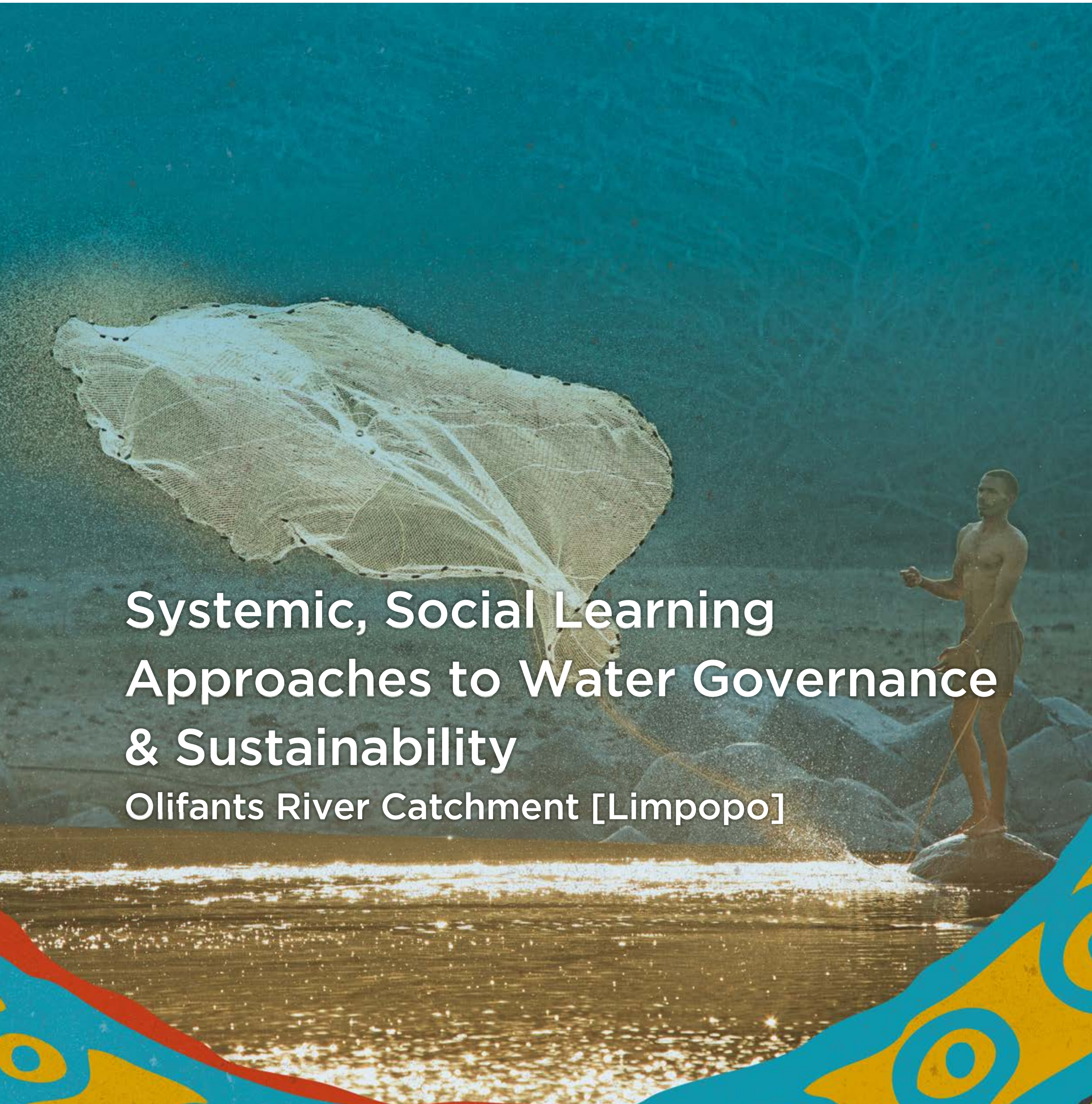

Systemic, Social Learning Approaches to Water Governance & Sustainability

Olifants River Catchment [Limpopo]

award

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USAID: RESILIENCE IN THE LIMPOPO BASIN PROGRAM (RESILIM) – OLIFANTS

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Authors

Sharon Pollard, Hugo Retief & Jai Clifford-Holmes

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Association for Water and Rural Development (AWARD)

P O Box 1919

Hoedspruit 1380

Limpopo, South Africa

T 015-793 0503

W award.org.za

Company Reg. No. 98/03011/08

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1 The Olifants Catchment: The broader context

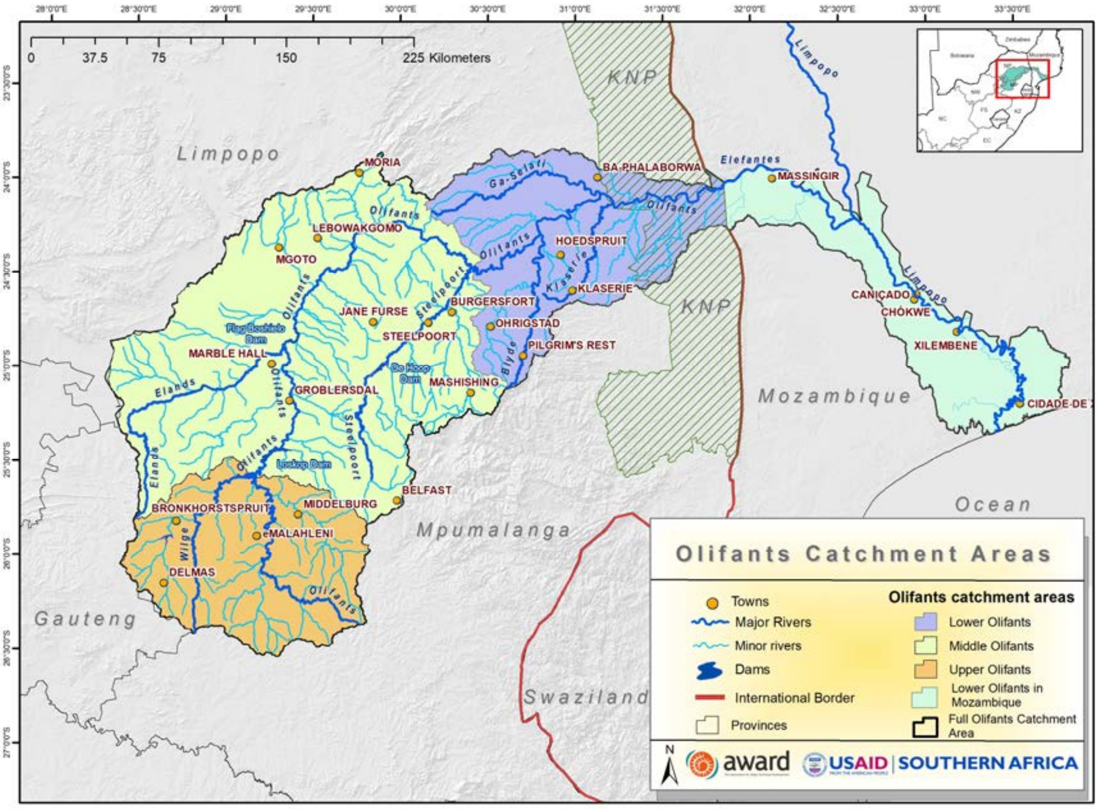


Figure 1: Map of the Olifants River Catchment showing the upper, middle and lower regions of the catchment and the lower Limpopo Basin after the confluence between the Olifants and Limpopo

The Olifants River Catchment falls within the Limpopo River Basin, which is part of an international drainage basin that stretches across South Africa, Mozambique, Zimbabwe and Botswana. The Olifants River contributes nearly 40% of the water that flows in the Limpopo River making it important for the basin as a whole. Currently, the Olifants River is the only tributary that sustains flows of the Limpopo River in the dry season.

The Olifants River is a vital artery that flows for 560 km through South Africa and into Mozambique, where it is known as the Rio dos Elefantes. This mighty river originates in South Africa's Highveld, traversing three provinces (Gauteng, Mpumalanga and Limpopo) before flowing through the iconic Kruger National Park and into Mozambique before reaching the Indian Ocean near Xai Xai, just north of Maputo. The Olifants Catchment occupies an area just short of 55 000 square kilometres and is home to about 3.5 million people in South Africa and 0.7 million people in Mozambique.

From both an aquatic and terrestrial perspective, the Olifants Catchment is a rich and diverse landscape. It is home to areas of endemism and high biodiversity. Declining water quality and decreased flows threaten aquatic systems along the entire Olifants River within South Africa and to the Xai Xai estuary in Mozambique. Intact river systems are limited to the Blyde and some tributaries of the Steelpoort and the lower Olifants. In Mozambique, the estuarine area is a *National Maritime Ecosystem Priority* area.

Unchecked pollution, inappropriate land and resource use, poor enforcement of regulations and poor protection of habitats and biodiversity impact on the livelihoods of all the catchment's residents.

2 The RESILIM-Olifants program & water governance

In 2012, AWARD secured a seven-year USAID grant to build resilience in the Olifants Catchment. The overarching aim of this program, known as RESILIM-O (or Resilience in the Limpopo - Olifants Catchment) is as follows:

RESILIM-Olifants Goal

To reduce vulnerability to environmental (climate) change through building improved transboundary water and biodiversity governance and management of the Olifants Basin through the adoption of science-based strategies that enhance the resilience of its people and ecosystems through systemic and social learning approaches.

Further details of the RESILIM-O program are given elsewhere (*see www.award.org.za*). Of the seven key result areas adopted, a central one was **Water governance** and **Enhanced water security and water resources protection under (climate) change.** The overall objective of this focus was to secure enhanced long-term water security and protection by supporting collective action, informed adaptation strategies and practices and tenable institutional arrangements for transboundary **Integrated Water Resources Management (IWRM).**

Purpose of the brochure

This brochure provides an overview of the approach used and the outcomes of AWARD's efforts to build resilience in support of improved water governance in the Olifants River Catchment, based on a re-orientation of praxis towards a systemic, social learning approach. We build on earlier work in the Lowveld which introduced an alternative systemic context-based framework for planning, research and decision-making (Pollard et al. 2014).

We provide an overview of the foundational theories and a description of how these shaped implementation in our work. We discuss some of the successes and challenges and, some seven years on, the emergence of new vulnerabilities and potential points of leverage. A highlight was successfully maintaining flows during the most extreme drought on record, which continued through to late 2019.
(see Resource 1: Keeping the Olifants River flowing).

Governance & Management

Governance is a socio-political process to manage the relationships between people and rules and norms. Good governance refers to the structures and processes that are designed to ensure accountability, transparency, responsiveness, rule of law, stability, equity and inclusiveness, empowerment, and broad-based participation.

Often there is a tendency to conflate governance with management. However, the latter primarily refers to the planning, implementation and monitoring functions in order to achieve pre-defined results to reduce vulnerability to environmental (climate) change through building improved transboundary water and biodiversity governance and management of the Olifants Basin through the adoption of science-based strategies that enhance the resilience of its people and ecosystems through systemic and social learning approaches.

The document is intended for water resource practitioners and managers as well as those interested in the theories and practice – or praxis – of systems and social learning approaches. It is, in part, a guideline insofar as it documents what was done without providing detailed steps. The intention rather, is to illustrate the possibilities offered by a different way of thinking; one that recognises interrelationships and uncertainty and sees people as part of governing water.

3 Vulnerability & water security in the Olifants Catchment

Despite 'normal' rainfall, the lower Olifants River ceased flowing for over 33 days in 2005, prompting widespread concern and calls for an integrated focus on all of the easterly-flowing rivers of the Lowveld of South Africa. These impacts spread into Mozambique where flows also ceased for an extended 78-day period. At the same time, declining water quality in the upper reaches raised concerns about the viability of the Olifants River to produce clean water for human consumption as well as riverine health downstream (see Ashton & Dabrowski 2011; Dabrowski et al. 2013; 2014). Further studies in the lower Olifants, including Mozambique, pointed to serious toxicity loads and the potential connections between mining in the upper reaches and downstream water quality *(see http://www.ehrn.co.za/lowerolifants/project/index.php)*. Fish kills and crocodile deaths in 2010 also pointed to major water quality problems.

Turning to water balance (availability versus demand), it was also clear that many of the sub-catchments were closed or reaching closure, meaning they had run out of water (Figure 2). In fact, these data underestimate water use and so the picture is potentially worse *(see Resource 1: Keeping the Olifants River flowing)*.

