scenarios to be incorporated in the CMP. As part of the reflection process the pilot of ComMod ADD evaluation took place; this highlighted the failures and successes of the ComMod project thus far.

Cycle Four and Five overlap each other. As a result Cycle Five started in March 2006 and ended in November 2006. Planning in this cycle involved developing various scenarios by both the Cirad team and Rhodes Team using the information that had been obtained from participants since Cycle One up until Cycle Four. In the Fourth ComMod workshop participants had to choose scenarios from the given list that best represented their intended practices in order to be explored further. The chosen scenarios, provided that all participants agreed on them, were going to be drafted in the CMP. Reflections in this cycle comprised the ADD ComMod evaluation which highlighted acknowledge gained and interrelations that were formed as a result of the ComMod process.

The ComMod process took twenty-six months to implement. Tables 3.1-3.5 give details of each cycle in terms of dates, activities, participants and the main foci. Figures 3.7-3.11 show how these activities relate to the three phases of a spiral cycle. However, as ComMod is a continuing process, it continued after the end of this Masters project; this further work has not been included here.

Table 3.1: Table representing Cycle No1 of action research in the Kat River Catchment

Cycle 1	Date	Activity	Participants	Focus synopsis
A	October 2004	**Planning:** Introduction of the ComMod approach and simulation tools to the Kat River Catchment project "A stakeholder driven process to develop a catchment management plan".	▪ 1 WRC member ▪ 1 Cirad team member ▪ 1 CMP project manager ▪ 1 CMP project co-coordinator ▪ 4 KRWUA members	To present the iterative process of the ComMod approach for facilitating negotiations about water allocation at the catchment level.
B	February 2005	**Planning:** Introduction of the role-playing game to the Research team at Rhodes University and a DWAF representative.	▪ 2 Cirad project team members ▪ 1 DWAF official ▪ 8 Dept. of Geography honours students ▪ 4 Rhodes social team members ▪ 1 CMP project manager ▪ 1 CMP project co-ordinator	To role-play the AWARE game as developed in the Steelpoort sub-basin and to discuss ways to transform the game into the context of the Kat River Catchment.
C	February 2005 –May 2005	**Planning:** Collection of socio-economic data from secondary sources(Farolfi and Jacobs, 2005). *Population of the catchment (Statistics SA's Census, 1996 and 2001). *Maps of the catchment (DWAF,2001; Jhagoroo et al., 2000). Collection of primary data by various students *Development of GIS maps by myself *Small scale farmers irrigation schemes (Mlilo, 2005). *Small scale farmers local economic outputs (Ngqangweni, 2000). *Labour-related issues (Mujkanovic, 2005). *Citrus production factors (Edgren, 2005). *Rural domestic water use (Naidoo, 2005). Development of the prototype model KatAWARE.	▪ 2 Cirad project team members plus 1 intern ▪ 1Phd Geography Department ▪ 2 Honours Swedish Geography Department ▪ 1 SA Honours Geography Department ▪ Myself ▪ 1SA Masters Geography Department	To develop the multi-agent tool in the context of the Kat Valley.
D	28 May 2005	**Planning:** Preparation meeting for the KatAWARE prototype workshop	▪ 2 Large scale farmers ▪ 1 Domestic user ▪ 1 Rhodes social team member ▪ Myself ▪ 1 CMP project co-coordinator	To explain the purpose of the KatAWARE tool and ComMod process.
E	31 May 2005	**Planning:** Preparation meeting for the KatAWARE prototype workshop	▪ 35 Kat River Catchment Catchment Forum members ▪ 8 Rhodes social team members ▪ Myself ▪ 1 CMP project manager ▪ 1 CMP project coordinator	To explain the purpose of the KatAWARE tool and ComMod process.
F	3 June 2005	**Planning:** Preparation meeting for the KatAWARE prototype workshop	▪ 2 Domestic Users ▪ 2 Small scale farmers ▪ 1 Emerging farmer ▪ 5 Rhodes social team members ▪ Myself ▪ 1 CMP project manager	To build capacity and to encourage participation.

			▪ 1 CMP project coordinator	
G	9 June 2005	**Action:** The KatAWARE prototype Workshop.	▪ 3 Catchment forum members ▪ 3 Domestic users ▪ 3 Large scale farmers ▪ 3 small scale farmers ▪ 1 municipality member ▪ 5 Rhodes social team members ▪ 1 CMP project manager ▪ Myself ▪ 1 CMP project coordinator ▪ 2 Cirad project team members plus 1 intern	To present the prototype version of the model to the participants and to allow participants to populate the model with data.
H	10 June 2005	**Reflection:** A debriefing session took place to reflect on the workshop proceedings.	▪ 2 Cirad project team members plus 1 intern ▪ 5 Rhodes social team members ▪ Myself ▪ 1 CMP project manager ▪ 1 CMP project coordinator	To allow all team members to give feedback on what worked, what did not work and to propose a way forward.

Cycle 1

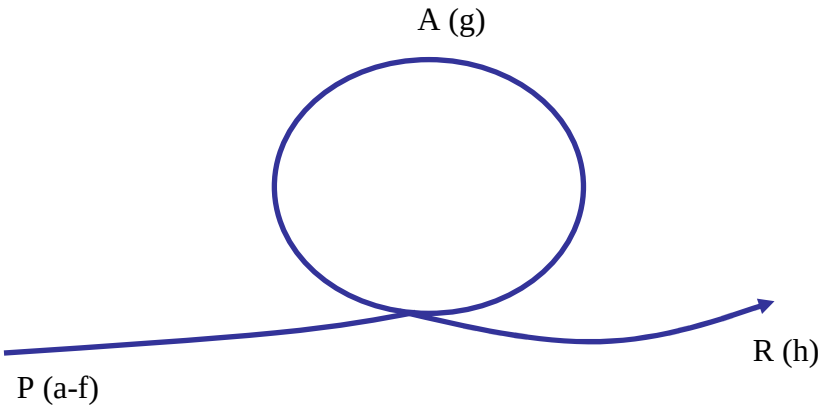


Figure 3.7: Cycle No1 linking to Table 3.1

In this cycle the ComMod approach was introduced to Rhodes Researchers and KRWUA members by the Cirad Team, and the positive response obtained from this rendered ComMod to be applied in Kat River Catchment. As part of the ComMod process the interaction and exchange of information started between the researchers (Cirad team and Rhodes) and the KRWUA. There are various activities that were involved in this cycle, namely: data collection, capacity building, information feedback and reflections. The collection of demographic and socio-economic data was used to populate the prototype version of the KatAWARE model. Secondary data was obtained from SA Census and from DWAF (Statistics SA's Census ,1996 and 2001; DWAF, 2001). GIS shapefiles

were used to relate data from Statistics SA and the population in the catchment was found by overlapping maps of the catchment (obtained from the Map Shop web site of DWAF) with those available from the South Africa Explorer software (Jhagoroo et al. 2000). Some primary data was collected in addition to demographics information, from Surveys and Mapping Digital Sales offices in Cape Town. Maps of the Kat River catchment were prepared from GIS, which included a Digital Elevation Model (DEM), land use, vegetation types, relief, inland water sources and structures, rainfall, soils and geology. This information was used to develop the model with visual presentation so as to allow the mapping of local knowledge and to spatially represent the reality of participants.

The primary data that was collected by various students include the information on domestic water use, particularly in rural areas of the Kat River Catchment, was collected by a Master's Student (Ms Merle Naidoo) supervised by Prof. Kate Rowntree. She interviewed, in 2004, 101 households in the villages and farms (Naidoo, 2005). Her findings were used to model water demand and consumption of domestic water users. Ms Ntando Mlilo, an honours student in the Rhodes Geography Department, conducted most of her interviews on small-scale farmers and on emerging citrus farmers and further additions to Ms Mlilo's data were done by Dr Farolfi (Mlilo, 2005; Farolfi and Abrahams, 2005). Her findings were used to model the labour requirements of a typical small-scale irrigation scheme and emerging citrus farm. The information on local economic outputs from small-scale irrigation schemes was collected by Mr Simphiwe Ngqangweni a Rhodes University PhD student (Ngqangweni, 2000). His findings were used to model economic outputs from a typical small-scale irrigation scheme. The information on large scale farmers was collected by Mr Anel Mujkanovic and Mr Johan Edgren, two Swedish honour students working under the supervision of Prof. Kate Rowntree (Rhodes University Geography Department) and Dr. Stefano Farolfi (Ceepa, University of Pretoria). Mr Mujkanovic investigated labour-related issues on three large-scale citrus farms in the Middle and Lower Kat (Mujkanovic, 2005). His information was used to model the labour requirements of a typical commercial citrus farm. Mr Edgren focused on critical production factors related to citrus production (Edgren, 2005).

His information was used to model economic outputs from a typical commercial citrus farm. Both students used interview techniques and observations to obtain the information.

What is evident is that the cycle starts with a fairly small number of participants, but there is a gradual increase as more participants were included as the cycle progressed. The highlight of this cycle was the presentation of the prototype of the model KatAWARE that took place at a first ComMod workshop. Participants and researchers reflected on the procedures of the workshop by discussing and validating their feelings about the ComMod process. The key outcome of reflections were as follows:

- All participants enjoyed working in smaller groups; it gave them more time to engage and get to know each other's issues and viewpoints regarding water and land,
- Most participants, in particular small and large scale farmers, felt positive that the KatAWARE model will help them to resolve the existing water issues (such as dam management, water quality in the lower catchment, water storage in weirs, water tariffs, and water that must remain in the river for aquatic life).
- Xhosa participants experienced problem with language (English), this prevented them from fully expressing themselves during discussions
- All participants were happy with the way the workshop was facilitated, particularly with the English to Xhosa translations.

At this stage new knowledge received by KRWUA participants collectively include; leaning that citrus trees consume more water, changing from cabbage crops to citrus will result in a farmer making profit after six years and leaning about upstream-downstream interlinks.

Individually KRWUA participants for instance learnt the following;
A small scale farmer in the upper Kat learnt that the upper Kat has more water and the lower Kat suffers from water shortages. A large scale farmer in the middle Kat learnt that there is enough water in the catchment to sustain all water users. The domestic user in the lower Kat learnt about the maximum and minimum flows in the Kat river. There were no changes to the ComMod process as a result of the reflections made by participants.

However, changes needed to be made to the KatAWARE tool and this led to the activities that were carried out in next cycle.

Table 3.2: Table representing Cycle No 2 of action research in the Kat River Catchment

cYCLE 2	DATES	ACTIVITY	PARTICIPANTS	FOCUS SYNOPsIS
I	July 2005 –August 2005	**Planning**: Data Collection on; *Domestic use, small scale irrigation and water service providers (Farolfi and Abrams, 2005)	▪ Myself and Marthe Abrams a Belgian Student who came to work with me on data collection for two months	To collect data from the following participants: Water service providers, domestic water users (tap and non-tap users) and irrigation schemes (small scale farmers)
J	June 2005-September 2005	**Planning**: Development of the model KatAWARE version 1	▪ 2 Cirad project team members + 1 intern	To develop the multi-agent tool on the basis of the reactions, comments, remarks and information obtained during the previous workshops
K	22 September 2005	**Action**: The KatAWARE version 1 workshop	▪ 1 municipality member ▪ 2 visiting researchers ▪ 5 Rhodes project team ▪ Myself ▪ 1 CMP project manager ▪ 1 CMP project coordinator ▪ 2 Cirad project team + 1 intern ▪ 1 Catchment forum member ▪ 2 Large scale farmers ▪ 2 domestic user ▪ 1 DWAF –forestry member ▪ 2 small scale farmers	To present KatAWARE version 1 and to present the changes that have occurred to the model since last time.
L	23 September 2006	**Reflection**	▪ 5 Rhodes social team members ▪ 2 Cirad team members + 1 intern ▪ Myself ▪ 1 CMP project manager ▪ 1 CMP project coordinator	See row h
M	October 2005	**Reflection:** KatAWARE model evaluations	▪ 1 Municipality member ▪ 3 Large scale farmers ▪ 3 Domestic users ▪ 3 Small scale farmers ▪ 2 Catchment forum members ▪ 2 Rhodes social team members ▪ Myself	To find out the participants' perceptions about the ComMod process and their ability to understand and work with the KatAWARE model.