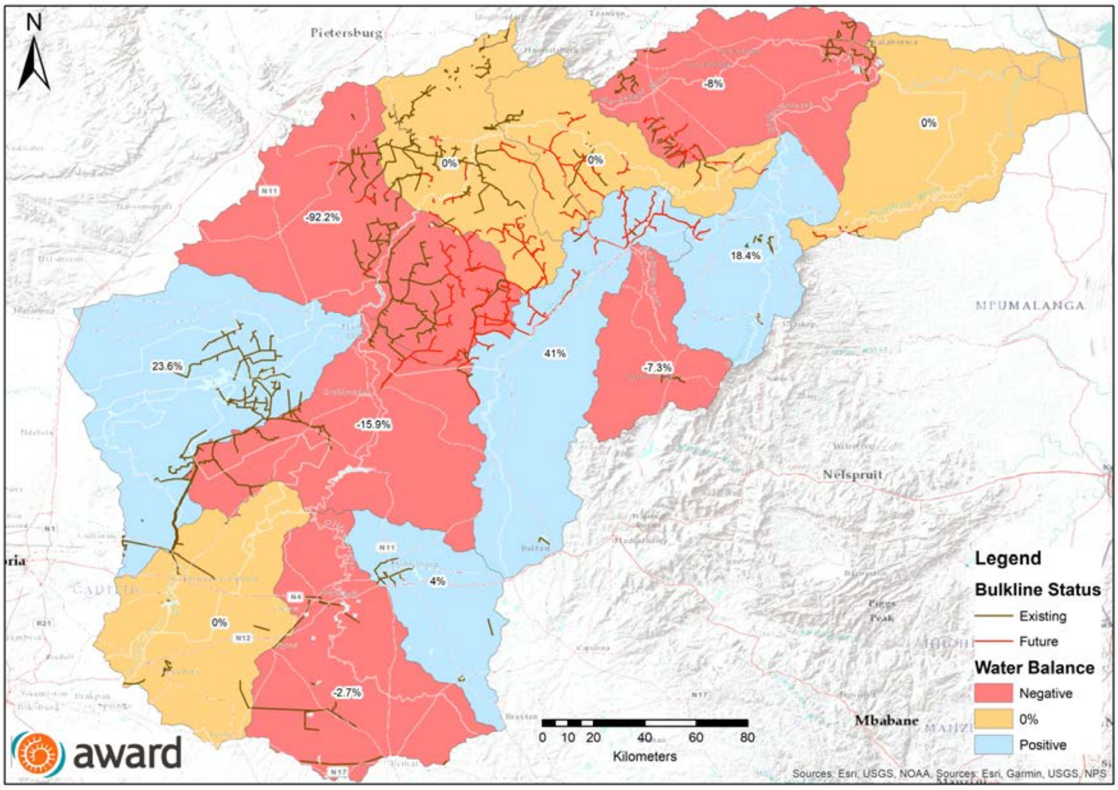


Figure 2: Water balance in the South African portion of the ORC. Note that this is based on data that needs updating

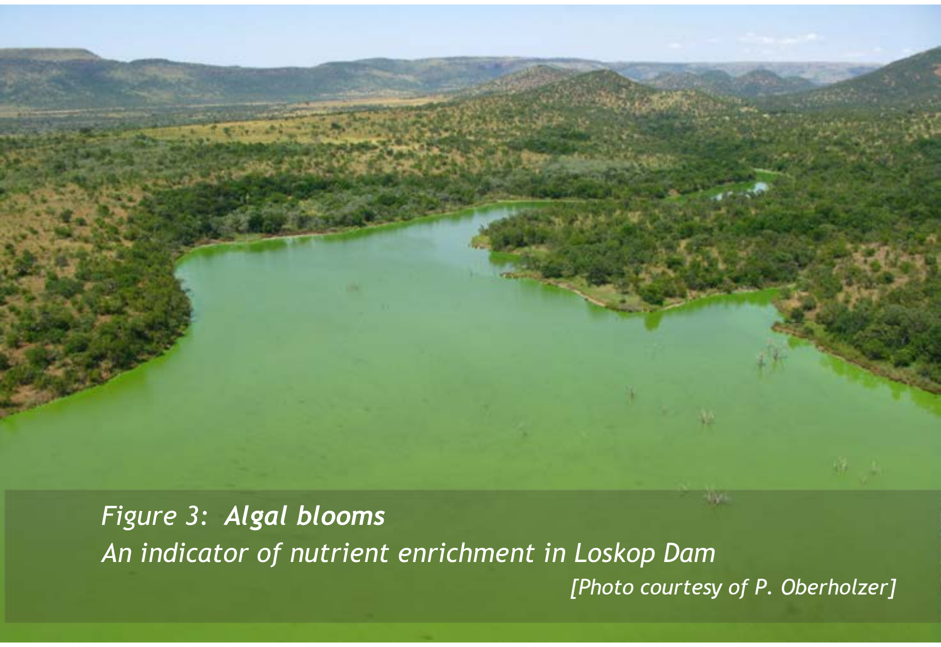


Figure 3: ***Algal blooms***
An indicator of nutrient enrichment in Loskop Dam
[Photo courtesy of P. Oberholzer]

Figure 4a & 4b:
Fish kills & warnings

Despite the enabling legislative framework for water reform in South Africa since 1998, and the requirements for compliance with the Reserve (or Environmental Water Requirements), the regular non-compliance also pointed to increasing vulnerability (Pollard and du Toit 2011; Pollard & Riddell 2011). The inability to maintain a healthy river system severely compromises the ability to deliver goods and service to biota and people in the catchment and beyond *(see Resource 1: Keeping the Olifants River flowing).*

In international terms, the state of the Olifants catchment is a particular concern given that it is the largest contributor of flow to the transboundary Limpopo Basin. Indeed the lower Limpopo floodplain and estuary is maintained mainly through flows from the Olifants River into Massingir Dam.

All-in-all the picture was one of a catchment in crisis. The integrity of most rivers in this catchment appeared to be continuing to degrade both in terms of quality and quantity as a result of a complex interaction of factors in different parts of the catchment and along the length of the river. Key drivers included a rapid growth in mining, irrigated agriculture and various industries, coupled with weak governance, regulation and enforcement which, when combined with the threat of climate change, rural poverty and food insecurity particularly in Mozambique, threatened to cause widespread livelihood vulnerability, environmental degradation and intensifying conflict over resources.

A Systemic, Social Learning Lens to Addressing Vulnerability: Sustainability of the Source

Given the programmatic goal, AWARD focused efforts on water resources protection. It goes without saying that water is a basic necessity in people's livelihoods and well-being and the foundation for this is healthy water resources. Thus securing the 'Reserve' (comprising water for both basic human needs and the environment) was key for ensuring a viable and sustainable catchment now and into the future.

However, we also adopted a fundamentally different approach, namely that of systemic, social learning for integrated water resources management (IWRM). We also noted that without a viable governance system, achieving water resources protection within IWRM will not be possible.

4 Working in complex & uncertain situations: Building resilience for IWRM & water governance

Some Key Frameworks of a Systemic, Social Learning Approach

- Complexity
- Systems thinking
- Socio-ecological systems or SES
- Resilience
- Expansive learning
- Social learning
- Activity systems & systems practices
- Communities of practice
- Strategic adaptive planning & management
- Adaptive capacity

In this section we provide an overview of important theoretical frameworks, and then show how these were used in practice in the RESILIM-O program in the following section. Given the focus on water resources governance and the central role of systemic, social learning, we emphasise these two 'frameworks' and associated ideas. This section therefore acts as a reference resource for IWRM practitioners.

4.1 How do we work in complex, dynamic & uncertain situations?

When RESILIM-O started in 2012, no-one would have predicted or planned for the dis-establishment of Catchment Management Agencies and Water User Associations, both foundations for the decentralisation of water governance. The knock-on effects were enormous, with many unintended consequences.

Over the years it has become apparent that natural resource management – and especially water resource management – is complex and beset by uncertainty and surprise. The technicist 'hydraulic mission' of the 1960s and 70s, where dams and infrastructure were seen as 'the solution', is no longer tenable in a rapidly changing world. Indeed, these linear approaches, based on a simplistic paradigm of 'cause and effect' have failed to deliver long-term sustainability (see Ison, 2014 for example). This is because as socio-political, economic and environmental factors come into play – especially in a more connected and water scarce world - solutions are often more complex than technical responses can deliver.

The emergence of systems thinking and complexity theory to address these shortfalls has also suggested that conventional thinking for resource and environmental management may have *contributed to problems* instead of providing solutions (Holling and Meffe, 1996). As Donella Meadows (1999) pointed out, taking a systems approach also provides an opportunity to surface "places to intervene" in a system - places where the most leverage may be gained because of the relationships to other parts in the system.

The rationale therefore guiding RESILIM-O is that managing water resources is complex and dynamic and requires different ways of thinking and practicing.

Accepting complexity means acknowledging that, despite the best plans in the world, the outcomes of actions are not entirely predictable; they cannot be known with absolute certainty. In other words, working towards integrated, sustainable water resources management does not work like a car engine, which is complicated but generally predictable. A huge drought, a change in policy or the expectations of stakeholders, or social unrest can lead to unanticipated consequences that need to be managed differently to other years. Any natural resources management or governance regime has to be able to work with this uncertainty which may cascade through the 'system' (the catchment), often in unexpected ways. Thus, the way we manage such systems must take this into account and adopt an approach that allows us to monitor, learn and adjust our strategies and actions over time.

For this reason we take a strongly **systemic, social learning approach** to the praxis of water governance and IWRM. We discuss frameworks that are applicable to supporting IWRM in this way.

We also share our experiences in using such frameworks in the Olifants to:

- Offer potential heuristics for framing water governance support;
- Share ways of designing support as a process,

A Catchment as a Socio-Ecological System

Once we recognise the complexity of socio-political, economic, technical and political factors in water governance and IWRM, we can recognise the catchment as a socio-ecological systems or SES (Holling, 1987), rather than simply a 'biophysical system' as it is normatively defined.

This integrative theory has been further developed through the closely related concept of resilience which broadly refers to the capacity of a system to absorb disturbance and re-organize so as to retain essentially the same function, structure and feedbacks (see Berkes et al. 2003). Indeed, the Resilience Alliance (www.resalliance.org) has popularized the handling of complexity through the exploration of resilience based on the central tenet that since variation absorbs shocks and confers resilience it should be embraced - not ignored. Further, a focus on resilience shifts attention from growth and efficiency to recovery and flexibility.

4.1.1 Systems thinking for complex situations: reframing a catchment as an SES

By adopting a systems-thinking approach, we adopt a holistic worldview that emphasises interrelationships rather than parts, and patterns over time, rather than static components (Meadows, 2011). If we apply systems thinking to water governance of a catchment or basin, we shift from a focus on isolated situations such as non-compliance in one area, to **management of a system** made up of interacting parts sitting in the biophysical, social, economic and political spheres of the setting.

Feedback & Emergence

- A reinforcing loop is one in which an action produces "more of the same" resulting in growth or decline (for example, bank balance and interest).
- A balancing loop attempts to move some current state (the way things are) to a desired state (goal or objective) though some action. For example, when the internal temperature of your body increases, sweat and evaporation cool you thereby balancing the initial increase.
- Emergent properties account for surprise and innovation, meaning properties or behaviours emerge only when the parts interact in a wider whole. Neither hydrogen atoms nor oxygen atoms in isolation possess the solvent properties of water; a bicycle and a rider on their own do not produce motion.

Indeed, a catchment (and neighbouring catchments) can be thought of as a socio-ecological 'system'. It is influenced by multiple 'external' factors, or drivers, such as socio-economic, technical or political factors and equally, it influences the surrounding area and beyond. That is, it is embedded in a broader socio-political, technical and political landscape and relationships between the biophysical and social environment evolve over time. We call this a coupled socio-ecological system or SES (see Figure 5). This 'integrative' framework helps us to think about the nature and quality of relationships, and various other characteristics such as interdependence, holism and emergence, goal-seeking behaviour, feedbacks and regulation, hierarchy, differentiation, equifinality (alternative ways of attaining the same objectives - convergence) and multifinality (attaining alternative objectives from the same inputs - divergence). These concepts are reviewed by various authors (see for example Cilliers 2000). Probably the most important in this context are emergence and feedbacks.

Over and above linkages, a fairly unique aspect of catchments relates to the unidirectional flow of water, such that problems originating at one point in the catchment are transported downstream. This means that people from many different contexts need to be able to act together in order to address the concerns of the catchment as a whole.

Box 1: Key Ideas for Co-Managing a Catchment's Water Resources

- Water resources management is embedded in a socio-ecological and governance system (SES);
- IWRM is a practice and ongoing process, not an end in itself;
- Systems thinking is therefore an important framework for the collaborative management and governance of catchments as complex socio-ecological systems;
- We can build resilience in complex, dynamic socio-ecological systems through:
  - Social learning and expansive learning
  - Systems thinking
  - Strategic Adaptive Management.

One of the most important lessons from systems thinking is that management processes can be improved by developing a **practice that is adaptable and flexible**, able to deal with uncertainty and which builds the capacity to adapt to change (Berkes et al., 2003). Therefore, systems thinking can be used to bridge social and biophysical sciences to understand, for example, climate change, culture, history and the effects of human action on natural resources well-being.

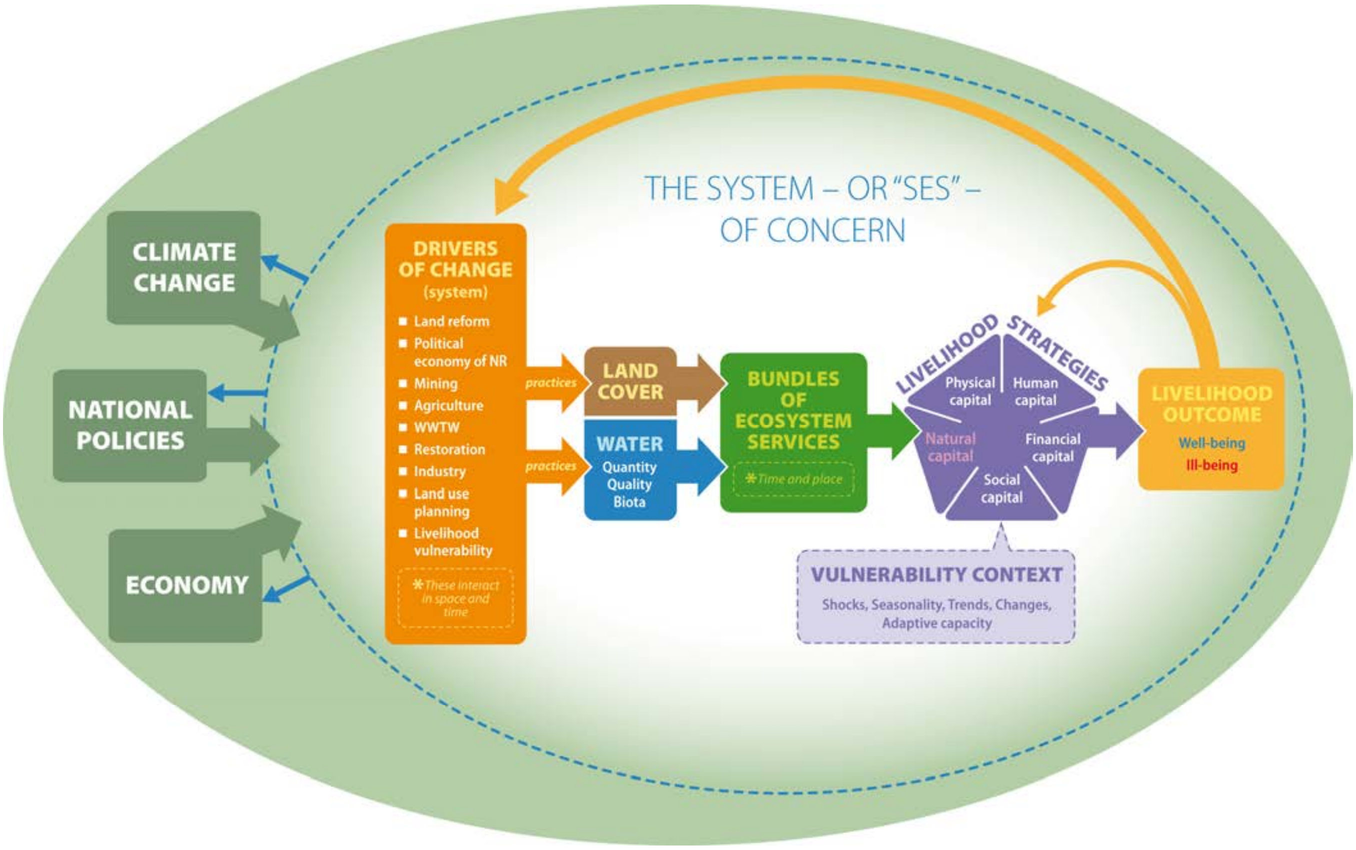


Figure 5: A schematic of the Olifants Catchment as a SES

There has been some criticism that the SES framework simplifies some of the social dynamics (see for example Cote & Nightingale 2012). We suggested that insufficient attention was paid to learning and the nature of learning. For this reason, we focused on additional theories regarding learning, governance and collaborative practices.

4.1.2 Expansive learning

Many of the processes and tools we used form part of an ***expansive learning process*** (Figure 6). Engeström (1987) refers to this is the collective mastery of societal problems (e.g. co-management of water resources) which is achieved by resolving systemic challenges to the practice (or set of integrated practices) in question. Since learning literally happens 'along the way' as new practices are co-created, the process cannot be designed from the start as a blueprint. This does not mean the process is chaotic, indeed there are seven generally recognised steps, but as for systems theory, we must learn as we go along, accept this, be prepared for a certain degree of uncertainty and change and be able to adapt.

Various tools are available to support expansive learning such as "activity systems" and "CHAT" to which we have added others, described below. Indeed, in supporting IWRM in the Olifants, we also relied on learning tools drawn from the systems thinking tradition (activity system analysis, causal loop diagrams, concept maps and modelling) and activities such as biomonitoring of rivers as pedagogic devices to deepen a co-analysis as part an expansive learning process.

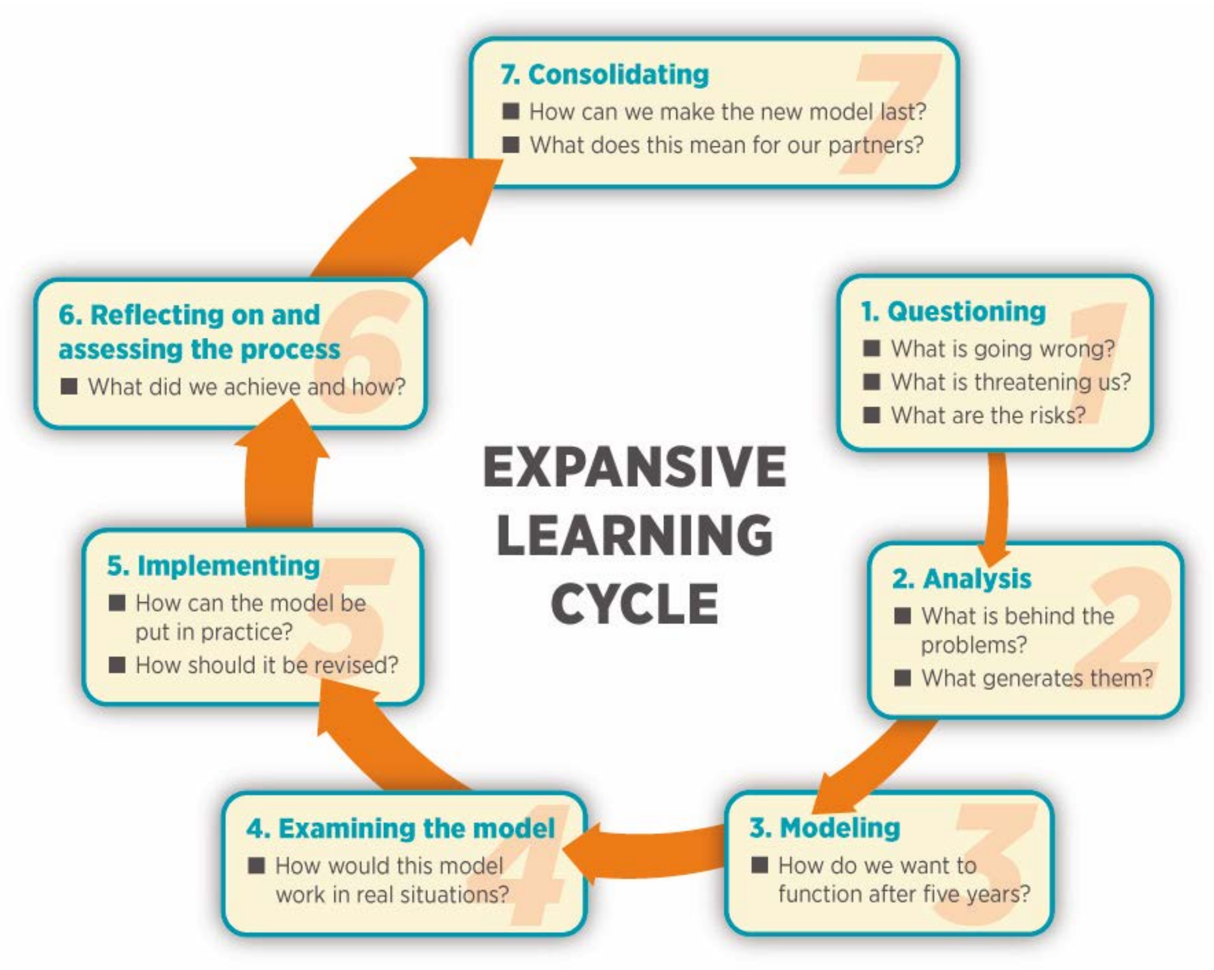


Figure 6: Expansive learning spiral showing specific learning actions

4.1.2.1 Social learning & communities of practice

IWRM takes place within a strongly developmental space and so the theories of participation, livelihood support, action-research and action-learning all have bearing. However, for the purposes of this guide we assume that the practitioner or facilitator is well-versed with these. Nonetheless we emphasise that whoever facilitates the process has knowledge and experience of the 'development sector' and capacity development. We turn now to theories of learning that may be less familiar to many.

For many of us, the concept of learning refers to what an individual does, and conjures up images of classrooms or training sessions. Yet learning is an integral part of our everyday lives and is part of our participation in our communities and organizations (Wenger 2009). In IWRM, both government and stakeholders (mainly water-users in a catchment) are embarking on a collaborative learning journey of managing water – in essence forming a *community of practice*. An example may be a catchment management forum where together participants are co-learning about an area of a catchment. This community of practice can be viewed as a *social learning system*.

Attention to how learning happens and how we can support learning that enables growth and progress is foundational. None of the parties know exactly what to do to effect good governance: they need to co-construct an understanding of what it means to co-manage water; that is to make new meaning of the concept by practicing, learning and adapting. A practice is something that is produced over time by those who engage in it.

Thus we emphasise support for a social learning process in a safe space. But what is social learning? Social learning is not just learning in a social context. This would make any interaction a learning process. What distinguishes social learning from other forms of learning is that the aim is to transform and change practice. Social learning is defined as a change in understanding that goes beyond the individual and spreads throughout communities or groups through social interactions between people (Reed and others 2010). Ison describes social learning as a process of stakeholder learning together through which their "understanding and practices change, leading to transformation of the situation through collective and concerted action."

Arjen Wals (2007) suggests important 'stages' in the process of social learning where one:

- critically analyses one's own beliefs, norms and values and those of others (confrontation)
- deconstructs them to better understand their roots and impacts (deconstruction)
- makes new collective meanings (reconstruction)

The term learning is taken in this case, in a very broad sense, to include new understandings, identity development, change of practices, institutional development and agency building. This includes developing trust, a collective identity (both of which are key attributes for ensuring collective action) and the ability to self-organise and self-regulate.

4.2 Processes & tools to support systemic social learning

In this section we look at the tools and processes that have emerged to support systemic social learning. We illustrate their use later in the document.

4.2.1 Strategic adaptive planning & management in uncertain environments

SAM & Adaptive Planning Cycles

SAM is a fundamentally stakeholder-centred management approach that facilitates the iterative development of a shared vision, rationalities and future-focused objectives, as the basis for adaptive cycles of consensual decision-making. Since values bound decision-making and a shared rationality leads to consensus, both explicitly underlie the SAM process (Figure 5).

As an overaching framework, we outline the process and use of Strategic Adaptive Management or SAM, which is well-described elsewhere (Biggs & Rogers 2003; Pollard & du Toit 2007).

Given the complex and often uncertain nature of IWRM, a management framework is needed that not only copes with but actively embraces learning, reflection and change over time. *Strategic Adaptive Planning and Management* is one such framework that is now widely used by SANParks and others for the management of highly variable environments such as rivers and fire-prone landscapes.

"Adaptive management" was first introduced to natural resource management by Holling (1978) with his concept of "Adaptive Resource Management". The practice of adaptive management (see Figure 5) morphed into many forms with Strategic Adaptive Management (Rogers and Bestbier, 1997) being one of them. SAM was developed by a group of South African scientists and natural resource managers in the late 1990s, with recognition of the limitations of "classic" forms of adaptive management.

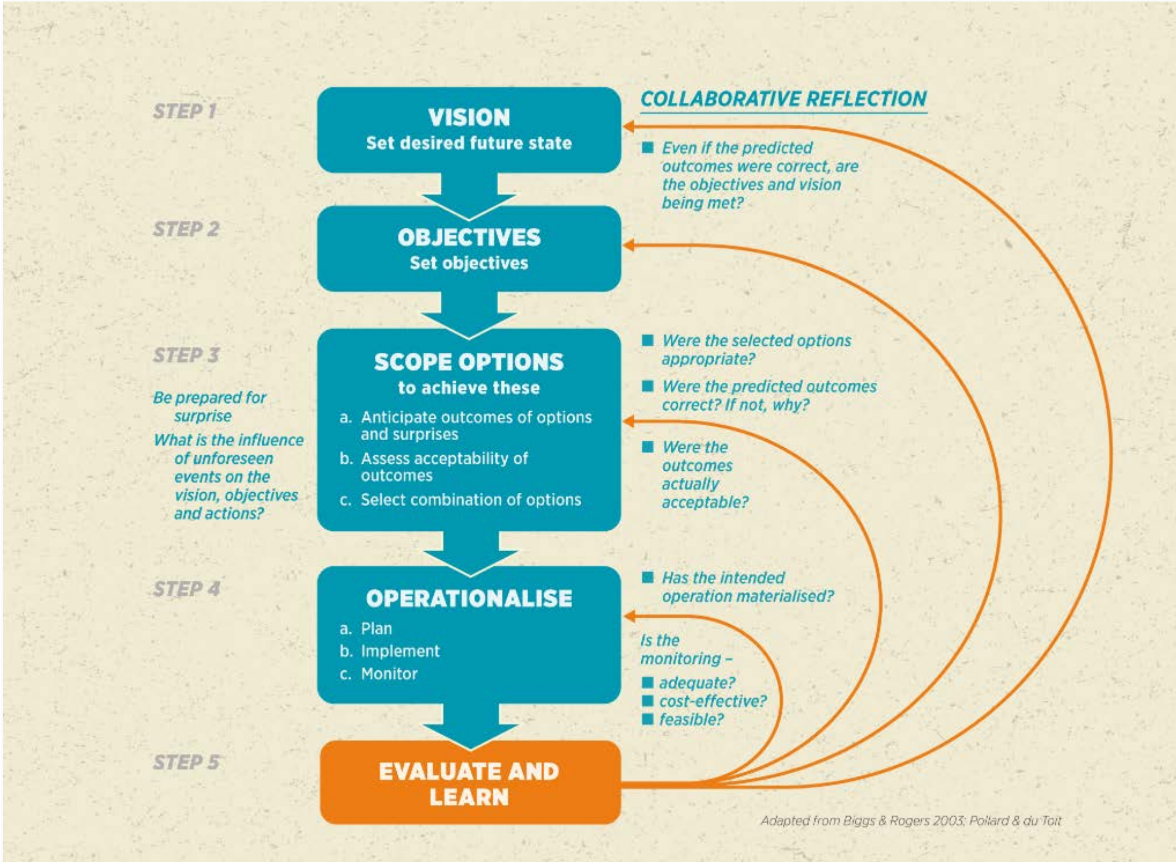


Figure 7: A framework for SAM indicating key steps

SAM is goal-oriented with a focus on a shared vision that emerges out of an understanding of context. Importantly, there is the recognition that *goals shift over time*, and that the *pathway to them is invariably tortuous*. This means that one may get there by different means than originally planned. *This does not mean that the process is ad hoc and unplanned;* rather it allows space for stopping, collaboratively learning and re-designing the path. In terms of our learning theory this is very important. SAM typically produces an "objectives hierarchy" that links strategic goals to operational goals and cascades to benchmarks or indicators. This means one can track a benchmark back to strategic goals and to context. The learning process is facilitated through periodic reflections at each level of the hierarchy as shown in Figure 7.