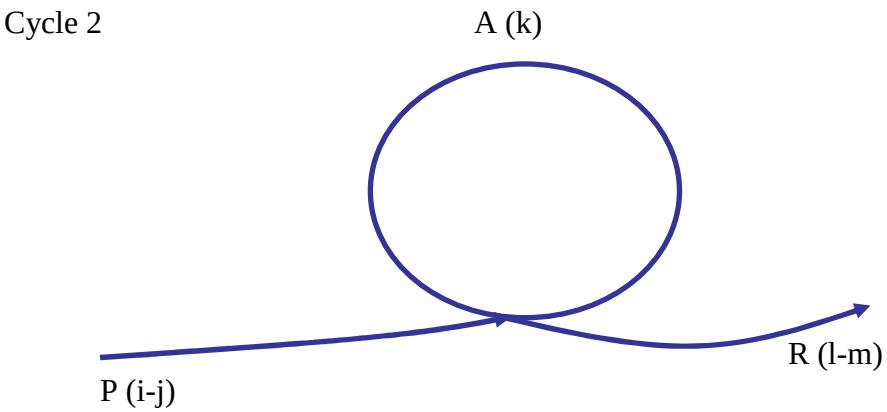


Figure 3.8: Cycle No 2 linking to Table 3.2

In this cycle more information was collected, which was used to further construct KatAWARE. This information included capturing villages, weirs and farm locations using the geographic positioning system by myself as well as obtaining the latest land use map from CSIR. This spatial data was used to make KatAWARE spatially representative of the Kat Valley. A Belgium student and myself conducted a survey using three sets of questionnaires directed to Nkonkobe municipality, domestic water users and smallholders irrigation schemes. All three questionnaires were developed by the Cirad team. A structure and semi-structured interview style with both open and closed questions was used. The findings were used to model labour requirements, economic outputs and water demand and water consumption of domestic users, small irrigation schemes and large-scale farmers. The second ComMod workshop was held and an amended version of KatAWARE was presented. In this workshop participants contributed with more information (such as information regarding access to water in the upper Kat and information regarding non-schedule users access water from the dam), which was later used to further develop KatAWARE. In the KatAWARE model evaluation participants reflected as follows:

- They regard the increase in interaction of different water users as a positive step towards collaborative water management in their catchment;
- The complexity of the model makes it difficult for them to interpret and understand the information it is presenting;

- Domestic users found the scenarios that were shown by KatAWARE less relevant to them and more focused on farmers, and this limited their engagement in discussions during the workshop.

The problems that arose were regarding lack of participation of other KRWUA members, in particularly domestic users. There is no particular new knowledge that participants reflected to have learnt in this cycle. The information that was contributed by participants in the workshop and during reflections was used to construct the KatAWARE role-playing game, which was meant to be less complex and more user friendly for participants.

Table 3.3: Table representing Cycle No 3 of action research in the Kat River Catchment

cycle 3	dates	activity	Participants	focus synopsis
N	June-November 2005	**Planning:** Development of the role-playing game KatAWARE version 1	▪ 2 Cirad team members plus 1 intern	To develop the role-playing game derived from the multi-agent model
O	10 November 2005	**Action:** KatAWARE role-playing game workshop I	▪ 5 Rhodes social team members ▪ Myself ▪ 2 Cirad team members plus 1 intern ▪ 1 CMP project manager ▪ 1 CMP project coordinator ▪ 3 Large scale farmers ▪ 2 Catchment forum members ▪ 2 small scale farmers ▪ 2 Domestic users ▪ 1 visiting researcher	To use the role-playing game on KRWUA as a way to develop negotiations and to support multi stakeholder participatory local water management.
P	11 November 2005	**Reflection**	▪ 5 Rhodes social team members ▪ Myself ▪ 1 visiting researcher ▪ 2 Cirad team members ▪ 1 CMP project manager ▪ 1 CMP project coordinator	See row h

Cycle 3

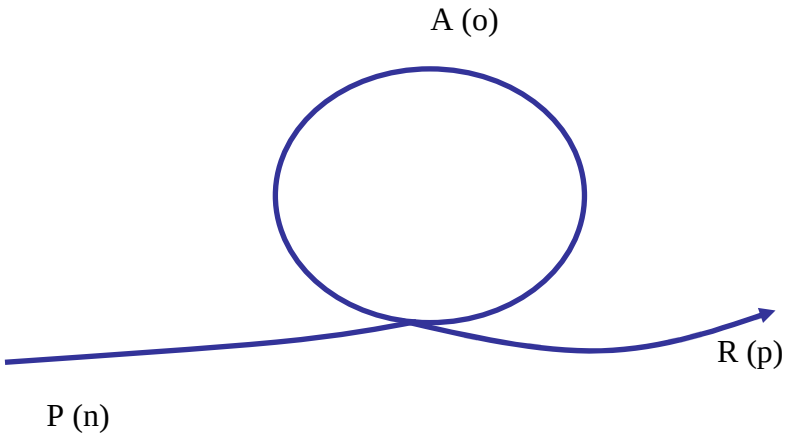


Figure 3.9: Cycle No 3 linking to Table 3.3

The construction of the role-playing game followed the same concept as that of the KatAWARE model, with visual presentation of the upper, middle and the lower Kat. The game was played by nine KRWUA members five (three small scale farmers and a domestic user) for the upper Kat, three (two large scale farmers and a domestic user) for played the middle Kat and two (large scale farmer and domestic user) for the lower Kat. The role-playing game consisted of three sub-catchments (upper, middle and lower) each one with different rainfall, different labour, three irrigation schemes in the upper Kat, three large citrus farms two in the middle Kat and one in the lower Kat, a dam in the upper Kat and three villages in each sub-catchment. Participants played a maximum of six years, each year with varying rainfall, labour and dam capacity parameters. After every year participants would have a role-play WUA meeting where information on stakeholders' individual and collective strategies regarding water demand, water use and water management would be discussed.

Reflections from participants regarding the role-playing game revealed that they appreciated the game because it was practical. The role-playing game facilitated negotiation and discussions among participants. Participants said that time for discussion in a role-play WUA meeting was limited, which often resulted in other relevant issues being ignored. The new knowledge regarding farming practices was learnt by small scale

farmers in particular. Large scale farmer reported to have learnt about improving dam management techniques. Domestic users learnt that it is important for water users to consider each other so that all users could get a fair share of water to use. The information that was obtained by researchers during the game session was used to further develop the second version of the role-playing game.

Table 3.4: Table representing Cycle No 4 of action research in the Kat River Catchment

cycle 4	dates	activity	participants	Focus synopsis
Q	November 2005-March 2006	**Planning:** Development of the role-playing game KatAWARE version 2	▪ 2 Cirad team members	To develop the role-playing game version 2 on the basis of the observations and comments resulting from the role-playing game workshop I.
R	9 March 2006	**Action:** KatAWARE role-playing game workshop II	▪ 5 Rhodes social team members ▪ Myself ▪ 1 CMP project coordinator ▪ 1 CMP project manager ▪ 2 Cirad team members ▪ 3 Large scale farmers ▪ 2 Domestic users ▪ 1 Catchment forum member ▪ 1 DWAF representative ▪ 2 Small scale farmers	To allow participants to raise questions with regards to participatory local water management.
S	10 March 2006	**Reflection**	▪ 5 Rhodes social team members ▪ Myself ▪ 2 Cirad team members ▪ 1CMP project manager ▪ 1CMP project coordinator	See row h
T (*)	August 2006	**Reflection:** Pilot ComMod process evaluation	▪ 1 small scale farmer ▪ 1 domestic user ▪ 3 Rhodes social team members ▪ 1 Cirad team member ▪ 1 Cirad evaluator ▪ Myself	To test the protocol that aims at evaluating the application of ComMod approach on more than 30 different fields all over the world. The Kat Valley was chosen as test area.

Cycle 4

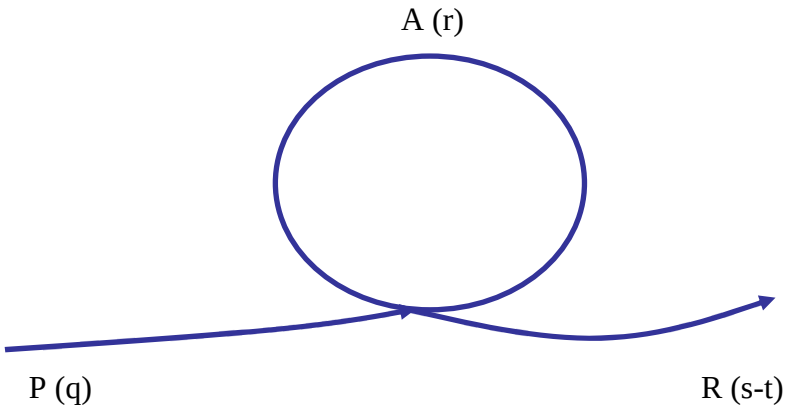


Figure 3.10: Cycle No 4 linking to Table 3.4.

Big changes were not made to the second role-playing game compared to the first one. However minor amendments were made regarding the following:

- Water availability was made lower
- Costs for domestic water provision was made higher
- Information on rainfall series and market prices was made available on request for players.
- Only one water user was allowed to represent his/her sector
- The WUA meeting was conducted in both English and Xhosa
- Water demands were adjusted to be more real
- Instead of three villages there was two
- A DWAF representative participated to the role-playing game playing his role as is in reality

As a result of these changes the outcomes of this game sessions were different from those of the first game session in the following manner:

- A higher catchment profit was accumulated
- Each farmer had a higher profit
- Village managers had difficulties in balancing profits and residents' satisfaction due to increase costs for water provision
- More water used from the dam simultaneously respecting the defined minimum amount that needed to be in the dam

- The ecological Reserve was better respected

Large scale farmers reflected by stating that playing the game was useful, however the game did not represent their reality calling is “it’s was just a game”. All participants were happy about the game and stated that it was not confusing and easy to follow. All participants felt positive about the discussions that commenced during role-play WUA meetings.

Participants, in particular farmers, learnt that good management of the dam is essential not only for their production, but for the environment as well. Domestic users learnt that even though giving tap water access to every household is essential, residents need to be able to pay for water and that failure to do so leads to accumulated debt for water service providers. All participants learnt about the importance of being represented in WUA meeting due to the fact that decisions that are taken there can not be reversed.

One of the problems that occurred during the playing of the game was that some of the strategies that players used were not realistic e.g. large scale farmers farming cabbages and all villages getting tap water. This made it difficult to decide the best scenarios for the catchment.

Table 3.5: Table representing Cycle No 5 of action research in the Kat River Catchment

cycle 5	dates	activity	Participants	focus synopsis
U	March 2006 –October 2006	**Planning:** Preparation of scenarios built from the role-playing game.	▪ 1 Cirad team member	To convert information obtained from participants during the role-playing game into scenarios for participants to explore.
V	20 October 2006	**Action**: Back to the KatAWARE version 1 model's scenarios workshop	▪ 1 DWAF representative ▪ 2 Large scale farmers ▪ 1 Small scale farmer ▪ 2 Domestic users ▪ 1 Municipality member ▪ 4 Rhodes social team members ▪ Myself ▪ 1 CMP project manager ▪ 1 CMP project coordinator ▪ 2 Cirad team members	To choose water allocation strategies by implementing and discussing scenarios through the KatAWARE simulation model V1.
W	21 October 2006	**Reflection**	▪ 4 Rhodes social team members ▪ Myself ▪ 1 CMP project manager ▪ 1 CMP project coordinator ▪ 2 Cirad team members	See row h
X (*)	November 2006	**Reflection:** ComMod Approach evaluations	▪ 3 Large Small Farmers ▪ 3 Domestic users ▪ 3 small scale farmers ▪ 1 Catchment forum members ▪ 1 DWAF representative ▪ 3 Rhodes social team members ▪ Myself	To evaluate the application of ComMod approach in the Kat Valley
Y	November 2006	**Reflection:** Role-playing game evaluations	▪ 3 Large Small Farmers ▪ 3 Domestic users ▪ 3 small scale farmers ▪ 1 Catchment forum members ▪ 1 DWAF representative ▪ 3 Rhodes social team members ▪ Myself	To find out the participants' perceptions about the ComMod process and their ability to understand and work with the KatAWARE role-playing game.