4.2.2 Systemic approaches to understanding context in an expansive learning process

"It doesn't matter if you classify a driver as ecological or technical; what matters is that you're thinking broadly and noting the many influences at work in an area."
Dr Harry Biggs

Systems theory and the use of an SES framework encourage practitioners to take a broad view of context, recognising that water governance and management take place within a broader socio-political, technical and environmental context. This acknowledges that multiple drivers can influence and shape water, and these need to be taken into account as the practice of IWRM unfolds (See Figure 3). It is important to do so collaboratively because as individuals we may hold a particular perspective that can be broadened by engaging and learning from others. Various tools and processes have been developed or adopted from the field of systems thinking and SAM to support a systemic, social learning approach.

Under the RESILIM-Olifants program, we have complemented these with tools and processes that have emerged from expansive learning and social learning theory. We tested many of these tools and processes and share those that we have used successfully. Nonetheless it is worth noting that there are many more that practitioners are encouraged to explore, particularly those that fall under the rubric of soft-systems methodology (Ison 2010).

In order to plan systemically to support water resources management, understanding the catchment is essential. This sounds fairly obvious but is often very poorly done in that it is limited to a desk-top review of the literature. This forecloses two important opportunities:

- To discover & include other information not captured in reports
- To design the process as a learning one where stakeholders collaboratively learn about the catchment they live in or have a stake in

Understanding context will be an ongoing process, but in engaging stakeholders, the collaborative use of maps, timelines, and SES profiling (using the "V-STEEP" tool and concept maps or causal loop diagrams) may be useful in the following ways:

- A joint exploration of the area using maps enables people to think about the biophysical and social context very broadly;
- A timeline helps people to think about the key historical events or drivers that may have shaped what we see today;
- The V-STEEP process is a participatory device to support people to describe the context and characteristics of the catchment from different perspectives *(See Box 2);*
- Concept maps or causal loop diagrams are systemic tools to explore the inter-connected relationships of these drivers and characteristics. For example, 'poaching' may be the result of multiple factors (not just poverty) that need to be understood if one is to design a strategy to tackle it.

Box 2:
Scoping the Context as the Basis for Visioning

An important principle for developing a meaningful vision for a catchment management or IWRM, is that stakeholders need to understand the context from as holistic a perspective as possible, otherwise there is a danger of the vision being unrealistic and unattainable (Pollard & du Toit 2007). A useful framework is known as V-STEEP, which provides the prompts to examine different issues. It has a history of successful usage in Strategic Adaptive Management and was used for a decade and a half by AWARD, SANParks and others, particularly in the Lowveld area. It can be run by any experienced facilitator.

V-STEEP processes are designed to be part of ongoing engagement and not simply a once-off extractive exercise. The way in which stakeholders are engaged is central; promoting co-learning is of crucial importance. The approach is powerful because it brings people with various profiles, backgrounds, and interests together and enables them to start thinking about their context, while at the same time revealing its complexity. Stakeholders and residents are invited to participate in telling a story about the catchment; hence the process develops an understanding of what residents regard as important - the main issues and concerns in a region.

The V-STEEP framework is simply a way to remind us to describe the context and characteristics of the catchment from multiple perspectives: Values, Social, Technical, Environmental, Economic and Political (This does not refer to political parties but rather issues of governance and policy).

An example question that the facilitator may ask for each thematic area is: "As informed by our various views, what are the main social characteristics, factors, and drivers in the catchment and surrounds?". Importantly, values are done last as this often requires more time to explain. The facilitator should explain that we are trying to capture the societal values that shape (or have shaped) the area. For example, the need to address past injustices may be a key value (restitution), or water conservation and protection may be another.

4.3 Looking at practices or shared activities

At the core of IWRM is a set of practices or activities: stakeholder engagement, water reconciliation, water allocation, water use licencing, compliance monitoring and enforcement, and so on. Practices mediate the relationship between ourselves and water. A certain set of practices can render a resource sustainable or unsustainable even in similar contexts. For example, even in water scarce environments, how water is allocated (the practice of water allocation) can either ensure sustainability or throw the system into danger and risk of overuse.

Practices can be overwhelming to conceptualise, analyse and support in an integrated way, so we drew on a number of systemic, expansive learning tools to do so. We developed and used the following:

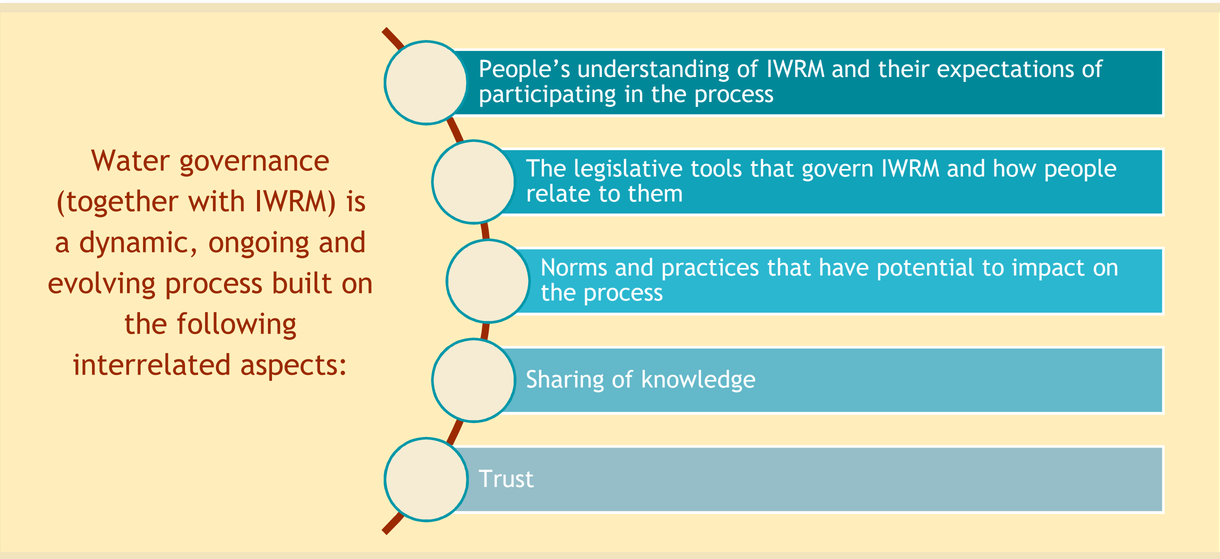
- A conceptual systemic model of the practice or practices
- Activity theory or Cultural-Historical Activity Theory (CHAT).
- Visual, dynamic models of certain issues of concern

4.3.1 Models for exploring bundles of practices

From our work on non-compliance with the Reserve (or Environmental Water Requirements) it was clear that failures could be traced back to multiple drivers and factors. Using systems theory and associated tools, we devised a conceptualisation of 'bundles of practices" as a starting point. We used concept maps and, in some cases, CLDs to explore multiple activities that contribute to compliance with the Reserve.

4.3.2 Models for exploring activity systems

In some theoretical frameworks, practices are seen as part of an *activity system (See Box 3)*. IWRM can be thought of as an activity system made up of many interacting sub-systems, for example, water resource planning at a national scale and water allocation at a sub-catchment scale. We can systemically explore what is needed to effect a certain practice and outcomes such as 'implementation of the Reserve'. Understanding activity systems, and multiple interacting activity systems is a key component of surfacing tensions and inconsistencies.



Box 3:
Activity Theory

Activity theory emphasizes that human activity is mediated by tools in a broad sense. Tools are created and transformed during the development of the activity itself and carry with them a particular culture from their development. The unit of analysis is an activity directed at an object (goal). This Includes cultural and technical mediation of human activity, and 'artifacts' in use (tools, documents). Constituents of activity are not fixed but can dynamically change. *(Engeström, 1999)*

Readers are referred to *CHAT Brochure (www.award.org.za)* for a detailed description of the CHAT methodology. In essence, a first-generation CHAT allows us to analyse relationships between human actions and the tools (e.g. a catchment management strategy). It entails collaborative learning and seeks to address new and emerging problems, create new knowledge and build institutional resilience. The 2nd generation CHAT (see Figure 8) adds questions about who does what, and how (e.g. water resources protection or water allocation). A 3rd generation CHAT process allows us to collaboratively learn about multiple interacting activity systems focused on a partially shared object (e.g. "implementation of the Reserve"), and the boundary-crossings between them (Engeström, 1999).

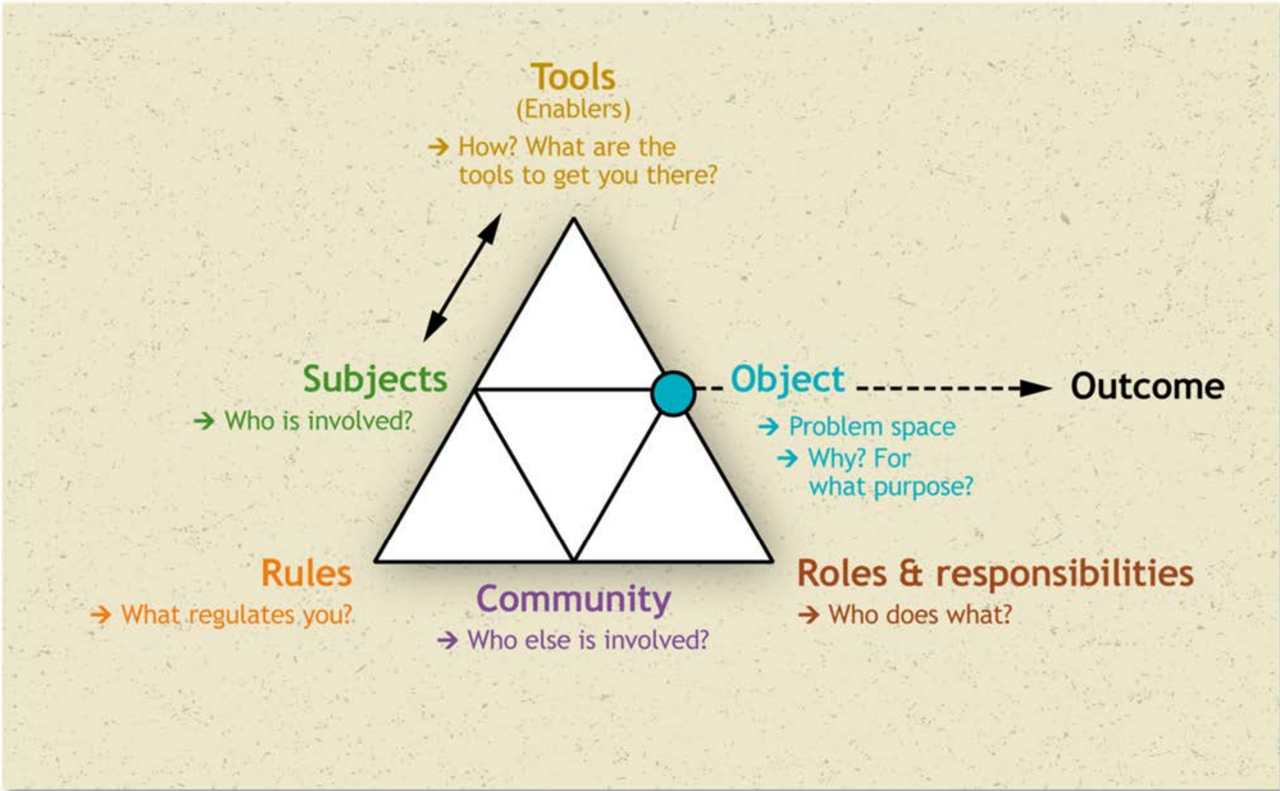


Figure 8: The CHAT framework (2nd generation)

5 Putting systemic, social learning approaches into practice: Experiences from RESILIM-O

In this section we share our experiences of using the various approaches and tools outlined above to support water governance and IWRM in the Olifants River Catchment.

5.1 Collaborative, systemic scoping of context & risk

In Section 4, Strategic Adaptive Management was posited as a viable strategic response to planning and acting in complex, uncertain environments. However, at the start of RESILIM-O there was no overall collaboratively defined vision for the catchment - an area of work that is the responsibility of the (emerging) CMAs. Given this, we adapted the SAM process in our early engagements with stakeholders.

Stakeholders were most often concerned about risks and ways to address these, prompting calls for vulnerability assessments. With the conceptual background of the previous section in mind, we designed a social learning process that was deeply committed to developing a collective understanding of context and vulnerability from the start, rather than using more conventional approaches which start with "expert knowledge". We emphasised that risk must be conceptualised and named by those experiencing it, as part of a systemic, collaborative co-enquiry. Whilst specialist data and analysis may be invaluable, it is the lived experience of risk that provides the context for much of the transformative action. Furthermore, specialist studies are not the only way of "knowing" the system. Given that they are often discipline-specific and not systemic in nature, they need to be appropriately embedded and used as elements of the overall systemic enquiry.

Understanding risk – and planning for change – cannot happen overnight; people and collectives need time to confront reality, and reframe this into some sort of "new meaning" for action. Resilience-building as a praxis, if it is to be transformative, is fundamentally a learning and engagement process. By supporting stakeholders to confront their own perceptions and those of others in a 'safe space', we aimed to support them to derive a common understanding (mental model) of the 'system' in question and thereby catalyse innovative types of plans and actions. Thus the risk assessment method needed to itself be part of the process of ***facilitating transformation***.

Equally, we wanted to support stakeholders to develop a systemic understanding of the world they live in and within which risks are experienced. The process would need to facilitate a collaborative reframing of risk and resilience-building such that stakeholders move from a position of linearity (seeing their problems through a simple cause-and-effect lens), to one that recognises multiple relationships and causalities as well as uncertainty and feedbacks within a jointly-described 'system'. Whilst noting that a 'system' is merely a social construct, the collaborative exercise of defining 'a system of interest' presents an opportunity to ***co-construct a collective understanding (or picture) of systemic risks*** rather than the risks of only one sector or individual.

Given this, we designed an overall process known as the Collaborative Resilience (or Risk) Assessment. This is described in detail elsewhere (Pollard et al, in prep.) but essentially consists of the steps and processes summarised in Figure . The Collaborative Resilience Assessment Process (ColRAP) is a conceptual and methodological innovation of the RESILIM-O program, developed as an alternative to conventional threat or risk assessments.

The first steps were largely preparatory in nature with an 'internal' scoping of the context using the VSTEEP heuristic *(See Box 2)*. This laid the foundation for scoping vulnerability and risk with stakeholders. Broad participative discussions with residents and other stakeholders were carried out in selected areas. Each meeting was guided by a central statement or question relating to management of land-water systems in a social-ecological framing. This helped to identify gaps and define a set of needs for specialist studies, with ongoing integration of the findings into a systemic picture. Once these outputs had been consolidated, a mirror-back process to stakeholders followed. Importantly, the process of mirror-back and re-engagement with stakeholders over time made it an expansive social learning process.

The ColRAP process was run in some 16 areas – or clusters – in the ORC, including Mozambique. Through this both the project teams and stakeholders learned about their catchment. The process not only built some level of trust and co-operation but helped stakeholders to jointly identify risks and strengths of their area, and to some degree to explore the wider consequences. When evaluated qualitatively against four criteria (water quantity, water quality, biodiversity and livelihoods) a differentiated picture of risk was evident, requiring differentiated resilience plans or actions (see Figure).

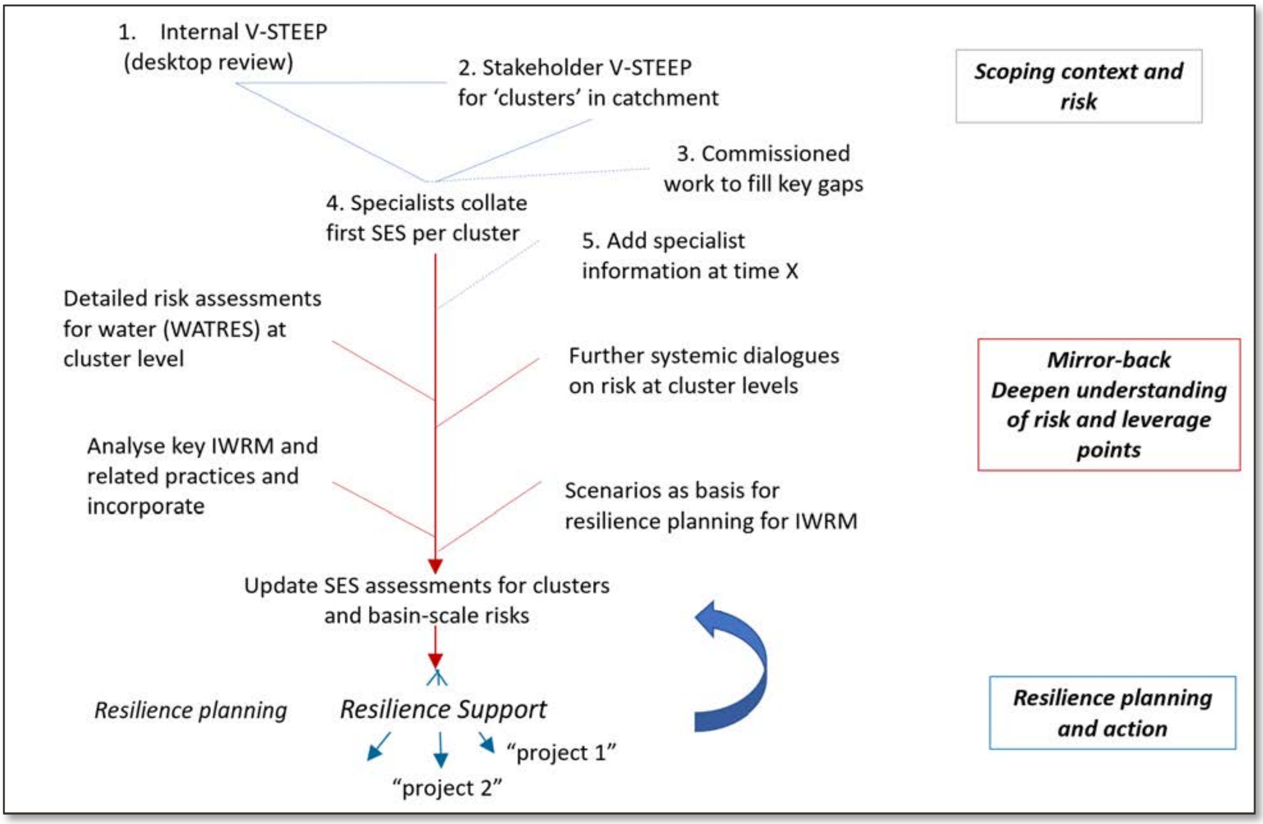


Figure 9: An overview of the scoping phase using a systemic, collaborative approach of co-enquiry

5.1.1 Identifying places to intervene

Systemic risks identified by stakeholders (i.e. risks at the catchment or basin level) included some key areas of concern with respect the long-term sustainability of the water resources and the governance capacity to manage risks and demands in the medium to long-term *(see Box 4)*.

Box 4:
Summary of Water-Related Risks Reported from the Collaborative Scoping with Stakeholders

Sustainability

- The persistent lack of compliance with Resource Directed Measures (benchmarks for sustainability) in terms of flow and water quality.
- The inability to monitor compliance in real-time.
- The deterioration of water quality, especially in the upper reaches, with consequent wider impacts downstream for both human health and ecosystem health.
- Climate change: Flow regimes that were changing and non-compliant with the Reserve.

Governance

- The lack of functional governance arrangements in South Africa (OCMA) and between South Africa and Mozambique.
- Incidents and reports of unlawful use either in uptake of water or in discharge or pollution of water.
- The lack of a systemic approach to water resources management including the lack of understanding of linkages between things and the need to manage the system as a whole.
- The limited understanding by residents and stakeholders regarding water resources.
- The lack of integration between water resources management and water supply (i.e. DWS/OCMA and local government)
- The lack of tools and processes to support a systemic, social learning approach.

These findings then set the stage for planning both systemic and specific interventions for support which were agreed to by stakeholders. The outputs from the Collaborative Resilience Assessment Process were combined with information on high priority areas (given by the program vision) to select some immediate areas for interventions. So for example, in the case of water security, strategic water source areas, areas of direct dependency for livelihood support, inflows to the Kruger National Park (high biodiversity and economic importance), outflows to Mozambique (as a transboundary imperative) and the Limpopo estuary at Xai-Xai were given specific attention.

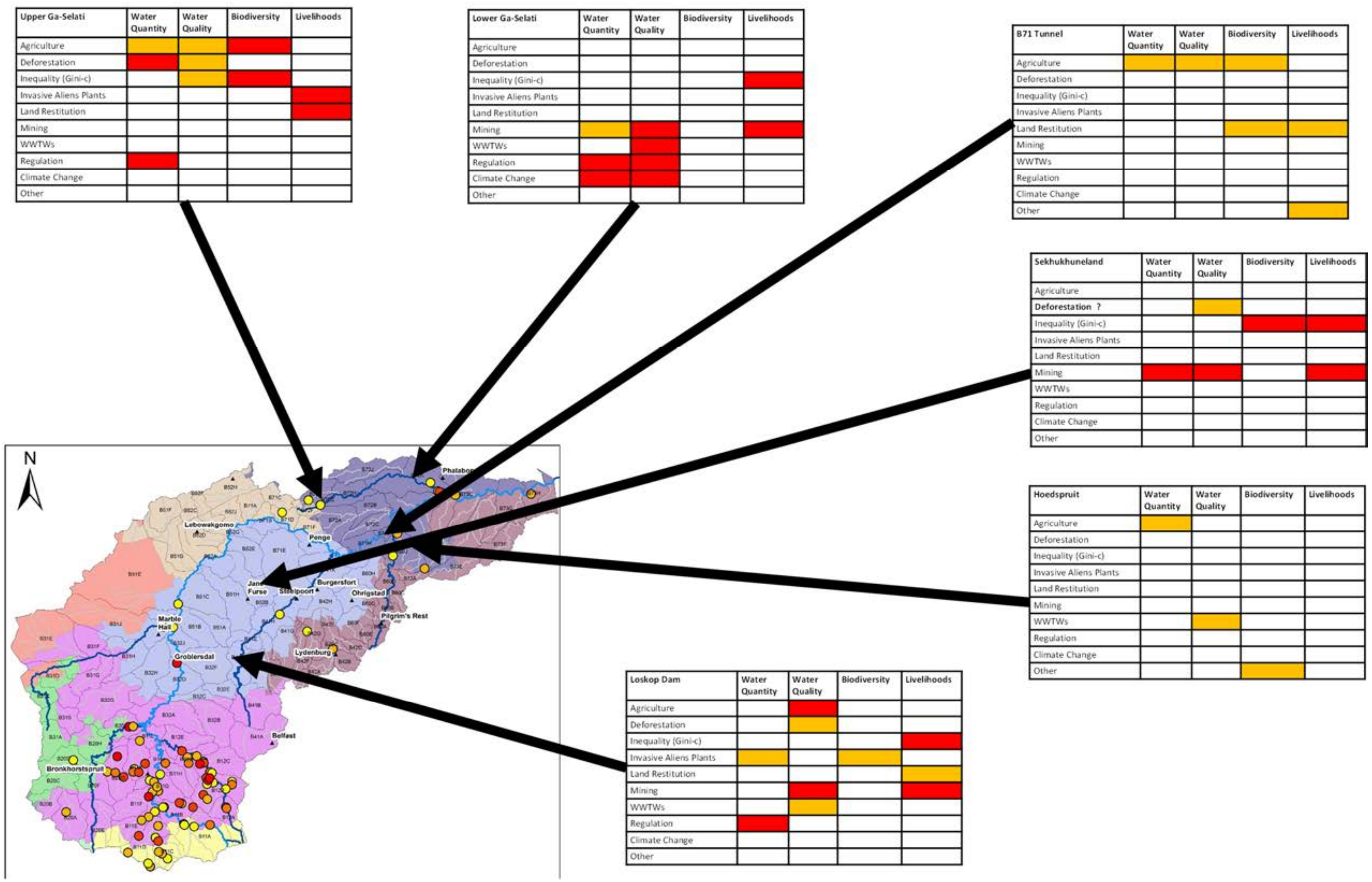


Figure 10: An example of a visual representation summarising results from collaborative risk assessments conducted with stakeholders at various sites in the middle and lower portions of the Olifants catchment in South Africa

5.2 Looking at practices & shared activities

5.2.1 A model of practices for "Reserve – or SEWR - implementation"

The Reserve or Socio-Environmental Water Requirements

The Reserve is a <u>legal requirement</u> to ensure sufficient water in a water resource (e.g. river) to meet Basic Human Needs (25 l/c/d) and ecological requirements (which must be determined). It must be met before any other water allocations are given. In this document we switch between the terms Reserve and EWRs. In accordance with global terminology, we often refer to Environmental Water Requirements or EWRs instead of the Reserve. However, seeing as Reserve determination takes into account water for basic human needs as well as the ecological component, we prefer the term

Socio-Environmental Water Requirements or SEWRs.

In the case of the Olifants, we were interested in understanding the practice of Reserve implementation - in other words, meeting the sustainability requirements as set out in policy. The idea of *Reserve implementation* had become so commonplace that the erroneous belief had developed that it was an activity in itself i.e. one "implements the Reserve". By adopting a more systemic approach to the issue, it became evident that the Reserve can only be achieved through enacting a number of practices. In other words, achieving compliance with the Reserve (the tool) can only be achieved through a bundle of practices as shown in Figure 11.

A key issue that emerged was the inability to monitor flows in real-time, which made taking any regulatory action almost impossible. Consequently we focused efforts on a real-time monitoring system, regulation and stakeholder engagement. (see Section 5.4).

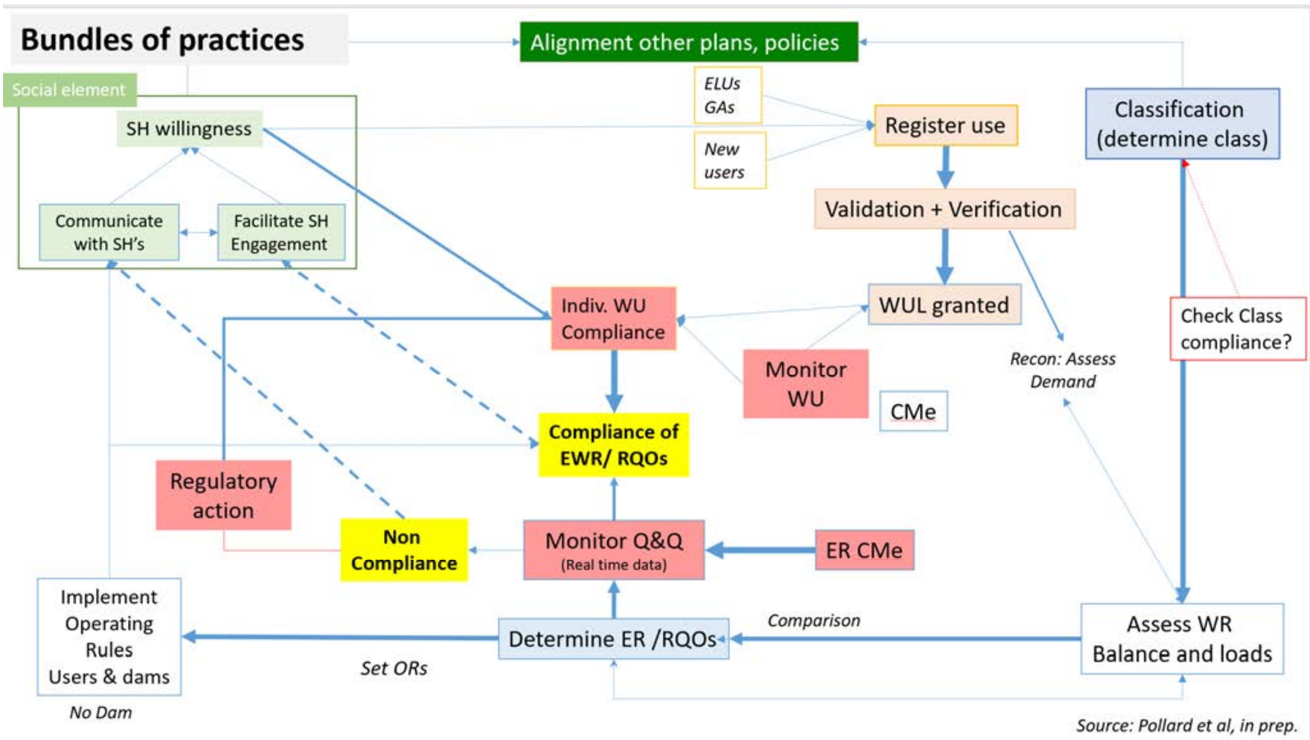


Figure 11: Systemic scoping of the bundle of practices needed to achieve compliance with "the Reserve"

5.2.2 IWRM as an activity system: Exploring compliance monitoring & enforcement (CME)

An activity system (Figure 12 comprises a group of people pursuing a goal in a purposeful way (Peal and Wilson, 2001). In this case, the goal is compliance monitoring & enforcement in the Olifants catchment (part of "regulatory action" in Figure 11) effect, the stakeholders and DWS (and possibly others) are a *community of practice* involved in a journey of co-learning and experiential practice of IWRM[1].