Cycle 5

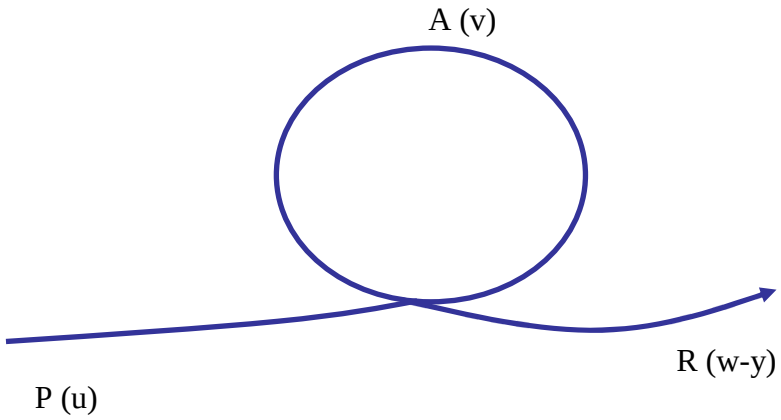


Figure 3.11: Cycle No 5 linking to Table 3.5

In this cycle the outcomes and scenarios of both role-playing game sessions were modified into the final version of the KatAWARE model. This was done so that participants may view KatAWARE as a tool for facilitating negotiations and discussions for common decision making. The final version of KatAWARE was designed in such a way that it represented individual and collective strategies. The fifth ComMod workshop was held, the following scenarios were presented to the participants for them to single out the ones they felt were suitable for their catchment:

In the following scenarios a 90% assurance of supply means that in 90 years out of 100 (or 9 out of 10) there will be at least that amount of water i.e. we can be assured of that amount of water in 9/10 years). A 98% assurance of supply means that we can be assured of that amount of water in 98/100 years – i.e. it is a smaller amount of water. If we plan for 98% assurance the risk that our undertaking will fail is smaller than if we plan for 90 %, but we do not maximize production in wet years.

- Scenario 1: Represents a relative abundance of water available
  - INPUTS
  - 90% assurance of supply – the minimum amount of that is available in 9 years out of 10 in the catchment
  - No change of consumption
  - Total/natural runoff
  - OUTCOMES
  - Very little use of water from the dam
  - Demand completely satisfied

- Flow out of approximately 8M m^3/year (-Forestry)
- Water storage in the lower Kat has no stress
- Therefore, even non scheduled farmers do not suffer in terms of production and profit.

- Scenario 2: Represents a relative scarcity of water available
  - INPUTS

  - 98% assurance of supply – the minimum amount of that is available in 98 years out of 100 in the catchment.
  - No change of consumption
  - Total/natural runoff
  - OUTCOMES
  - A higher use of water from the dam
  - Almost all demand satisfied
  - Flow out of approximately 1.5-1.8M m^3/year (-Forestry): but the dam is full and could be used
  - Water storage in the lower Kat has some stress
  - Therefore, non scheduled farmers do not suffer slightly in terms of production and profit.

- Scenario 3: Represents some years of real scarcity of water available
  - INPUTS
  - 90% assurance of water will be available in the Kat but years 3.7 and 8 when it is reduced to 98% assurance.
  - No change of consumption
  - OUTCOMES
  - Even after two consecutive bad years the dam refills easily
  - Gaps between demand and consumption after bad years
  - Dam could be used as a buffer for uses and for the Reserve
  - Consequences on water storages in the lower Kat and non scheduled farmers suffer severely in terms of production and profit.

- Scenario 4: Represents domestic water for all
  - INPUTS
  - 90% assurance of water supply
  - Change of domestic consumption (all indwelling taps making 7.6 m^3/c/y)
  - OUTCOMES
  - Flow out reduces only a few at the end of the period
  - Evolution of water provision in a rural village
  - No stress and no big increase in total demand
  - Domestic water improvement is not impacting quantitatively on water allocation, however there is a problem of infrastructure and environmental problems due to sewage and effluents.

- Scenario 5: Represents a development in the catchment

- INPUTS
- 90% assurance of water supply
- Change of domestic consumption (all indwelling taps making 7.6 m^3/c/y, plus an increase in agricultural surfaces for a total of 1700 ha, smallholders double annual crops, citrus scheduled up to 900 ha and non scheduled up to 400 ha
- OUTCOMES
- Flow out is good making more than 4M m^3/year
- Water from the dam not used enough, a lot is spared
- This shows that water could be used more effectively, and in these environmental conditions, more development is possible.

- Scenario 6: Represents a higher development in the catchment
  - INPUTS
  - 90% assurance of water supply
  - Change of domestic consumption (all indwelling taps making 7.6 m^3/c/y, plus an increase in agricultural surfaces for a total of 2600 ha, smallholders double annual crops, citrus scheduled up to 1500 ha and non scheduled users up to 700 ha.
  - Flow out is 1.8M m^3/year but it can be largely improved through dam releases
  - OUTCOMES
  - The dam refills easily every year
  - Stress is evident for unscheduled users have weirs and there is more production and profit
  - Therefore an improved use of the dam would allow: a) maintaining the Reserve, b) reducing stress of users.

- Scenario 7: Represents a high development in the catchment but using more effectively the water from the dam
  - INPUTS
  - As in scenario 6, but all citrus farmers scheduled
  - Flow out is 1.0M m^3/year but it can be improved through dam releases
  - OUTCOMES
  - The dam level now decreases (but still 9 years out of 10 rainfall is the same or higher)
  - No more stress users there are more weirs and there is more production and profit
  - Profit and jobs are very high

- Scenario 8: Represents a safer development in the catchment using more effectively the water from the dam
  - INPUTS
  - 90% assurance of water supply

  - Change of domestic consumptions (all indwelling taps making 7.6 m^3/c/y, plus an increase in agricultural surfaces for a total of 2000 ha, smallholders double annual crop by 400 ha and citrus scheduled up to 1600 ha.
  - OUTCOMES
  - Flow out is 2.5M m^3/year, but it can be improved through dam releases
  - The dam level refills easily and one could think of using it for the Reserve
  - No more stress users have weirs and there is more production and profit
  - Profits and jobs are still quite high even if lower than scenario 7

- Scenario 9: Represents a safer development in the catchment using more effectively the water from the dam and in situation of scarce rainfall.
  - INPUTS
  - 90% assurance of water supply but in years 3.7 and 8 supply falls to 98% assurance levels.
  - Change of domestic consumptions (all indwelling taps making 7.6 m^3/c/y, plus an increase in agricultural surfaces for a total of 2000 ha, smallholders double annual crops by 400 ha and citrus scheduled up to 1600 ha.
  - OUTCOMES
  - Flow out is low (almost zero in bad years) but it can be improved through dam releases
  - The dam level decreases in bad years but not below 6M m^3 (after 2 consecutive bad years)
  - No more stress users have weirs and there is more production and profit
  - Profits and jobs are still quite high even if lower than scenario 7

Two participants (a domestic user and a municipal member) were in favour of scenario 6. They stated that an increase in agricultural surfaces is needed and that indwelling taps for all people could encourage people to have home gardens, which will alleviate poverty. Also they felt that having more water to irrigate fields will increase production therefore create jobs.

Two large scale farmers were in favour of scenario 8. One farmer's reasons for choosing this scenario was that scenario 6 could be using too much water and that water needs to be utilized the best for all communities. The other farmer stated he likes this scenario due to the fact that more surface for planting could increase production, which is good for the economy of the catchment.

A small scale farmer was in favour of scenario 5, due to the fact that he would like to see small scale farmer irrigating more agricultural surfaces.

In their reflections participants stated that they found this workshop very useful in that every scenario that was chosen generated a discussion. They felt that negotiating for potential scenarios for the catchment was important and this workshop provided that.

The limited number of participants in this workshop made those participants that were present to have concerns regarding the participatory process of water management. A large-scale farmer stated that it seemed as though other members KRWUA were not interested in participating in water management, stating that a top down technocrat style is needed.

The outcome of this workshop showed that all participants would like to see an increase in production, profit and jobs as well as an increase in water access and allocation for all users.

3.5 Conclusion

In this chapter the researcher has described the ComMod process as well as gave a detailed background about the participants of ComMod. Describing the process of ComMod was a complex task seeing that there were dynamic steps influencing the process. The ComMod has proven to be a very complex process where field actions were continuously being questioned and amended. It is important to note that throughout the process the value of understanding, confrontation and analysis has been the key. The key ambition of ComMod has been enriching the negotiation and decision making process rather than the results outcome. In the next chapter we will be looking at (1) whether ComMod as a method was able to raise awareness of a complex system among participants in the Kat River Catchment and (2) whether it was able to facilitate the development of relationships amongst participants.

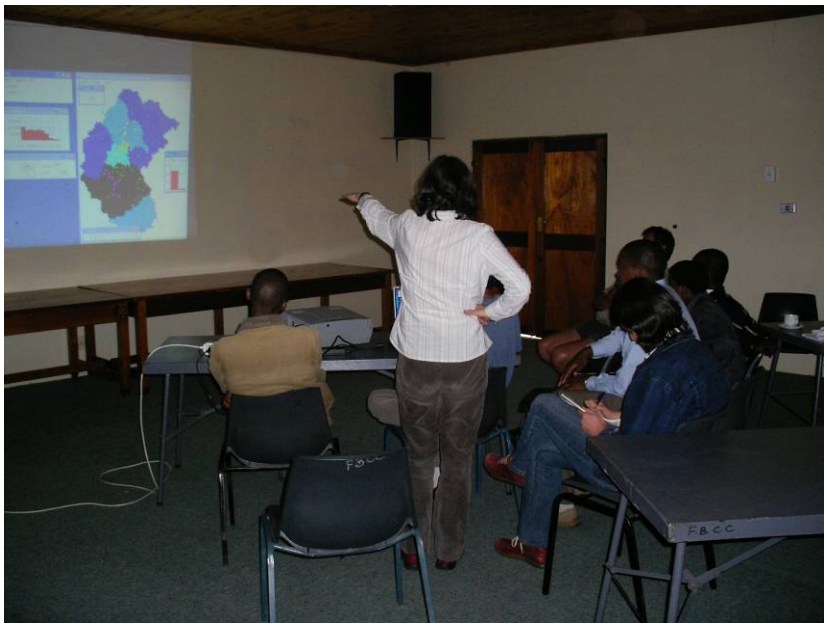
Pictures of the ComMod Process taken by various researchers from June 2005 until October 2006.

Picture (a) Participants and facilitators engaged in discussions during the 1st ComMod workshop in June 2005

Picture (b) Participants demonstrating their monthly water consumption with blocks to a facilitator during the 1st ComMod workshop in June 2005

Picture (c) Facilitator explaining a scenario to participants during the 2nd ComMod workshop in September 2005

Picture (d) Facilitator explaining to participants the different colours seen in the different subcatchments as a result of varying water consumption during a 2nd ComMod workshop in September 2005



Picture (e) Participants carrying their time sheets during a token WUA discussing their water strategies on the 3rd ComMod workshop in November 2005

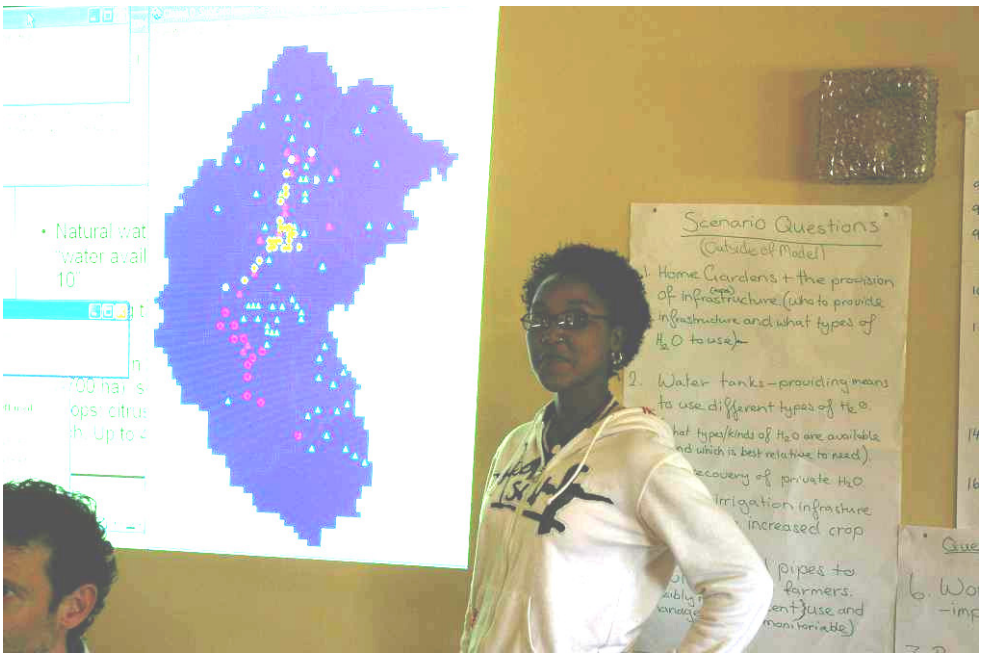
Picture (f) A large scale farmer and a Village Manager during a role-playing game on the 3rd ComMod workshop in November 2005

Picture (g) Participants during a role-playing game on the 4th ComMod workshop in March 2006

Picture (h) Participants gathered around the Cirad Team to hear about the outcome of their strategies during the 4th ComMod workshop in March 2006

Picture (i) Participants exploring their chosen scenarios during the 5th ComMod workshop in October 2006

Picture (j) Facilitator facilitating a workshop during the 5th ComMod workshop in October 2006



CHAPTER FOUR

AN ASSESSMENT OF COMMOD IN THE KAT RIVER CATCHMENT

4.1 Introduction

This chapter seeks to assess the ComMod process by answering the following question:

Has the ComMod approach led to any change within the WUA members in respect of knowledge, particularly on a) complexity and b) interrelation among different elements of the system.