We used the framework to surface tensions and discrepancies relating to the practice – or activity – of CME (detailed in Figure) that could then be taken forward as part of a workplan. It was clear that being able to respond timeously to unlawful use (either existing or new use) was a major need and we supported this ultimately through an integrated DSS and capacity development of DWS staff (see Section 5.4).

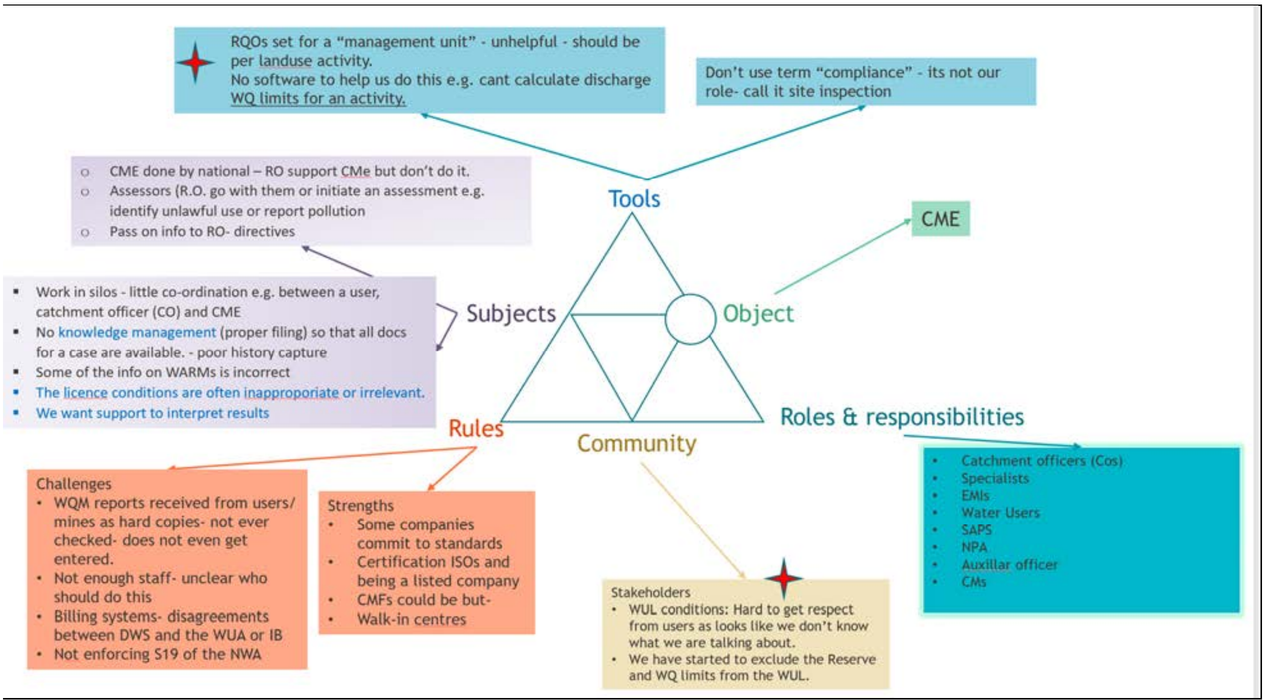


Figure 12: Outputs from the Activity Systems analysis of CME

Taking the time to support stakeholders to think more systemically, to confront their own perceptions and beliefs and to make new meaning based on an understanding of others (including lived experience and science-based evidence) placed us, as a program, in a much better position to support water governance.

For example, exploring the basis of water resources sustainability revealed multiple practices that need to be secured to deliver an intended outcome. Implementation has become a major challenge in South Africa and in IWRM, regulation and CME is a critical component. In the Olifants, representing CME more systemically (as a CLD and as an activity system) allowed participants to recognise that addressing one or two issues may not necessarily result in the hoped-for outcome.

[1] *In CHAT terminology those involved are called actors or subjects*

5.3 The use of systemic models

Peter Checkland's (1981) Soft Systems Methodology (SSM) aims to foster learning and appreciation of the problem situation between stakeholders. SSM uses different devices to unpack and define the problem and to move understanding from a simplistic cause (such as "the waste-water treatment works") to an understanding of complexity and emergence (upstream acid spills, poor management, inadequate capacity, unlawful use and so on). In RESILIM-O, we tried several methods that fall broadly under the SSM banner and found ourselves continuously returning to them.

5.3.1 Collaborative systemic exploration of a vexing problem (CLDs and more)

Throughout our support for IWRM, conceptual systemic models of issues of concern were a key tool for understanding the underlying complexities and feedbacks in the 'system of concern'. In general the process started with a scoping of history and context (using maps, timelines and the VSTEEP process) followed by a facilitated process of co-constructing a shared 'mental model' of the situation using a causal loop diagram (CLD). A causal loop diagram aids in visualizing how different variables in a system are interrelated, how they get 'stuck' or reinforced and how issues may be addressed.

In the simplest cases, CLDs were used very effectively in communities with low levels of literacy but a very good knowledge of their context. They were used in an informal way without concerns about the sign on the links or the feedback loops (to indicate how the variables are interconnected and what type of behaviour the system will produce). Essentially, they were used as a mediating device to get participants to think systemically about a stated problem. In other cases, we developed somewhat more sophisticated CLDs and in some particularly vexing problem spaces, used these as part of a dynamic modelling process.

Here we give three illustrative examples: the first being to explore community concerns around fish health in the middle Olifants, the second to explore implications of increased water transfers out of the middle Olifants, and the third to address persistent toxic spills in to the Selati River. In all cases, CLDs were used to facilitate initial engagements with stakeholders, but each group was supported by different tools as the work progressed.

5.3.1.1 Understanding water quality issues at Penge Village

Penge is a town situated along the Olifants River, 37 km north of Burgersfort in Sekhukhune District Municipality in the Limpopo Province. It was established after amosite was discovered there in 1907. During the scoping process and ColRAP, residents raised concerns about water quality and the impacts on fish and crops.

Penge lies along the river bank of the Olifants River, a reach with very low flows

They pointed to a recent Andalucite mine as the source of the problem. We facilitated a systemic discussion using general CLDs, and also for water-related ecosystem services[2].

The work revealed that in addition to effluent discharge into a small tributary by the new mine, water quality issues were likely being exacerbated by 'slow variables' in the system – variables that change slowly and are therefore often overlooked. Upstream impacts of mining, acid mine drainage and the mobilisation of metals, agricultural effluents, the raising of the fFlag Boshielo Dam wall and the lack of regular flows in the middle Olifants, all contributed to a complex outcome. As we have noted, this needs a different response to the simplistic, linear solutions based on simple models of cause-and-effect. Whilst frustrating to local communities, the need to address the systemic drivers at a broader scale was starkly apparent.

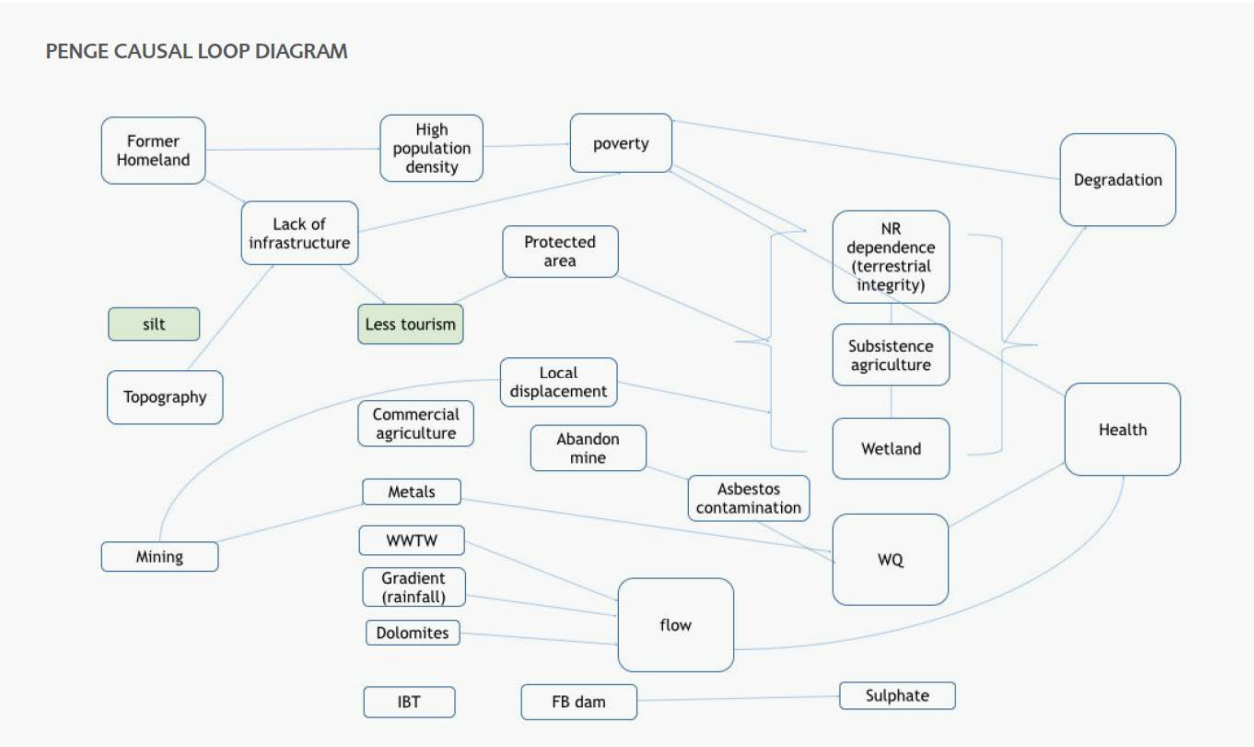


Figure 13: Penge causal loop diagram (CLD)

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[2] *Using a detailed process for understanding water-related ecosystem services known as WATRES*

5.3.1.2 Exploring potential impacts of increased water transfers out of the middle Olifants

The middle reaches of the ORC, from Loskop Dam to the confluence with the Steelpoort River, is a crucial part of the overall catchment, supporting a wide range of users and ecosystem functions both within, and outside of, the catchment. The high demands on the middle Olifants (Figure 16) combined with the multiple *pressing issues* had highlighted the lack of collective action and collaborative planning and management in the area (as required by the NWA of 1998). Thus our support aimed to build a network in the middle Olifants – and between the middle and lower Olifants - to facilitate collective action towards adapting to climate change and enhanced water security in the ORC. One major issue of concern *(see Box 5)* was the proposal to increase the amount of water being transferred out of the catchment to meet increased demands for Polokwane and mining at Mokopane (potentially increasing from 30 ML/d to 120 ML/d or even 150 ML/d) through a scheme known as the Olifants River Water Resource Development Project (**ORWRDP**).

Box 5:
Managing Inter-Basin Transfers out to Polokwane in the Face of Water Shortages & Increasing Water Security under Different Scenarios (Climate Change)

- Can the ORC transfer water out to Polokwane and for mining at Mokopane when demands in the ORC and internationally are not being met and there is demonstrable water insecurity
- Polokwane demands are projected to increase substantially
- There will be impacts for middle and lower Olifants (ORC)
- Can further stress on the ORC internally be justified? without
- demonstrable WCWD measures in the receiving catchment
- Understanding internal impacts
- Climate change: Increased temperatures will reduce water yields between 40 – 60%

(Sawunyama & Mallory 2014; Shulze and Davis 2018)

Our work revealed, with few exceptions, an almost complete disconnectedness between most of the stakeholders and a complete lack of understanding about planned water resources developments. Any reductions in flows and water quality would impact downstream in various complex ways. Thus, using a systemic approach, we **synthesised information** and **integrated perspectives**, focusing primarily on the analysis of the ORWRDP and the ORC reconciliation strategy. Systemic CLDs were used to represent the perceptions of multiple stakeholder groups regarding water security in the middle Olifants (Figure 16) and to include scientific data (hydrology, water quality, water balance and climate change).