Firstly the reader will be taken through the ComMod evaluation literature as derived by the ComMod ADD team. Secondly a brief indication of the way in which the evaluation process was carried out will be presented. The methods used to evaluate will be outlined. Methods of data collection and methods of data analysis that were used in this research project are introduced. Lastly the presentation of results and an evaluation of the ComMod process based on the ADD ComMod evaluation conducted (refer to ADD ComMod webpage).

4.2. The Evaluation of the ComMod approach.

Kelly *et al*., (2005:25) define evaluation as "*the planned activity of systematically collecting, analyzing and reporting information that can then be used to change attitudes or improve the operation of a project or program*". Holloway (2001) and Martin (2001) write that an evaluation looks at the operation of a project, whereby it describes the process and tells us how the outcome has been achieved (Patton, 1987).

According to Jones *et al* (submitted), general principles of evaluation point out that an evaluation process should seek to fuse together theory and practice by looking at what works, why it works and how it could work better. She states that possessing concrete understanding of the contextual background of the study area is important for it helps in setting what the evaluations will be based on. The evaluation process should seek to uncover the objectives of the study and the use of methods that were applied in the study.

When evaluating a process Jones *et al* (submitted) writes that often participant observations and questionnaires are used in order to acquire relevant information.

In this thesis the results of the evaluations were analysed specifically to find out if the ComMod approach has led to any changes within the Kat River Water Users Association members in respect of knowledge, particularly on a) complexity and b) interrelation among different elements of the system. By questioning the learning that occurred amongst various participants as a result of the ComMod process, the aim had been to understand how collective learning emerges from interactions around model-based mediating objects and to assess the role of ComMod in modifying responsibilities, behaviors, values, beliefs and intentions among actors. The evaluation methods that were applied were participant observations, participants' reflections and interviews. The order of that the evaluations occurred is as follows:

1. Workshop observations, conducted by myself during every ComMod workshop.
2. Workshop interviews, conducted by the social team during each ComMod workshop in order to capture participants' impressions and reflections so as to improve the ComMod tools and process.
3. Post workshop interviews, conducted by myself. Those after workshop 1 and 2 sought to assess how the participants perceived the ComMod process, whether it was useful, whether it needed to be improved and how they had found the simulation model. Interviews conducted after workshop 3 and 4 sought to assess how the participants related to the role-playing game, whether is was useful and how the game related to their daily lives.
4. The ADD evaluations. These ComMod evaluations took place as part of the ADD project [refer to the ADD ComMod web page (http://www.cirad.fr/ur/index.php/green_en/themes_et_projets_de_recherche/projets_en_cours/add_commod)]. There were two types of questionnaires a) the Designer Questionnaire[7] and b) the Participant Questionnaires[8]. The designing of the ADD

[7] The Designer Questionnaire was designed to obtain information from the ComMod process facilitators e.g. Rhodes social Team and Cirad Team. It seeks to find out what happened in each project, how it happened and when. The perception that are held by the project team are then compared to those held by participants (Jones, 2006).

evaluations questionnaires took place at Rhodes University with Dr Farolfi, Ms Natalie Jones (an observer from the ADD team in Australia), Ms Jane Burt, Mr Monde Ntshudu, Prof. Kate Rowntree and myself.. Since the ADD is a project that is in progress within ComMod community and aims at defining the protocol for ComMod evaluations, in designing the questionnaires we therefore ensured that the questions are context-based as these would be used later in the thirty-four countries that have been using the ComMod approach all over the world. The Kat River Catchment was used as a pilot study to test the first version of the protocol for ComMod evaluations. These evaluations were conducted by myself, Dr Farolfi, Ms Jane Burt, Ms Natalie Jones and Mr Monde Ntshudu. The data that was obtained from the evaluation was analyzed by Ms Jane Burt and myself and part of the data that I analyzed was used for this Master's study.

4.3 General Introduction to the Methods of Evaluation

The methods used to evaluate the ComMod process included the reflections with the KRWUA after every ComMod workshop, the survey that was done after the two sessions of the KatAWARE model (which intended to evaluate the ComMod process and the KatAWARE model), the survey that was done after the two sessions of the role-playing game (which intended to evaluate the ComMod process and the role-playing game) and the ADD ComMod survey. As a researcher I was involved in observations, recording conversations, facilitating, interviewing as well as the recording of events.

The multiple measures of data collection - interviews, observation, questionnaires - were used in order to cater for different types of error. These multiple perspectives assisted in explaining the reality in a comprehensive manner and often referred to as data triangulation. Triangulation according to Miller and Dingwall (1997) is the combination of more than two research methods in a single study. This use of different methods is a way of confirming information (Wolcott, 2001). Miller and Dingwall (1997) state that this may lead to replication of findings, which may increase the validity of the findings through minimizing biases. Emerson (1981), however, argues that triangulation is not necessary for validating research findings, but offers opportunities for reflexive

[8] The Participant Questionnaire was designed for participants e.g. the KRWUA

elaboration. Miller and Dingwall (1997) write that using triangulation as a method of analyzing data may render different research findings and this may create problems when trying to compare data. They further state that corroborating different methods in order to analyse data may be the same as "seeking to compare chalk with cheese" (1997:39). Even though triangulating data has positive aspects, it does not always give consistent results. For example an interview might give different results to a close ended questionnaire because in an interview the interviewer is able to ask probing questions, which allow the interviewee to provide more information. Whereas in a close ended questionnaire the participant may choose to use short answers such as yes and no, which at times might not be desired by the researcher. Therefore, because of this, the use of field observations might convey the same information with at least one other research method that has been used, therefore making the data reliable (Miller and Dingwall, 1997).

The interpretation and translation of all data into meaning was done using a coding technique. The use of coding in analyzing data according to Miller and Dingwall (1997) involves extracting reliable information from the interviews and organizing such information into simpler categories. For each question, responses of all participants were recorded. Responses were then categorized into themes based on what was common. This was done in order to identify the similarities and differences on the data as well as to allow deeper data insight. Kitchen and Tate (2000) warns that placing qualitative data into meaningful categories can be a complicated task. In order to further the analysis process, research questions were then used. This gave the analysis a focus and connected the data into logical and written meaning.

4.4 Methods of data collection

The evaluation methodology evolved during the project implementation so that no standard procedure was followed for categories 1-3. However the ADD evaluation (category 4), which was used to design the ADD protocol, took advantage of the experience gained in other evaluations, these being the workshop's interviews and post workshop interviews. The results from the ADD evaluation were found to confirm in a more quantifiable way the workshop's interviews and post workshop interviews, therefore the ADD evaluation was chosen as the main focus of analysis in this study.

The ADD evaluation interviews took place in the Kat River Valley in November 2006. The participant questionnaire was used (see appendix one). The questionnaire was divided into four sections namely:

- Context questions, these questions intended to find out about the background regarding the issues that the participants are facing as well as to find out the reasons that made them to be part of the ComMod process;
- General process questions: these questions intended to find out what were the participants' thoughts about the ComMod process, what captured their attention the most and why;
- Method questions: these questions intended to find out from participants how they saw the ComMod tools (the role-playing game and the simulation model). The questions focused on whether participants learnt something, whether they found the tools useful and what did they liked or disliked about the tools and why; and
- General reflection questions: these questions intended to find out whether there was any change of thought or practise that was brought by the ComMod process and also to find out whether the participants that participated were sufficient or others were left out.

There were twelve participants who participated in the ADD evaluation, namely: one government official, three large-scale farmers, three small-scale farmers and five domestic users. The participants were visited in their homes by Ms Jane Burt, Mr Monde Ntshudu and myself. Ms Jane and myself took turns in asking the questions and recording the answers on a notebook, while Mr Monde was translating from English to Xhosa and visa versa when needed. A maximum of four interviews were conducted per day, as we were in the field for three and half days. After all the interviews were completed, data that was collected during the interview sessions was ready to be processed.

4.5 Methods of data analysis

The coding method was used in this study for the processing of data. Here data was coded into meaningful values. Since data was in a form of textual answers to open questions, numbers were assigned to the range of responses that had been obtained for each question. A coding frame was designed after the data was collected, which allowed the number of categories used to be dictated by the overall size of the sample obtained. For example in Question three (see appendix one) participants were asked *why are you participating in the project? What's your motivation to be involved in the KatAWARE project which uses the model and RPG.* Based on their answers the reasons can be split into two categories, 1) personal reasons and 2) represent a broader group.

The criteria that have been used in analyzing the data were developed after the ADD evaluation, the workshop's interviews and post workshop interviews were conducted. The bases for choosing these criteria relate to one of the questions that this study is trying to answer. ***Has the ComMod approach led to any change within the WUA members in respect of knowledge, particularly on a) complexity and b) interrelation among different elements of the system.***

Twelve participants participated in the ADD evaluation process. The rate of positive answers provided by the twelve participants for each criterion is chosen as an indicator of the level of achievement/failure of the ComMod process in the related field.

Table 4.1: The criteria for the analysis

Field	Criteria: Participants to the ComMod process have/are:	Indicator
Learning	* Acquired new knowledge. (1) This knowledge could either be practical or theoretical. * Reached an holistic vision of the catchment . *Reinforced their existing knowledge and ideas. (*2)*	1-4 Low 5-8 Medium 9-12 High
Interrelationships	*Improved their	1-4 Low

	communication level throughout the process. *Shared their view points whether they are relevant to the project or not. *Increased their trust levels, through revealing their personal problems to others. *Adopted more flexible sitting arrangements. *Reached consensus and team spirit.	5-8 Medium 9-12 High
Awareness	*Acknowledged their level of information and skills *Willing to change a behaviour as a result of the information /knowledge acquired. *Willing to refer the consequences of an individual action to the broader system.	1-4 Low 5-8 Medium 9-12 High

4.6 Results

(The reader is advised that data that is presented in this thesis is a synthesis coming from reflections with participants after every ComMod workshop (Category 1), the survey that was done after the two sessions of the KatAWARE model [which intended to evaluate the ComMod process and the KatAWARE model (category 2)], the survey that was done after the two sessions of the role-playing game [which intended to evaluate the ComMod process and the role-playing game(category 3)] and the ADD ComMod survey (category 4). The presentation of results focuses strongly on category 4 because category 1-3 were based on informal questions, in addition category 4 served as an umbrella for the other three categories).

The first set of questions in the ADD questionnaire (see Appendix one) were the Context questions, which prompted the participants to give a brief background regarding the

issues that they are facing in the catchment (see Appendix one). The issues that participants raised were: the need for pipes in order to transport water from the Kat dam using gravity, access to water, more land for expansion, improved water allocation, effective dam management, paying water tariffs, social issues (learning about one another), drafting of business plan and CMP, improving water quality, environmental concerns and lastly confusion of policy and law. Some issues appealed more to certain participants than others. For instance, for large-scale farmers acquiring more land for expansion, improved water allocation and effective dam management were important issues. Small-scale farmers on the other hand viewed the need for pipes in order to transport water from the Kat dam using gravity and access to water as important. In addition domestic users saw improving water quality was important. These issues played a role in influencing the way participants were involved in the ComMod workshops as well as in obtaining the knowledge and interaction.

The tables presented here are all important and therefore are not presented according to the order of importance. However they follow the sequence as presented in Table 4.1.(The criteria for the analysis).

4.6.1 New Knowledge

The questions that were used to evaluate participants' knowledge are as follows (see appendix one):

1. What were the workshops that used the model and RPG about (generally speaking)? *Probe: What do you remember about the workshops when the model and the RPG were used?*
2. What happened at the workshops where the model was used?
3. Was the model useful? How was it useful? Did you apply this to your daily life
4. Did you learn anything through using the model? Did you learn from the other members of the WUA (municipality or DWAF)?
5. How did the way you think about the issue change from when you used the model to when you used the RPG? *Prompting questions: Did your interactions with the other participants change, did the way you learn or what you learnt change? Did you change your actions in daily life? Explain.*

Judging from the answers obtained from these questions, participants demonstrate that they have obtained practical and theoretical knowledge through ComMod. Practical knowledge is the kind of knowledge that participants can practice in their lives in general and theoretical knowledge is the kind of knowledge that participants can keep in their heads and is useful to know. The new knowledge that participants reflect to have gained through the ComMod process is presented in Table 4.2.

Table 4.2: Knowledge obtained by participants through ComMod

New knowledge (1)	***No of participants***	***Who?***	***Some relevant quotes from participants***
Learnt about farming practices (practical knowledge)	1/12	Small-scale farmer	A quote from a small-scale farmer, "*From playing the game I now plan before I plant, now I look at season of the year, market, weather, water quantity and the closeness of the fields to a water source.*"
Learnt about water pollution (practical knowledge)	2/12	Domestic user and small-scale farmer	A quote from a domestic user, "*I learnt about how to care about the river, what we should and should not do in the river (like washing in the river, using the river as a toilet and throwing litter in the river) and that we should not think only about ourselves; we should also think about the river ecosystem including the insects and animals."*
Learnt about improving dam management (practical knowledge)	5/12	Two large-scale farmers, a small-scale farmer, a domestic user and a government official.	A quote from a large-scale farmer, *"To me we have to improve the management of the Dam."*
Learnt about generating more profit (practical knowledge)	3/12	Two Domestic users and small-scale farmer.	A quote from a small-scale farmer, "*I learnt that more farming surface equals more profit and that less farming surface equals less profit."*
Learnt about other participants (theoretical knowledge)	12/12	All participants.	A quote from a domestic user, "*It was interesting for me to hear about water users in the area, also to hear some farm citrus, some farm annual crops.*" Also a large-scale farmer stated: *" I think the workshops just make you understand other peoples point of view. You know, look at the whole situation out of a different point of view."*
Learnt that water users should be considerate of other water users (practical knowledge)	5/12	Three domestic users and two small-scale farmers.	A quote from a small-scale farmer : *"I learnt that the Kat River has many people that are concerned and taking care of it. We must respect people living upstream as well as downstream."*
Learnt that there is enough water to sustain all water users in the Kat Valley	5/12	Two large-scale farmers, two small-scale farmers and a	A quote from a large-scale farmer, "*we want to try and get more water to develop. We're probably more confident now that we're going to get it because we know now that there is enough water in the catchment for all users."*

(theoretical knowledge)		government official.	
Learnt that the upper Kat has more water and the lower Kat suffers from water shortages (theoretical knowledge)	5/12	Two small-scale farmers, a large-scale farmer, a domestic user and a government official.	A quote from a small-scale farmer, "*The model particularly helped us a lot to learn that we understand that we have lots of water in the upper Kat and the lower Kat has little water compared to us."*
Learnt that water users will need to pay water tariffs (practical knowledge)	2/12	Two small-scale farmers.	A quote from a small-scale farmer, "*I learnt about the fact that water has to be paid for because that came out of the workshops"*
Learnt about the importance of representing and being represented (practical knowledge)	9/12	Three domestic users, two large-scale farmers, three small-scale farmers and government official.	A quote from a large-scale farmer, *"I learnt about the importance of being represented in every WUA meeting because decisions that are taken there can not be reversed."*
Learnt about effective systems of irrigation (practical knowledge)	3/12	Two small-scale farmers and a larger scale farmer.	A quote from a small-scale farmer, *My Views about water issues have changed by being part of WUA. I have been made aware, and I've changed my management style. I've learnt a lot that one can change to an effective system of irrigation that will use water effectively not waste water. I've been exposed to so many kinds of knowledge*
Learnt about negotiation skills (practical knowledge)	2/12	Domestic user and large-scale farmer.	A quote from large-scale farmer, *"the KatAWARE I think it is about... we see different scenarios and it helps us to say which type of scenario we want and then take that thing and add another on top of it. …. Not necessarily telling us what to do, but opening our minds with negotiations*."
Learnt about minimum and maximum flows in the river (theoretical knowledge)	2/12	Domestic user and large-scale farmer.	A quote from a domestic user, "*What I found was that sitting with large-scale farmers, we were able to discover that we have limited or very small rights to water. And that we are relying on them if they need water downstream that is how we are able to get water."*

The information that is presented in the table shows that according to the criteria of evaluation the participants gained more practical knowledge than theoretical knowledge. However indicators of this knowledge gain were very low as 7 out of 13 fell between 1- 4 (refer to Table 4.2). Small-scale farmers mostly gained practical knowledge, followed by domestic users and large-scale farmers were the least. Once more, both small-scale

farmers and domestic users gained most of the theoretical knowledge followed by large-scale farmers. This shows that in terms of knowledge gained, the ComMod process appealed more to small-scale farmers and domestic users. This is as a result of the limited education that small-scale farmers and domestic users have as a result of South Africa's history of apartheid where black people were not exposed to useful information and resources like white people were. Large-scale farmers did not gain a lot of practical knowledge from the process because they already knew most of the things as a result of their good education, experiences and exposure.

The knowledge that has been gained by participants has allowed them to understand and see a holistic and comprehensive vision of their catchment. For example they learnt that improving management of the dam is important from an ecological perspective and that it also provides economic and social benefits. As a large-scale farmer stated "*We need proper management of the dam so that the ecological Reserve will not suffer so will our plants and all the people that depend on the river for survival*". In addition, the fact that water users need to be considerate of other water users helps reasonably in the sharing of limited resources among participants in the catchment. As a domestic user stated "*I thought that as water is running down we can use water any way we want. And even irrigators should not use all the water flowing in the river, they should think about the ecosystem as well and domestic users and these are the things I learned and it changed the way I view the river.*" These results show that ComMod served the purpose of developing capacity among historically disadvantaged individuals and enabled them to have the same information and knowledge as the large-scale farmers. As a small-scale farmer stated "*I feel honoured to be part of this process. I learnt a lot even from large-scale farmers because they have more knowledge of what is happening in the catchment, so it's good to learn from them.*" The new knowledge gained by small-scale farmers and domestic users empowered them to take part in negotiating sessions, whereas for large-scale farmers the new knowledge gained has been an insight that will help them improve their management of resources.

ComMod also reinforced existing knowledge among participants. This existing knowledge had been acquired through the previous projects that were facilitated by the social team in the Kat River Catchment. The kinds of knowledge gained, which were reinforced by ComMod include:

- Learning about the importance of representing and being represented in WUA meetings, learning about water pollution and learning about the fact that water users should be considerate of other water users upstream and downstream.

Activities through which these learnings took place included environmental workshops, the landcare project and representation workshops.

What correlates with the above statements is that even during my observation participants looked very interested during workshops. Of particular note is the first ComMod workshop where participants were focusing their attention on the model and the scenarios that were shown. Large-scale farmers seemed to understand the model much better than the rest of the participants as they were nodding and asking clarity seeking questions such as *"What would happen if the yield of the river is not stored but drained into the sea"* asked by a large-scale farmers from the middle Kat.

The workshops of a role-playing game were more appealing to small-scale farmers and domestic users, due to the fact that the role-playing game was practical and interactive. As a domestic user stated "*I liked more the workshop where we played the game. I learnt a lot from the game because I was doing things there and I had an opportunity to interact with other players during the WUA meetings. I got to know and learnt also about other people's strategies in those meetings and Stefano would put the strategies in the computer for us to see.*"

Based on the results that have been presented, it is evident that new knowledge was gained by participants as a result of the different tools (simulation model and role-playing game) used during ComMod process. This knowledge illustrate that a catchment is not a linear system, which is able to function in a solitary manner, but is a complex system that needs to function in harmony. Knowledge gained by participants encompassed

environmental, economic and social characteristics. The knowledge was used by participants in debates relating to their preparations of the CMP as a large-scale farmer stated *"I got enough information and I feel that I could handle any debate now that could lead us to developing a CMP."* Also another large-scale farmer stated "*I liked being involved in the model because it is trying to suggest to us that before we go to negotiations about what will go on a CMP, we must prepare ourselves; it provides the tools to negotiate, we look at scenarios, we have learnt to interact, we understand one another now, people's perceptions have changed about each other and about the way water is used."*

4.6.2 Interrelationships formed

Participants agreed that they have formed interrelationships during the ComMod process. The questions that were used to evaluate participants interrelationships are as follows (see appendix one):

1. How did you interact with different members of the WUA (municipality or DWAF)? Did this change through using the model?
2. How did the way you think about the issue change from when you used the model to when you used the RPG? *Prompting questions: Did your interactions with the other participants change, did the way you learn or what you learnt change? Did you change your actions in daily life? Explain.*

The interrelationships that participants reflect to have formed during the ComMod process are presented in Table 4.3.

Table 4.3: Interrelationships formed through ComMod

Interrelationships formed	***No of participants***	***Who?***	***Some relevant quotes from participants***
Participant relationships enhanced	12/12	All participants	A quote from a small-scale farmer. *"In the beginning of the process there were tensions because we did not know each other, but not people are more at ease with each other because they have been communicating in the workshops."*

Sharing viewpoints of participants	8/12	Two large-scale farmers, two domestic users, three small-scale farmers and government official.	A quote from a domestic user, "*It is very interesting to hear people telling their stories and sharing their views. I like it a lot."*
Working together of participants	8/12	Two large-scale farmers, two small-scale farmers, three domestic users and government official.	A quote from a large-scale farmer, "*There is a feeling that we are in this thing together, and domestic users are less of a threat now."*
Friendships formed among participants	1/12	Small-scale farmer	A quote from a small-scale farmer, "*We communicate so nicely now and I can tell my problems knowing that I can get advice. It's like we are friends*."
Exchange dialogue among participants	9/12	Two large-scale farmers, a government official, four domestic users and two small-scale farmers.	A quote from a domestic user , *"When you hear other water users sharing their problems it just make you understand other peoples point of view."*
More consensus is reached	8/12	Three large-scale farmers, two domestic users and three small-scale farmers.	A quote from domestic user, "*There is unity now, during the role-playing game we discuss issues and come to an agreement*."
Spirit of togetherness has been created	6/12	Two large-scale farmers, two domestic users, a government official and a small-scale farmer.	A quote from a small-scale farmer, "*What I found was that sitting with large-scale farmers, we were able to discover that we have limited or very small rights to water. And that we are relying on them if they need water downstream that is how we are able to get water."*
Participants are careful not to offend each other.	5/12	Three large-scale farmers, a domestic user	A quote from a large-scale farmer, "*In workshops people do not engage fully in discussions. They are too careful about the things they are saying to each other."*

and two small-scale farmers

According to the criteria of evaluation, the table shows that participants found the ComMod process to have contributed in improving their communication levels with each other. ComMod provided a platform from which the sharing of view points was possible. Throughout the process participants became more flexible with each other as noted in their sitting arrangements during workshops observations and a sense of team spirit was observed in their discussions and activities that occurred in workshops. As a small-scale farmer stated, "*The interaction is increasing more and more. I never thought I would sit in one table and interact with people like large-scale farmers.*" The indicators of interrelationships formed ranged from medium to high as 7 out of 8 fell between 5-12 (refer to Table 4.3). The table shows that all participants benefited in the formation of interrelationships. In their evaluation participants reflected that they found the role-playing game to have been responsible for the formation of interrelationships. As a small-scale farmer stated, "*The role-playing was practical and interactive and we were able to engage with other participants."* They stated the reason for this was that the role-playing game was practical and gave room for them to interact with each other. They also emphasized that it was through the role-playing game that their trust for each other increased, which allowed them to bring forward their issues in order to be heard by other participants.

Observations show that the relationship amongst participants improved from what it was in the beginning of the process. Though at times domestic users still needed to be probed in order to engage with others, the rest of the participants were interacting and engaging in discussions generously. The following are how participants assert to have participated:

- Domestic users participated by being present, listening, taking down notes and gaining information at workshops;
- Small-scale farmers participated by being present, gaining information and contributing with information;

- Large-scale farmers participated by having an impact, making suggestions and giving information at workshops

According to one of the researchers who was involved in the ComMod process "*participation in the Kat River Valley has been an integrated visual representation of all the work and research that has been conducted in the Kat area. The ComMod process created a link from which the stakeholders were able to see how all the information that has been collected from the stakeholders over many years was being used in order to develop a catchment management plan."*

When participants started to mix interactions increased, there was dialogue exchange and flexibility in communication. Interactions increased especially between large-scale and small-scale farmers. The reason for this may be that they all are involved in farming and have a much common ground to communicate on, even though they plant different crops. Also because they are the most users of water, an initiative that looks at water management such as ComMod would appeal to them the most. However domestic users interacted less throughout the process. The reason for this may be that in reality domestic users sit on WUA meetings for transparency reasons, they should be represented by municipality. It is municipality that negotiates on behalf of domestic users. Also the issue of language prohibited domestic users from participating as most of them only communicated in Xhosa; even though a translator was present there were still language barriers. The ComMod tools used in the process had a different though similar effect on participants. For instance, the role-playing game united participants and made them feel at ease with one another, thereby giving them a platform to interact. The simulation model led to improved interactions as it provided a platform for all participants to exchange information regarding what they do and how they do it. Therefore the discussions that occurred throughout both the role-playing game and the model led participants to interact and share information.