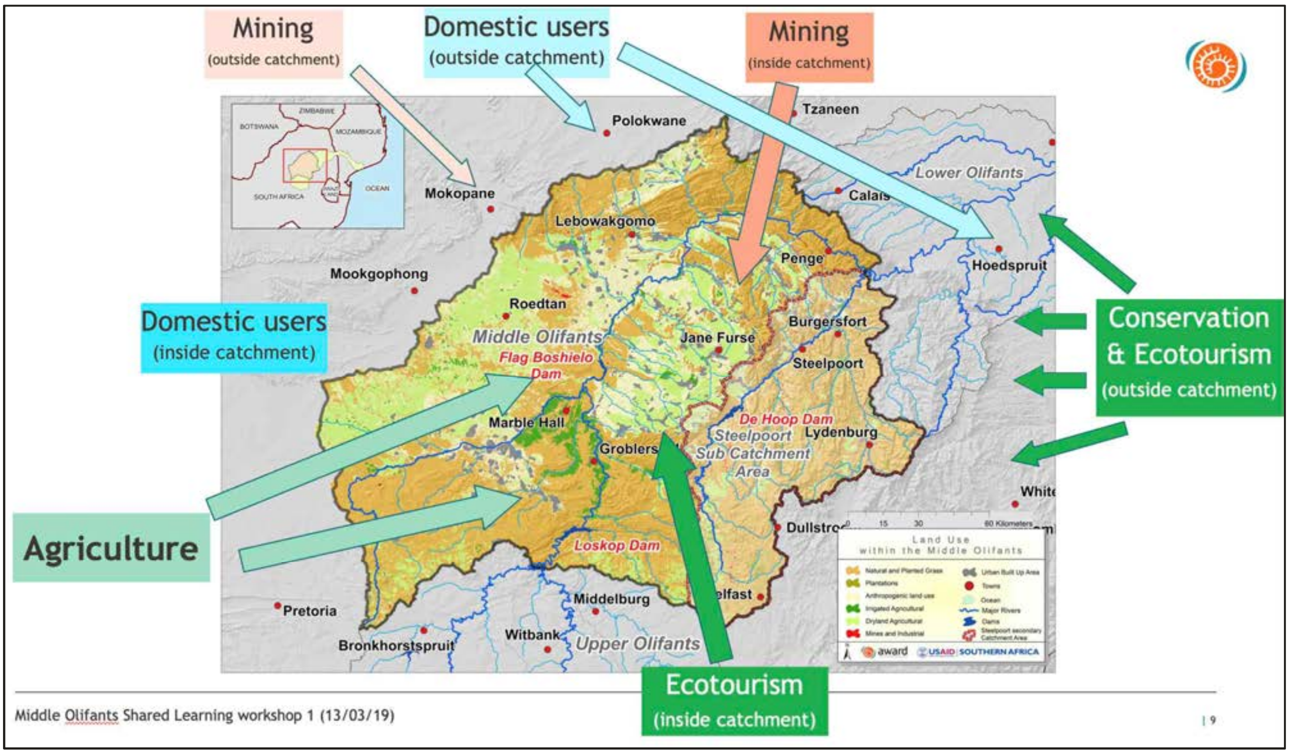

Figure 15: Overview of the Middle Olifants area, focusing on the mainstem of the Olifants River from below Loskop Dam until the confluence of the Loskop and the Steelpoort Rivers (see the locality map in Figure 1 for the positioning of the middle Olifants within the broader ORC).

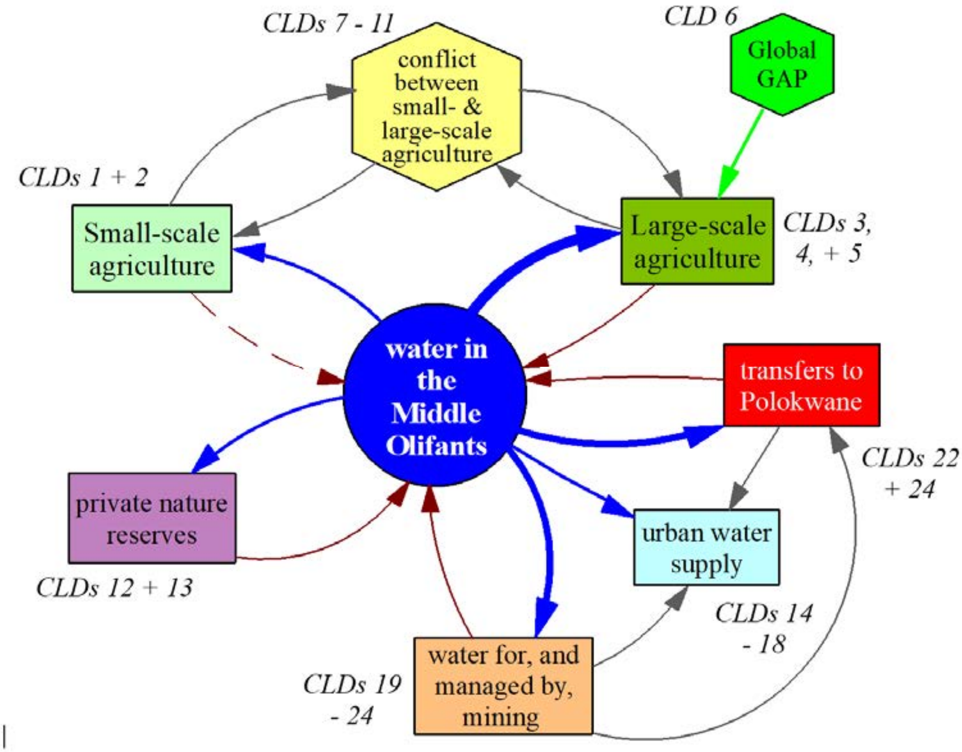

Figure 16: Summary of the sectoral systemic analysis across the eight domains, with primary relationships between domains indicated. The 24 causal loop diagrams (CLDs), which describe the sectoral perspectives, are numbered in relation to each domain

Although impacts are usually transferred downstream, a systemic perspective revealed a key feedback loop between increased water stress in the lower Olifants impacting upstream by placing further demands on Loskop Dam to release additional flows, thereby affecting local water demand.

The work culminated in a joint workshop involving stakeholders from the middle and lower Olifants (see Figure 1). Discussions focused on the proposed increased offtakes from the highly-stressed middle Olifants. The proposed mitigation interventions (which would need to be fully implemented all at the same time) were evaluated for feasibility likelihood of success. If implementation is partial or fails, then either (a) the ORWRDP allocations need to be reduced or (b) the ORWRDP demands will compete with and impact on other users. This includes demand from emerging farmers in the middle and lower ORC (some who have been waiting for over a decade for water), established uses, the EWRs and Mozambique's needs. The area already cannot cope under water stress such as that imposed by the recent drought. *(see Resource 1: Keeping the Olifants River flowing).*

Stakeholders concluded that since the catchment is effectively 'closed' (there is no further available water to allocate) meeting the ORWRDP demands will compromise long-term water security. Moreover, climate change is expected to decrease yield by 40 – 60%. *(see Resource 4: Predicted impact of climate change on water resources in the Olifants catchment).* The recognition of these implications, along with the improved understanding of available water resources, highlighted the urgent need for an updated reconciliation study and a review of the ORWRDP.

5.3.2 A visual, dynamic model of a system at risk – the Selati

This case presents our experiences of using a systemic, social learning approach to address persistent water quality issues in the Olifants River as it enters the Kruger National Park. The initial engagements involved a scoping process and then, over the course of 3 years, deepened through a process of co-inquiry using systemic conceptualisations (CLDs), together with a formal modelling process to demonstrate the impacts of different management actions. Finally the outputs were rendered through a visual interface, as a dynamic 'picture' showing change over time.

Figure 17: Spill from the Bosveld tailings dam being monitored by SANParks and AWARD

The Selati Spills: A Trigger for a Systemic Approach

On 31 December 2013, Bosveld Phosphate mine captured the attention of the media, industry and the public when it spilled significant amounts of contaminated water into Selati River, near the Phalaborwa entrance to the Kruger National Park (www.mg.co.za, www.legalbrief.co.za). The Selati River flows into Olifants River near the KNP border.

The cause of the accident was the collapse of the tailings retaining wall that resulted in the release of the contaminated process water from fertiliser production. The collapse was triggered by high water levels in the tailings dam from high rainfall. On the 30th December a local fisherman, who noticed fish kills 12km away from the discharge site, alerted the Kruger National Park staff who investigated. The highly acidic spill, with a pH of 1.5 at discharge site, flowed for a week, damaging natural systems which provide valuable (but unpriced) ecosystem services to society. Another minor spill occurred on 6th March 2014 after heavy rains, but this was quickly contained and neutralised.
These events indicate the vulnerability of the company wastewater operations, and consequently the environment downstream of the company including the Kruger National Park, to extreme rainfall events. These are likely to be compounded by climate change (Sawunyama & Mallory, 2014; AWARD BaPhalaborwa brochure).

According to WISE Uranium Project (2002), the typical composition of spilled water from the phosphogypsum tailings (similar to those at Bosveld Phosphate Company) include high fluoride concentration, radio-nuclide radium -226 which upon decay emits harmful alpha particles; and heavy metals (Cd, Cr, Pb, As, Hg, etc) that may enter into the food chain through potable water, aquatic life and agriculture products. Both the immediate effects and the potential long-term effects of the accident could be severe.

Since then a series of meetings have been held with affected stakeholders to devise immediate, medium and long-term action plans to avoid another process water spill disaster. These were initially led by the Phalaborwa Disaster Management Committee, and later by Department of Water Affairs (DWA) regional office, Ba-Phalaborwa Local Municipality and NGOs including AWARD.

At that time a number of stakeholders pointed out that the waters of the Selati, and hence the Olifants River, were also being contaminated by untreated discharge from the wastewater treatment plants in Phalaborwa. A ‘blame-game’ developed and AWARD, through RESILIM-O agreed to facilitate a process to support stakeholders to resolve the issues and chart a way forward for the governance of the water resources of the area. Initial engagements also raised concerns about the operation of the Phalaborwa Barrage which supplies water to Phalaborwa town but which also has a crucial role in discharging water downstream to the KNP.

It was clear that this was a vexing or ‘wicked’ problem that needed an alternative approach to allow stakeholders to surface their understandings and perceptions whilst allowing them to hear those of others, in a way that could build trust and include the best available scientific information and simulations wherever appropriate and possible. We therefore designed a process known as CoDyM or Collaborative Dynamic Modelling. This was accompanied by formal System Dynamics Modelling and the development of a model for the Selati known as RESIMOD.

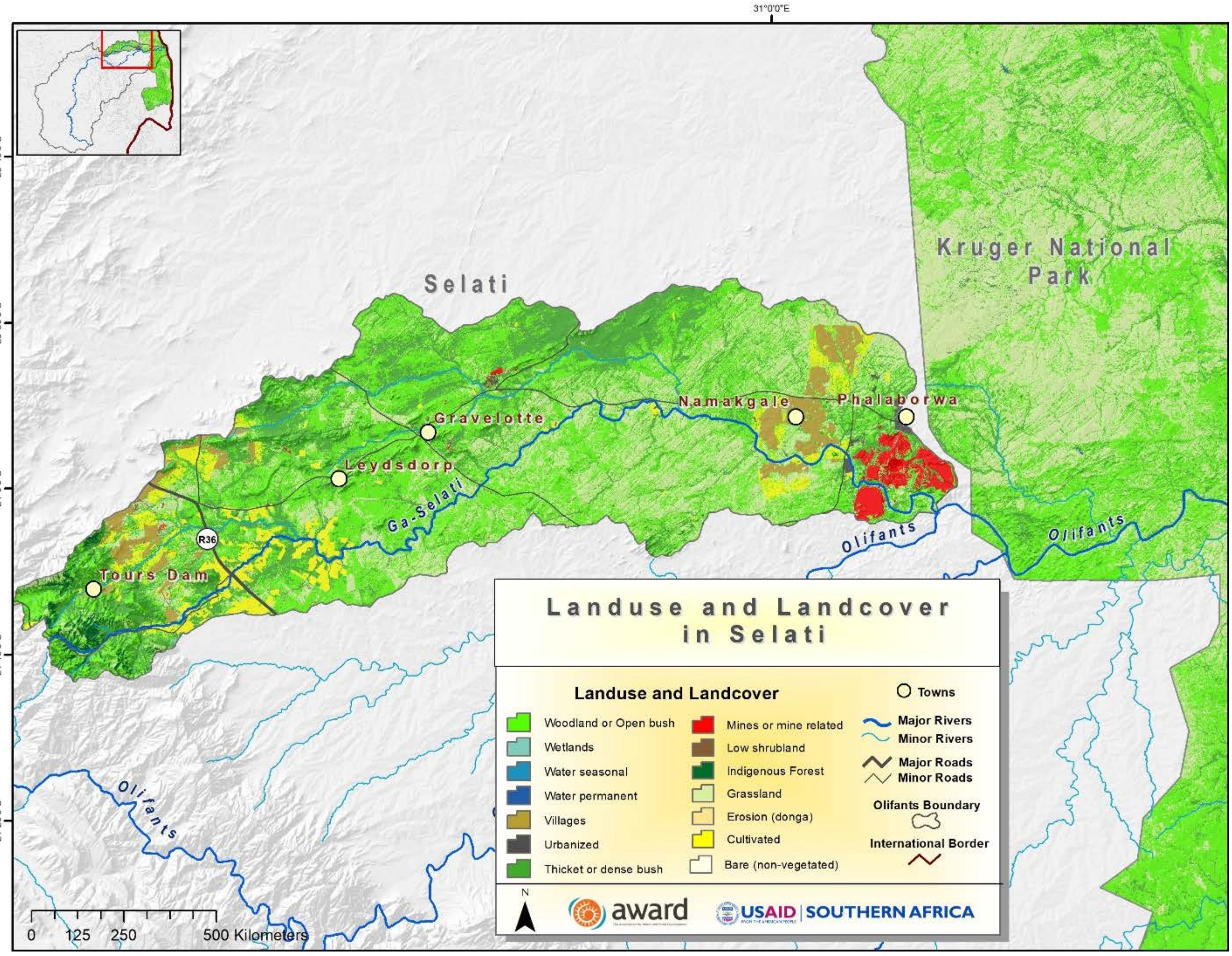

Figure 18: Map showing the Selati sub-catchment, location of mines and Phalaborwa Town and Selati inflows into the Olifants and KNP

The Collaborative Dynamic Modelling process

Acknowledging the interconnected nature of the challenges affecting water in the lower Olifants, ranging from over-use of resources by many sectors, to inadequate waste-water management, damaged ecosystems, harmful industrial development and climate change. *(see Resource 4: Predicted impact of climate change on water resources in the Olifants catchment & Resource 8: Historical trends and climate projections for Local Municipalities).* ***The objectives of CoDyM*** were to foster collaborative action, improve communication and improve systems thinking capacity. By seeking to build the capacity of stakeholders around the above three elements, CoDyM hoped to support a more resilient management of the ORC.