While the CoMod process generated a number of positive outcomes regarding interrelationships as discussed above, some important negative outcomes also surfaced during the ComMod processes. These were:

- Fear

The ComMod process has revealed that water needs to be paid for by domestic users and that small-scale irrigators who previously have not been required to pay. This has raised fears in these participants and to some extent some became reserved in meetings in avoidance of the water payment issue. This kind of awareness increased the gap between stakeholders, more especially between those who can pay and those who can't pay. Some of these participants fear that their inability to pay for water will result in them being restricted or limited to use the resource. As a small-scale farmer stated "*I don't like the fact that water has to be paid for because that came out of the workshops… If I don't have money to pay it means I will not get water*"

- Power

Where there is an assembling of multiple stakeholders, power is always an issue of concern. Patel et al. (2007) argue that during interactive participatory processes all participants become empowered, but some become even more powerful than others. This unequal power, which is embedded in social, cultural and political spheres, works against achieving harmonious participatory decision making. During the ComMod process in the Kat the stakeholders who were most powerful at the start of the process continued to dominate the discussions, information sharing and negotiation process. A large-scale farmer stated "*Some people try to influence you to see their point of view*" which makes it seem as that their views make much more sense then other people's views. It is therefore true that being more aware and informed can allow one to have freedom of expression, which is very much linked to power. Hence a person who has more knowledge does become powerful than those with less knowledge. As a large-scale farmer stated "*I got enough information and I feel that I could handle any debate now*". It is worth noting that these large-scale farmers were the ones who came in better informed, and now feel even stronger.

- Tension

One issue of concern to small-scale farmers is the fact that water needs to travel from the dam to their farms in pipes rather than down the river. However this issue has not been

attended to whenever it is raised in meetings. As a result there is a strain created where a small-scale farmer sees his needs as not being addressed through the ComMod process. This has created tensions in a sense that some stakeholders see concerns that are raised by other stakeholders being more prioritized than others. As a small-scale farmer stated "*It was general discussions because initially when we put up the proposal of getting water through pipes in our fields in the upper Kat he was never interested but when large-scale farmers from the lower Kat suggested that Stefano release a certain amount of water from the dam more than they usually released he was interested and it was actually experimented through the model but at a later stage when we were telling him that because we don't have money it will be difficult for us to pump water to our reserves so if we can start using gravity because we don't need electricity or diesel and now he is starting to accept that.*"

Concerns, such as this one, cannot easily be addressed by the model which simply looks at the amount of water being delivered/used, not the mode of delivery. This demonstrates that the stakeholder misunderstood what the model could and could not do. He was not fully aware of the limitations of the model; a model is not the real world but a limited representation of it.

4.6.3 Awareness of the complexity of a catchment

Through the use of simulation model and role-playing in the ComMod process, participants attained a higher level of awareness and knowledge of their catchment that resulted in enhanced level of shared knowledge. They have collectively increased their capacity to formulate and explore scenarios. As a researcher stated, "*The model first allowed quantifying and representing spatially the problems, and the RPG then facilitated the discussions and the debates around these problems*"

All participants have increased their ability to participate in the WUA meetings, even though some made greater input than others. The relations between participants from different areas of the catchment became stronger as a result of the process and their capacity to engage in decision making processes increased. ComMod has provided participants with an opportunity to begin exploring complex concepts related to water resource management in a way that related directly to their context within the catchment.

Participants were able to explore how different scenarios influence different uses and the catchment as a whole, as well as discover similarities in problems that other participants are faced with. As a small-scale farmer stated, "*Being involved in Stefano's model helped me to understand things and I was able to have an input in discussions when we were making decisions.*"

Through ComMod participants were aware that the issues they raised to have been important (see section 4.6) are part of a complex system, which exist within their catchment. As a domestic users stated "*I learnt that it is not easy to give everyone the opportunity to have water from taps. It's a process that involves time and money*". As a result of being aware, participants' perceptions changed from thinking that others are being selfish and self-centered to acknowledging that they can learn more from each other; from being individualistic to be willing to compromise; from being less interactive to being more interactive; from having more tensions to having less tensions; from not considering the ecological Reserve to considering the ecological Reserve; from thinking that water issues in the Kat can be solved overnight to recognizing that water issues are complex and can not be solved over night.

The new National Water Act of South Africa (NWA 1998) which promotes integrated and decentralized water resource management required the establishment of catchment level water management institutions known as 'Water Users Associations' (WUAs) (Farolfi 2004). The Kat River Valley has the KRWUA, which was established in 1999 through the transformation of an Irrigation Board that existed at the time. The KRWUA is responsible for the availability and quality of water in the Kat River. The KRWUA is made up of the following representatives, namely: three large-scale farmers, three small-scale farmers, five domestic users, one municipality member and Department of Water Affairs and Forestry (DWAF) regional office member. Relations between some of the members of the KRWUA are marked by mistrust and preconceived ideas about one another due to a complex history of social and economic disparity, as a result of the apartheid era. Getting the above mentioned representatives to sit around the table to begin addressing water issues together is an important step in working towards decentralized

water resource management. The ComMod process has contributed to achieving this. The ComMod process (with the use of KatAWARE model and role-playing game, which were developed concurrently with the participants using an iterative process) was piloted in the Kat River Catchment with an intention to assist the KRWUA to develop a Catchment Management Plan (CMP). Participatory simulation tools which were used to in the ComMod process were able to:

- Provide these participants with an opportunity to begin exploring complex concepts related to water resource management in a way that related directly to their context.
- Enhance participants' knowledge about water allocation strategies and their associated socio-economic and environmental impacts and
- Facilitate dialogue and improve negotiation skills.

All of these elements have led to the building of capacity within the KRWUA to conduct negotiations making the ComMod approach relevant to have been used for the preparation of the Catchment Management Plan.

4.7 Limitations of ComMod

A number of limitations on the ComMod process were noted. These limitations can be endogenous to the approach, due to the way it was adopted in the Kat, or due to the constraints imposed by the socio-economic background of the study area. These limitations are illustrated below, as their avoidance might improve concretely the effectiveness and the applicability of the approach into other similar cases in South Africa or elsewhere.

- The ComMod approach was implemented using numerous workshops, which became very time consuming for participants as they had other daily life events to focus on. This resulted in some participants pulling away from the process, which was then interpreted by other participants as having lack of interest. As a small-scale farmer stated *"I cannot say I disliked this because I learned a lot from these workshops and they taught me a lot. I have never been upset and the only reason I am not attending now is because of my problems and if I don't look after my cows they get*

taken away and I don't get them back and I don't get compensated for the loss of them so I have to stay and look after them." Also, participants seemed to be exhausted towards the final stages of the ComMod process as was observed on their attendance on the 5th ComMod workshop which had only seven participants.

- Local participants faced logistic problems when it came to attending workshops. They lacked means of transportation to the workshop venues and were greatly dependent on Rhodes University to provide transportation. As a researcher stated "*There is a logistical problem of collecting people in the upper Kat. Problems of their ability to come to meetings always come up*". This shows that participatory processes, especially those that focus on local participants, can not be prolonged without external help. In South Africa local structures are expected to be involved in participatory process on a voluntary basis, which leads to people not having money for transport to go to meetings. This is a problem in a country like South Africa where there is a high rate of unemployment and poverty.
- Due to the complication of the model, the participants failed to use the model successfully to explore scenarios, most participants (namely; five domestic users three small-scale farmers and two large-scale farmers) got lost and could not follow the ComMod process into the next stage. It became apparent that as the model became more complex, participants focused on understanding how it worked; they failed to interpret the information that was given by it. As a researcher stated "*Clearly some people were following the model while others were not. The model is very sophisticated which is part of the problem. The model is too complex, but the ComMod approach is not the problem*".

  In fact, the model used to explore scenarios was a slightly modified "Version 1", instead of a "Version 2" that should have emerged from the findings of the two role-playing game sessions. "Version 2" was conceptually ready and was supposed to reproduce spatially the

playground of the role-playing game. This would have increased substantially the understanding of simulations by participants and, at the same time, would have reduced the "prescription character" that the "version 1" has due to its realism of the catchment representation. What happened is that the conceptual model of "version 2" could not be implemented into a running model to be used in a negotiation context because the modelling platform (Mimosa) chosen for its implementation was not ready on time, and the modeller supposed to do the work on it was not able to use the old platform (Cormas). This incident shows how ComMod is highly dependent on modelling and computer science skills that were located in overseas institutions.

- Although domestic water supply was included, the main socio-economic focus of the KatAWARE model (agricultural income, costs, employment generation) made it difficult for domestic users to identify themselves in the model, thus leading them to be unable to ask relevant questions and make a lot of contributions during the ComMod process. As a domestic user stated "*We found ourselves isolated in the workshop, end up not discussing anything…We are concerned about water related issues not irrigation. When the agenda is being drafted we should be given a chance so that we have an input into the agenda, the issues that we would like to be discussed in the workshop. Farmers are concern about extending their land and having dams. And we are concerned about getting water for our gardens and getting water for drinking…'According to me the aim of the workshop focused on the farmers*".
- ComMod tools are developed using strong technical language. Even though translation was satisfactory, whereby technical issues were being translated to Xhosa, it is not known as to what extent the message was put across.
- Participants did not have enough understanding about the complexities of a catchment in order to know how to test scenarios using the ComMod tools. As a result this created misconceptions

among participants. Some were seen as taking over while others were left behind.

- ComMod evaluations took place six months after the last ComMod workshop and it became very difficult to get participants to reflect back on what happened during the ComMod process, what they learnt and what they liked or disliked about the process.

4.8 Conclusion

The results demonstrated that participants responded differently to both the modeling workshops and the role-playing game workshops, as they had different objectives. The objectives of the modeling workshops were (i) to provide a common platform to learn about the complex system and (ii) to critique the way the model represents the system (Burt et al, 2005a: 2005b) The modeling workshops proved to have had limited success in creating a space for dialogue exchange. This was due to the fact that the model was too complex for the participants to understand and engage with. The large-scale farmers appeared to understand the model the most as it specifically addressed issues of water allocation, which they view as important. All other participating saw the model as something they must learn about rather then a tool they could use to help them. However all participants felt that the model was too technical.

On the other hand the objectives of the role-playing game workshops were to: (i) facilitate understanding of the model from which the game was designed and (ii) provide researchers with further information on individual and collective water use and management strategies (Fox ***et al.***, 2005: 2006: 2007). The role-playing game workshops were more successful in enabling interactions and dialogue exchange. The understanding of the participants was higher and the discussions were more effective and this increased the participants understanding of complexities. These are important outcomes when considering the historical context in which the WUA is established (see Section 1.5) and the role which they are required to fulfill to effectively manage their water resources in the future. However less time was allocated for discussions where most learning took place. The important issues (access to water and water quality) as identified by small-scale farmers and domestic users were not addressed during ComMod. This had an

impact in negotiations as these participants did not have much to say as their issues were not covered. The results have demonstrated that, the socio-economic and educational background of participants played a part in influencing the extent to which participants engaged with the process.

This Chapter has shown that the ComMod approach has led to changes within the KRWUA members with regards to (a) knowledge and awareness about a complex system and (b) interrelationships among different participants. The ComMod process has also enabled participants to see links that exist within ecological, social and economic aspects that are required in holistic and comprehensive catchment management even though risks and shortcomings have been experienced.

CHAPTER FIVE

CONCLUSIONS, DISCUSSIONS AND RECOMMENDATIONS

This research study focused on answering three questions namely :

- Has KatAWARE followed the ComMod approach?
- Has the ComMod approach led to any change within the WUA members in respect of knowledge, particularly on a) complexity and b) interrelation among different elements of the system.
- Has the ComMod approach been relevant for the process of building the capacity of the Kat WUA to conduct negotiations leading to the preparation of the Catchment Management Plan?

The construction of KatAWARE as detailed in Chapter Three followed as iterative process consisting of numerous action research cycles proves that the ComMod process was followed in this study. The results that are presented in Chapter Four have revealed that the use of the ComMod approach in the Kat River Valley has led to changes within the KRWUA members in respect of knowledge on complexity and interrelation among different elements of the system. In addition, results also show that the ComMod approach has been relevant for the process of building the capacity of the Kat WUA members in conducting negotiations leading to the preparation of the Catchment Management Plan.

ComMod process was able to:

- Provide the KRWUA members with an opportunity to begin exploring complex concepts related to water resource management in a way that related directly to their context.
- Enhance participants' knowledge about water allocation strategies and their associated socio-economic and environmental impacts and
- Facilitate dialogue and improve negotiation skills.

The aim of the study was to describe and evaluate the ComMod approach applied in the Kat River Catchment for building capacity and knowledge and negotiating water allocation strategies. The process was based on the co-development and application of two main tools, namely the model KatAWARE and the related role-playing game. In fulfilling the study purpose the complex literature that influenced the development of ComMod has been reviewed; this literature ranges from post-normal science, to constructivism, up to action research. The ComMod process has been described and documented as it was implemented in the Kat River Catchment. The information obtained through workshops, surveys, secondary data, interviews and Geographic Information Systems (GIS) has been used to contribute to the construction of the KatAWARE model. Reflections on the ComMod process were conducted using the ComMod evaluation. Limitations of the process were addressed and recommendations were made for future applications of ComMod in other similar contexts.

The general conclusion from the analysis is that the ComMod approach has led to changes within the KRVWUA participants. The participants agreed that they had gained diverse entities including: new knowledge, formation of interrelationships and the generation of awareness to see the interconnections of ecological, social and economic issues that exist in their catchment.

The results have shown that the ComMod process proved to be useful because is provided new knowledge, facilitated the formation of interrelationships and an increased awareness of the complex issues in the catchment amongst the Kat River Water Users Association members.

Even though the ComMod process presented positive outcomes in the Kat River Catchment area, a number of key limitation are noted (refer to Chapter Four for a detailed explaination) namely;

- There were complications that were associated with the use of one of the ComMod tools in particular, the computer model. Participants found the computer model to be complex.

- The socio-economic focus of the computer model made it difficult for domestic users to identify themselves in the model.
- ComMod evaluations took place six months after the last ComMod workshop, therefore it became difficult to get participants to reflect back on what happened during the ComMod process.

Having in mind the limitations of this study, the following general recommendations are made for the future adoption of the ComMod approach in contexts similar to the Kat in South Africa or elsewhere. My recommendations to address the stated limitations are as follows:

- The outputs of the computer model should be simplified and made user friend so as to accommodate the people with very minimal education.
- Issues that are directly linked to domestic users should be researched and incorporated into the computer model so as to enable domestic users to identify themselves in the model.
- Evaluations need to take place soon after the process. Evaluations need to be conducted during the ComMod process so as to capture the relevant and correct information while it is still fresh in the participants' minds.

This research study was designed around two approaches, ComMod and Action Research, which draw their philosophical underpinnings from Post-normal science, Constructivism. ComMod approach enabled participants' to engage with the model and role-playing game contributed in building comprehensive decision-making and negotiation skills. The knowledge of participants was improved, dialogue exchange occurred and interrelationships were enhanced. In the model workshops by exploring scenarios participants acquired an improved understanding that a catchment functions as a complex system. Parallel in the role-playing game workshops participants were flexible to engage with each other and improved their negotiating skills. This study demonstrate that ComMod as it was piloted in the Kat River Valley provided positive results, therefore it can be used in other parts of South Africa.

References

Agriculture et Developpement Durable project web page (http://www.cirad.fr/ur/index.php/green_en/themes_et_projets_de_recherche/projets_en_cours/add_commod)

Allen, W., 2000: The role of action research in environmental management, working paper on the website: [online] http://nrm.massey.ac.nz/changelinks/ar_working.html

Bacic, I.L.Z., Rossiter, D.G., Bregt, A.K., 2005: Using spatial information to improve collective understanding of shared environmental problems at watershed level. Wageninge, Netherlands.

Barnaud, C., Promburom, P., Gurung, T.R., Le Page, C., and Trebuil, G., 2006: *Companion Modelling for Collective Learning and Action in Water Management: Lessons Learnt from three case studies in northern Thailand and Bhutan.*

Barreteau, O., 2003: The joint use of role-playing games and models regarding negotiation processes: characterization of associations. *Journal of Artificial Societies and Social Simulation,* 6(2) [online] http://jasss.soc.surrey.ac.uk/6/2/3.html.

Barreteau,O., Bousquet, F., and Attonaty, J-M., 2001: Role-playing game for opening the black box of multi-agent systems: method and lessons of its application to Senegal River Valley irrigated systems. *Journal of Artificial Societies and Social Simulation,* 4(2), [online] http://www.soc.surrey.ac.uk/JASSS/4/2/5.html.

Barreteau, Olivier and others (2003) 'Our Companion Modelling Approach' *Journal of Artificial Societies and Social Simulation,* 6 (1),

[online] http://jasss.soc.surrey.ac.uk/6/2/1.html.

Birkholz, S., and Gumede, H., 2005: *Basic GIS coverages of the Kat River Catchment, Eastern Cape.* Unpublished report to the Water Research Commission (Project no. K5/1496), the Institute of Water Research. Rhodes University. Grahamstown.

Blackstock, K.L., Kelly, G.J., and Horsey, B.L., 2007: Developing and applying a framework to evaluate participatory research for sustainability. *Ecological Economics*, 60(4):726-742.

Burt, J., 1999: Dramatic Learning, Unpublished M.Ed Dissertation, Rhodes University, Grahamstown.

Burt, J., 2005: A Strategy for participatory Water Resource Management in the Kat River Catchment. Unpublished Report to the Water Research Commission. Project No. K5/1496. Institute for Water Research. Rhodes University, Grahamstown.

Burt, J., de Jong, M., Fox, H., Gumede, H., Ntshudu, M., and Vanderford, P., 2005a: Workshop 1: The Construction of the AWARE model for the Kat River Catchment. Unpublished Report to the Water Research Commission. Project no K5/1496. Institute of Water Research. Rhodes University, Grahamstown.

Burt, J., de Jong, M., Fox, H., Gumede, H., Ntshudu, M., and Vanderford, P., 2005b: Workshop 2: The Construction of the AWARE model for the Kat River Catchment. Unpublished Report to the Water Research Commission. Project no K5/1496. Institute of Water Research. Rhodes University, Grahamstown

Castella, J .C., Tran Ngoc Trung, and S., Boissau, 2005: Participatory simulation of land-use changes in the northern mountains of Vietnam: the combined use of an agent-based model, a role-playing game, and a geographic information system. Ecology and Society 10(1): 27.[online] URL:http://www.ecologyandsociety.org/vol10/iss1/art27/.

Commod Research Team, 2004: ComMod : a Companion Modelling Approach, [online] http://www.cirad.fr/ur/index.php/green_en/themes_et_projets_de_recherche/projets_en_cours/add_commod

Constanza, R., Wainger, L., Folke, C., and Maler K-G., 2006: Modelling Complex Ecological Economic Sytems. *Bio Science,* 43(8): 545-555.

Dor, G., Himlin, B., and Ruiters, G., 2002: Eco-social Injustice for working –class communities: The making and unmaking of neoliberal infrastructure policy. Chapter Four in Bond, P (2002), Unsustainable South Africa, Environment, Development and Social Protest. University of Natal Press, Pietermaritzburg. The Merlin Press.

DWAF., 2001: *Fish to Tsitsikamma Water Management Area, Water Resources Situation Assessment*. WMA 15 Report No. P WMA 15000/00/0203. 161 p. + annexes.

Edgren, J., 2005: Water the most critical factor in Citrus Production? A case study of commercial citrus production in Kat River Catchment, South Africa. Unpublished Research Report, Rhodes University, Grahamstown.

Emerson, R.M., 1981: Observational Field work, *Annual Review of Sociology*, 7: 351-378.

Farolfi, S., 2004: Action research for the development of a negotiation support tool towards decentralized water management in South Africa, Working paper n. 04-01. Dpt. Of Agricultural Economics, University of Pretoria.

Farolfi, S., and Abrams, M., 2005: Water uses and their socio-economic impact in the Kat River Catchment: A report based on primary data. Unpublished Water Research Commission Report. Project no K5/1496. University of Pretoria, South Africa.

Farolfi, S., and Bonté , B., 2005: *KatAWARE: A negotiation-support tool for participatory water resource management in the Kat River Catchment: prototype model.* Unpublished report to the WRC, the IWR, Rhodes University, Grahamstown.

Farolfi, S. & Bonté, B. 2006: *KatAWARE: From Prototype to Version 1 : Development of the Model Following the Iterative Process of Companion Modelling.* Unpublished report to the Water Research Commission, the Institute of Water Research. Rhodes University. Grahamstown.

Farolfi, S., and Bonté , B., 2006: *KatAWARE: A negotiation-support tool for participatory water resource management in the Kat River Catchment: version 1*. Unpublished Report, WRC, IWR, Rhodes University, Grahamstown.

Farolfi, S., and Jacobs, J., 2005: Water Availability, requirements, and water-related socio-economic aspects of the Kat River catchment: a survey on secondary data, unpublished report, WRC Project no.K5/1496,34p.

Farolfi, S., and Rowntree, K., 2005: Accompanying Local Participants in Negotiation Processes Related to Water Allocation Through Simulation Models and Role-playing Games: an Experience from South Africa. University of Pretoria-Rhodes University 16p.

Farolfi, S., Hassan, R., Perret, S., and MacKay, H., 2004b: A role-playing game to support multi-stakeholder negotiations related to water allocation in South Africa: First applications and potential developments. University of Pretoria. South Africa.

Fishman, D.B., 1997: Postmodernism comes to program evaluation III: A critical review of Stringer's Action Research: A Handbook for Practitioners. *Evaluation and Program Planning*, 20(2): 231-235.

Fox, H.E., 2005: The role of anthropogenic disturbance in the creation of a socio-ecological landscape. Unpublished MSc thesis, Rhodes University, South Africa.

Fox, H., Burt, J., de Jong, M., Gumede, H., Ntshudu, M., and Vanderford, P., 2005: Workshop 3: The Aware Role-Playing Game in the Kat River Catchment Unpublished Report to the Water Research Commission. Project no K5/1496. Institute of Water Research. Rhodes University, Grahamstown.

Fox, H., Burt, J., Brown H., Gumede, H., and Ntshudu, M., 2006: Workshop 4: The Aware Role-Playing Game in the Kat River Catchment Unpublished Report to the Water Research Commission. Project no K5/1496. Institute of Water Research. Rhodes University, Grahamstown.

Fox, H., Burt, J., Brown H., Gumede, H., and Ntshudu, M., 2007: Workshop 5: The implementation of water allocation strategies based on the KatAWARE model in the Kat River Catchment. Unpublished Report to the Water Research Commission. Project no K5/1496. Institute of Water Research. Rhodes University, Grahamstown.

Funtowicz, S.O., and Ravetz, J.R., 1991: A new scientific methodology for global environmental issues. In: Costanza, R. (Ed.), *Ecological Economics*: The science and Management of Sustainability. Columbia University Press, New York p 137-152.

Funtowicz, S.O., and Ravetz, J.R., 1994: The worth of a songbird: ecological economics as a post-normal science, ELSEVIER. *Ecological Economics*, 10, p197-207.

Janhoff, S., and Weisbord, M., 2006: Future Search as “real-time” action research. *Futures*, 38(6): 716-722.

Jhagoroo, R., Hepburn, T., and Pillay, L., 2000: *SA Explorer*. Version 2.0.
Municipal Demarcation Board. South Africa.

Jones N., Perez P., D'Aquino P., Measham T., Kelly G., Dray A., Ferrand N., Daniell K., submitted: 'Evaluating Participatory Modeling: developing a framework for cross-case analysis', *Environmental Modeling and Assessment.*

Kelly, G., Measham, T., Horsey, B., Leitch, A., and Smith, T., 2005: *Reflections on the Stream: The Theory and Practice of Participatory Research- Lessons from the field.* CSIRO Sustainable Ecosystems, Gungahlin. (251 pages).

Lewin, K., 1946: Action research and minority problems, *Journal of Social Issues,* 2 (4): 34-46.

Lindqvist, K., Timpka, T., and Schelp, L., 1996: Ten years of experience from a participatory community based injury prevention program in Motala, Sweden. *Public Health,* 110 (6):339-346.

List, D., 2006: Action Research cycles for multiple Futures perspectives. *Futures*, 38(6): 642-655.

Liu, M., 1996: Action research and development dynamics, in: Sebillotte (ed.) *System-oriented research in agriculture and rural development*, Cirad, 111-116.

Luks, F., 1999: Post-normal science and the rhetoric of inquiry: deconstructing normal science. *Futures*, 31(7): 705-719.

McCall, M.K., 2003: Seeking good governance in participatory GIS: a review of processes and governance dimensions in applying GIS to participatory spatial planning. *Habitat International*, 27 (4): 549-573.

McMaster, A., 2002: GIS in participatory catchment management: a case study in the Kat River Catchment, Unpublished MSc Thesis, Rhodes University, Grahamstown, Eastern Cape, South Africa.

McMaster, A., Motteux, N., and Rowntree, K., 2001: GIS in participatory research: a case study in the Kat River Catchment, Eastern Cape, Proceedings of the *Fourth Biennial International Conference of the Society of South African Geographers, Goudini Spa, 02-05 July 2001*.

Miller, G., and Dingwall, R., 1997: *Context and method in qualitative research.* SAGE Publications. London, 226pgs.

Mlilo, N., 2005: Research about emerging Citrus Farmers in the Kat River Catchment. Unpublished Research Report, Rhodes University, Grahamstown.

Motteux, N., 1999: Outcomes of a community to establish a water users association, Unpublished report, Kat River Catchment Project, Rhodes University, Grahamstown.

Motteux, N., 2000: Care for the river and the river cares for you: Environmental Awareness Workshops 2000, Kat River Catchment Project, Rhodes University, Grahamstown.

Motteux, N., 2001: *The Development and Co-ordination of Catchment For a through the Empowerment of Rural Communities*. WRC Project report K5/1014: Water Research Commission, Pretoria.

Motteux, N., 2002: Evaluating people-environment relationships : developing appropriate research methodologies for sustainable management and rehabilitation of riverine areas by communities in the Kat River Valley, Eastern Cape Province, South Africa / by Nicole Unpublished PhD Thesis, Rhodes University, Grahamstown.

Motteux, N., and Nel, E.L., 1999: Participatory techniques to elicit a community's environmental knowledge: The Kat River, in van Rensburg, E (Ed)., *Indigenous*

Knowledge in/as Environmental Education Processes, EEASA Monograph No.3, Regional Environmental Education Programme, Howick.

Motteux, N., Binns, T., Nel, E., and Rowntree, R., 1999a: Empowerment for Development: Taking Participatory Rural Appraisal Further in Rural South Africa, *Development in Practice* ,9(3): 261-273.

Motteux, N., Nel, E., Rowntree, K. and Binns, T., 1999b: Exploring Community Enviromental Knowledge Through Participatory Methods in the Kat River Catchment, South Africa, *Community Development Journal,* 34(3): 227-231.

Mujkanovic, A., 2005: Citrus Farmers as Employers in South Africa, a case study of Kat River Catchment in Eastern Cape. Unpublished Research Report, Rhodes University, Grahamstown.

Munda, G., 2004: Social multi-criteria evaluation: Methodological foundations and operational consequences. *European Journal Of Operational Research,* 158 (3): 662-677.

Naidoo, M., 2008: A situational analysis on the public participation process in integrated water resource management in the Kat River Catchment, Eastern Cape, South Africa. Unpublished MSc thesis, Rhodes University, Grahamstown.

Ngqangweni, S., 2000: Promoting income and employment growth in the rural economy of the Eastern Cape through smallholder agriculture, PhD Thesis, University of Pretoria, 191p.+annexes.

Perkins, J.C., and Wessels, J.J., 2004: NWA (Act 36 of 1998) *Taking and storing of water.* DWAF Document. South Africa.

Ramos, J., 2002: Action research as foresight methodology, *Journal of Futures Studies,* 7 (1): 1-24.

Ramos, J.M., 2006: Action Research and Futures Studies. *Futures*, 38(6): 642-655.

Ramos-Martin, J., 2003: Empiricism in ecological economics: a perspective from complex systems theory, in: *Ecological Economics*, 46, p. 387-398.

Ravetz, J. R., 1997: The science of "what – if?" *Futures*, 29(6):533-539.

Ravetz, J., 2004: The post-normal science of precaution. *Futures*, 36(3): 347-357.

Roling, N., 1996: Creating human platforms to manage natural resources: first results of a research program, in: Sebillote (ed.) *System-oriented research in agriculture and rural development*, Cirad, 391-395.

Rovai, A.P., 2004: A constructivist approach to outline college learning. *The internet and higher Education*, 7(2):79-93.

Rowntree, K., 2005: Integrated Catchment Management through LandCare in the Kat Valley, Eastern, Cape Province. Published at Rhodes University, Grahamstown. South Africa.

Rowntree, K., McMaster, A., and Duma, M.F., 2000: Building spatial concepts for community based catchment management: planning for LandCare in the Kat River Catchment, *International Symposium on Contested Resources: Challenges to Governance of Natural Resources in Southern Africa, 18th -20th October*, University of Western Cape.

Scott, S., Miller, F., and Lloyd, K., 2006: Doing Fieldwork in Development Geography: Research Culture and Research Spaces in Vietnam. *Geographical Research*, 44(1):28-40.

Tacconi, L., 1998: Scientific methodology for ecological economics. In: *Ecological Economics*, 27, p. 91-105.

Tognetti, S.S., 1999: Science in a double-bind: Gregory Bateson and the origins of post-normal science. *Futures*, 31(7):689-703.

Van de Kerkhof, M., and Leroy, P., 2000: Recent environmental research in the Netherlands: Towards post-normal science? *Futures*, 32(9-10): 899-911.

Van der Sluijs, J.P., 2002: A way out of the credibility crisis of models used in integrated environmental assessment. *Futures*, 34(2): 133-146.

Walker, B.S., Carpenter, J., Anderies, N., Abel, G.S., Cumming, M., Janssen, L., Lebel, J., Norberg, G., Peterson, D., and R. Pritchard., 2002: Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation Ecology* **6**(1): 14.[online] URL:http://www.consecol.org/vol6/iss1/art14/.

Wolcott, H.F., 2001: Writing up qualitative research 2nd edition. SAGE Publications. *International, Educational and Professional Publisher*. London.

World Bank, 1995: Implementing Geographic Information systems in Environmental Assessment, Environmental Assessment Sourcebook Update, World Bank, 9.

Appendix One

The ADD questionnaire which was designed and administered by myself, Ms Jane Burt, Ms Natalie Jones, Dr Farolfi, and Mr Monde Ntshudu.

KatAWARE Participant Questionnaire (Final Version)

Context Questions

1. Before the model and the RPG were introduced, what was the focus of the WUA? What were the main issues being discussed?

2. What organization(s) were responsible for managing this focus? Were they effective?

3. Why are you participating in the project? What's your motivation to be involved in the KatAWARE project which uses the model and RPG?

4. Who else is involved/participating? Why are they involved/participating?

General Process Questions

5. What were the workshops that used the model and RPG about (generally speaking)? *Probe: What do you remember about the workshops when the model and the RPG were used?*

5.1 Would you like to play the game again in trying to find better ways of understanding your catchment?

5.2 Would you have chosen to play the game if it was not part of working towards a CMP?

Method Questions (use pictures of the model and the RPG)

First, go through these questions (6 to 10) for the model and then repeat (6 to 10) for the RPG. Where the word 'model' is used, substitute with 'RPG' when asking about the RPG?

6. What happened at the workshops where the model was used?

7. What did you like about the modelling workshop? What did you dislike?

8. Was the model useful? How was it useful? Did you apply this to your daily life?

9. How did you interact with different members of the WUA (municipality or DWAF)? Did this change through using the model?

10. Did you learn anything through using the model? Did you learn from the other members of the WUA (municipality or DWAF)?

11. What did you like about the way the modelling workshop was facilitated? What did you dislike?

General Reflection Questions

12. How did the way you think about the issue change from when you used the model to when you used the RPG? *Prompting questions: Did your interactions with the other participants change, did the way you learn or what you learnt change? Did you change your actions in daily life? Explain.*

13. Who do you think should have been involved in the workshops but didn't participate? Why?

13.1. Before you participated in KatAWARE, what was your strategy of planning for access to and use of water?

13.2. What did you consider when making your decisions?

13.3. After participating in KatAWARE, what is your strategy of planning for access to and use of water?

13.4. What would you now consider when making your decisions?

14. How do you think the model could have been improved? How do you think the RPG could have been improved?

15. What's happening next? *Probe: Where is the project at now?*

16. Do you feel that your contribution to the modelling and RPG workshops was valued? *Probes: Did you feel your personal opinions were taken into consideration by the other participants? Do you think your level of involvement/participation had an effect on the way the modelling and RPG workshops developed? Check we know what they mean when they talk about their contribution.*

Appendix Two

This questionnaire was designed by Dr Farolfi and was used to collect primary data, which was used as additional information to secondary data. The survey was conducted by myself and a Martha (a Belgian research student) on water use practices that occur in the Kat River Catchment involving the domestic water users, small irrigation schemes and large-scale farmers.

Questionnaire

Smallholders Irrigation Schemes

This study is undertaken to make an economic evaluation of water as an input to the production process.

The results of this study will be used as input to a broader study undertaken by the Kat River Catchment team of researchers led by Rhodes University.

Important Notice Regarding Confidentiality

The information collected during the survey will be treated as confidential and will only be used for the purpose of the study. The results of the study will be published in terms of industry data – no information regarding particular respondents will be revealed. Final results will be presented to interested respondents for their approval prior to publication.

Should you have any queries regarding this or any aspect of the survey, please contact:

Dr Stefano Farolfi

Tel (012) 420 4659

Email: sfarolfi@postino.up.ac.za

Your input is a very useful tool in ascertaining accurate information on the critical issues of water use in the sub-basin and your co-operation, time and effort is highly appreciated.

Section 1: General information on the irrigation scheme

Name of irrigation scheme: _____

Start of Farming Activities _____/ _____/ _____

Contact Person _____

Position _____

Contact Numbers Tel: _____

How many farmers hold land in this Irrigation scheme?

How many hectares/farmer?

Is this scheme financed or co-financed by a community project?

If yes, which production inputs are financed?

Section 2: Use of Inputs

Land

Title/Ownership ❒ Private Ownership ❒ Owned by Company ❒ Owned by Trust
❒ Other: _____

Total Size of Land_____ha

Plot #	Area (ha)	Crops
1		
2		
3		
4		
5		
6		
…		

Is any land used for livestock production?

❒ No
❒ Yes -

	Cattle	Sheep	Pigs
Area (ha)			
Number of Heads			

Is the amount of land sufficient for the agricultural production outlined above?

❒ Yes
❒ No -What have you done to address the issue of land constraint?

_____
_____

Labour

Total Wage Bill (R/yr) _____

Please indicate the number of farmers busy over a year for each of the following farming activities in the irrigation scheme, as well as the number of days worked:

Activity	# of farmers			# of days		
Crop #	1	2	3	1	2	3
Land Preparation						
Planting						
Irrigation						
Weeding						
Fertilizer Application						
Post Harvest						
Livestock Tending						
Other (specify)…						

Capital

Please indicate in the table below the different items used during production:

Type of Capital Input	Size or Quantity*	Purchase Date	Purchase Value (R)	Expected Replacement Date
Buildings / Construction				
Equipment / Tools				

Intermediate Inputs (Operational Costs) for a year

Type of Intermediate Input		Quantity Purchased*	Price per Unit	Purchase Value
Fuel	- Diesel			R
	- Petrol			
	-			
Fertiliser	-			
	-			
	-			
	-			
Seed/Seedlings	-			
	-			
	-			
	-			
Pesticides	-			
	-			
	-			
	-			
Herbicides	-			
	-			
Other Inputs				

**** Please indicate units***

Water

Source of Water ❒ Municipal Supply
❒ River
❒ Borehole
❒ Other: _____

Quantity Extracted (m^3/yr) _____

Price (R/m^3) _____

Cost of transferring water from source to site (electricity) (R/yr) _____

How much water do you require for your operations? _____ m^3/yr

Please provide the following information regarding water use:

Crop	Area (ha)	Irrigation Period	Dates	# of Times per Week	m^3 Used per Session
1.		1st			
		2nd			
		3rd			
2		1st			
		2nd			
		3rd			
3		1st			
		2nd			
		3rd			

What is your opinion about the availability of water in the sub-basin?

❒ Absolute constraint ❒ Relative constraint ❒ Just enough ❒ Relative abundance ❒ Absolute abundance

Section 3: Output

Crop	Quantity*				Selling Price (R/ton)
	Produced	Consumed	Reserved for next season	Sold	

**** Please indicate units***

Livestock Production	Quantity*		Selling Price*
	Produced	Sold	
Cattle - Beef			

**** Please indicate units***

Thank You!

For Administrative Use		
Sub-Quaternary:	*Interviewer:*	*Date:*