Through the use of participatory modelling (conversation-based) approaches, CLDs were developed to derive a systemic, collaborative picture of risk and underlying drivers and impacts in the Selati River (Figure 19)

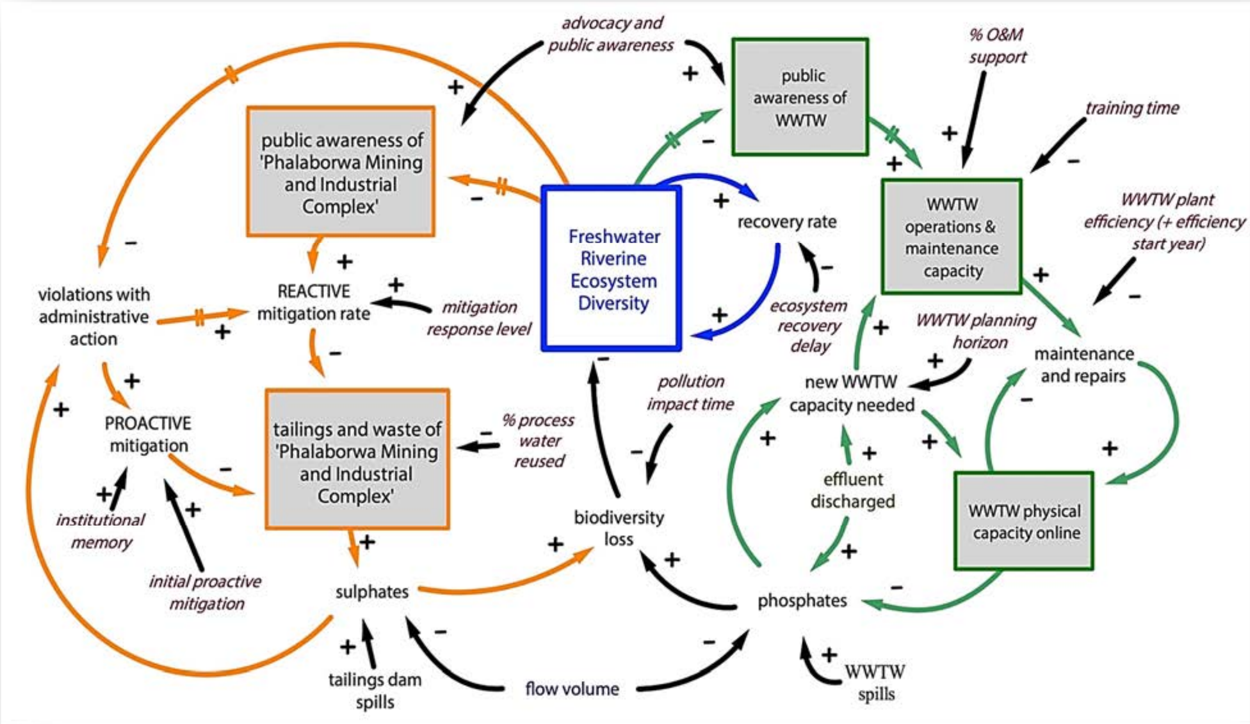

Figure 19: A summary causal loop diagram of the underlying causes and inter-linkages of a deterioration of Olifants riverine health as it enters the iconic Kruger National Park and ultimately flows into Mozambique

Introducing dynamics

As a first step, the above CLD represented a 'snapshot' in time of the problem at hand but could not show the dynamic nature of the situation in reality, such as for example, changes in rainfall or increased pressure on the WWTW.

We thus introduced System Dynamics Modelling to capture the dynamic nature of the problem and to explore the impacts[3] of various management actions *(see Box 6)*. Further details are given at www.award.org.za and, more technically, in Carnohan et al. in press[4].

Participatory modelling was once again used to refine RESIMOD (Figure 20). In order to drive home the potential impacts of climate change we explicitly included these through the incorporation of downscaled climate models.

The process culminated in a multi-stakeholder workshop where stakeholders explored the impacts and improvements on the key indicator, FRED under different scenarios (Figure 21) representing policy changes, improved management of mine tailings waste and function of WWTWs, as well as institutional capacity.

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[3] *http://award.org.za/index.php/focus-areas/climate/planning-systemically-for-climate-change-adaptation-in-the-selati/*

[4] *Shane A. Carnohan, A.A, Clifford-Holmes, J. McKnight, U.S. and Pollard, S.R. In press. Climate Change Adaptation in Rural South Africa: Using Stakeholder Narratives to Build System Dynamics Models in Data-scarce Environments. Journal of Simulation.*

Box 6:
Modelling the Impacts of a Deterioration of Water Resource Quality & Quantity on Freshwater Health

The central problem modelled in ResiMod is the impacts of water quality and quantity decline on freshwater riverine ecosystem diversity (FRED) due to effluent discharged from the Phalaborwa region, which enters the lower reaches of the Selati River and the lower Olifants River. The two main sources of this effluent are waste water treatment works (WWTW) (managed and overseen between the Ba-Phalaborwa Local Municipality and the Mopani District Municipality) and seepage and spills from the Phalabowa Mining and Industrial Complex (including Palabora Mining Company, Bosveld Phosphates, and Foskor Mining).

Different levers for change were considered in ResiMod in order to explore how (and when) stakeholders need to act to reduce the region's impact on biodiversity (and associated economies and ecosystem services) within KNP, especially under conditions of climate change.

The mining and industrial complex was modelled through sulphate concentrations and the WWTW's impact through phosphate concentrations. Levels of public awareness, the capacity of regulators, and the dilution capacity of flow from upstream, are some of the factors considered in ResiMod. By having a common model of the problem situation – and displaying a broad (albeit limited) series of interventions – stakeholders were able to adjust inputs and simulate system responses, both as they impact their sector and as they impact other, interdependent sectors.

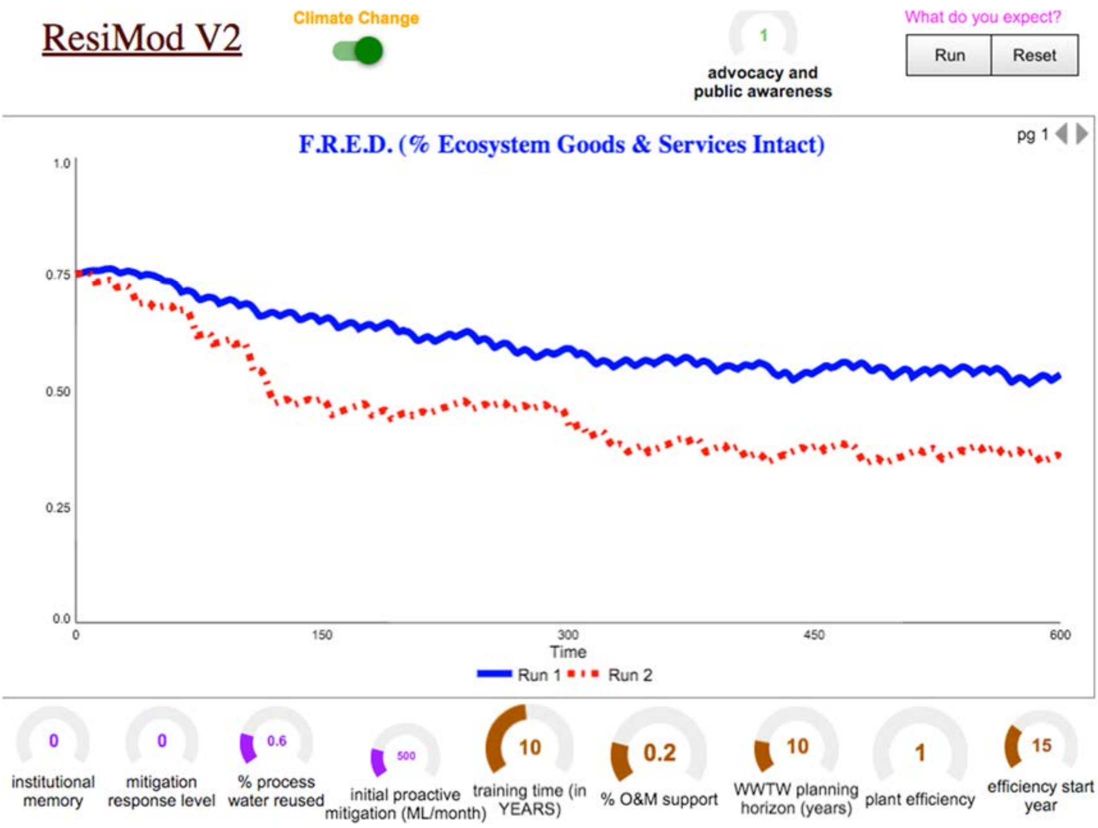

Figure 20: Simulation results for ResiMod showing impacts of certain actions on riverine health (through FRED). Each run represents a scenario selected by participants (blue) and again under climate change (red).

Facilitated through the CoDYM process, stakeholders engage in discussions regarding water quality problems in the lower Olifants and Selati Rivers

One key strength of this work is the unique ability of SDM to support integration of narratives with stakeholders. This allowed a small modelling team to operate in a high-conflict catchment to support stakeholder communication and facilitate insights about the impacts of climate change and what stakeholders could do about these impacts.

Exploring visual representations of dynamic systems

Though this type of modelling can often be time and resource intensive, it certainly helps people to 'see' a connected and dynamic world. One constraint is that many people, especially in the developmental context, struggle to understand graphs as a visual representation over time. However new technologies and strategies for stakeholder engagement can support aesthetically engaging interfaces to help close this gap. Indeed, given this concern we then went on to develop a Visual User Interface or VUI which will shortly be available on our website.

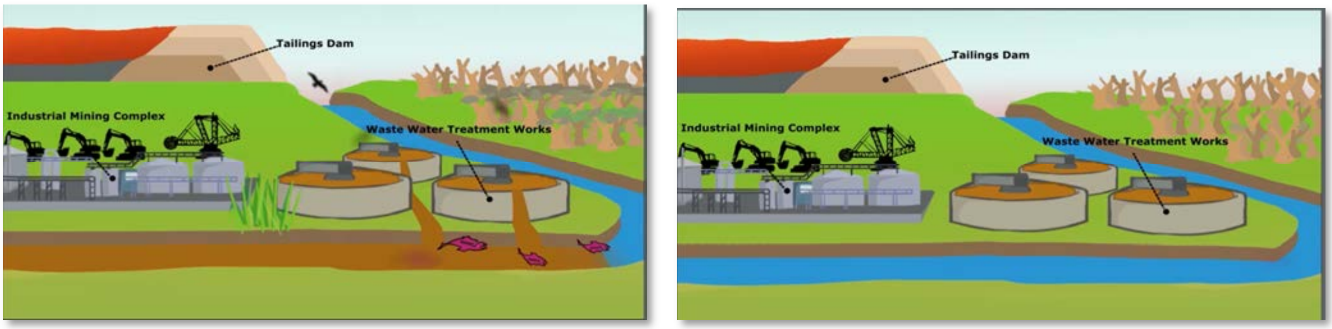

Figure 21: Examples of the VUI animations used to represent different actions simulated through the RESIMOD process

5.4 Technical tools to support systemic, social learning in IWRM

In practice, the success of IWRM has been hampered by the lack of integrative decision support systems (DSS) and tools for good governance, especially in contexts of limited resources and observation data. This is even more apparent in large transboundary systems where individual countries use different data management systems that are often incompatible; a situation hampered also by language differences (such as between Anglophone and Lusophone countries). Moreover, system compatibility needs to be supported with open communication and agreed systems for data sharing and use to facilitate the sustainable, efficient and equitable management of shared water resources.

The analysis of practices in the Olifants (Section 4.3) clearly pointed to the need for tools to support:

- Regulating water use through real-time monitoring (both for compliance and for ecological status) as part of CME;
- Water use licensing that accounts for context and cumulative impacts.

Both of these aspects needed to be embedded in a broader systemic model of the catchment which allowed for integration across scales and time. In response, AWARD developed the building blocks for an integrated approach that allows one to monitor, in real time, the compliance of water quality and quantity against established benchmarks (known as Resource Quality Objectives). A key consideration was to facilitate a rapid response. Without this ability, water resource managers were severely constrained in being able to take mitigatory action because verified data were only available after 14 days by which time the cause or culprit would be hard to identify. In addition, AWARD has been developing the first Integrated Water Resources Decision Support System (INWARDS) for the Olifants River Catchment.

A summary of these tools is given below and readers are referred to our communication brochure *(see Resource 2: Integrated Water Resources Decision Support System for the Olifants Catchment & Resource 6: FlowTracker)* for more details.

5.4.1 Tools for real-time compliance monitoring & early warning

A suite of integrated water resource decision-support tools has been developed to guide water resource managers in making short- and long-term strategic adaptive operational decisions. Both the tools and training were implemented in the Olifants River Catchment between 2016 and 2020. These currently include a mobile app and a desktop application. The former is designed for stakeholders in general and the latter for water resources managers, in support of decision-making.

5.4.1.1 INWARDS Software

Since the water resources problems were systemic in nature (both through multiple-causality and in terms of impacts – see Section 5.1.1) it was clear from the start that as much data as possible needed to be mobilised, and in a manner that would foster co-operative decision-making. This meant supporting both qualitative and quantitative data and ensuring that existing approaches could be complemented by other data (e.g. by incorporating different analytics).

Aside from providing a robust, flexible and 'user-friendly' platform with good visualisation options, the INWARDS is designed to address a number of key issues:

- The need for a systemic approach which considers multiple data sources (water resources, socio-economic and environmental data) for decision-making;
- The need for an open-source shared repository that provides consistency for data capture and analytics with good visualization options;
- The need to monitor against benchmarks in real-time so as to facilitate rapid action (e.g. Resource Quality Objectives, water quality standards in South Africa and Mozambique);
- The need to integrate water quality and quantity (through loads) so that these are managed as one system (as envisaged in the NWA and in the Integrated Water Quality Management System);
- The ability to complement and integrate with other data platforms; and
- The need to consider climate change scenarios;
- Please see the webwite for an overview *(http://award.org.za/inwards/).*

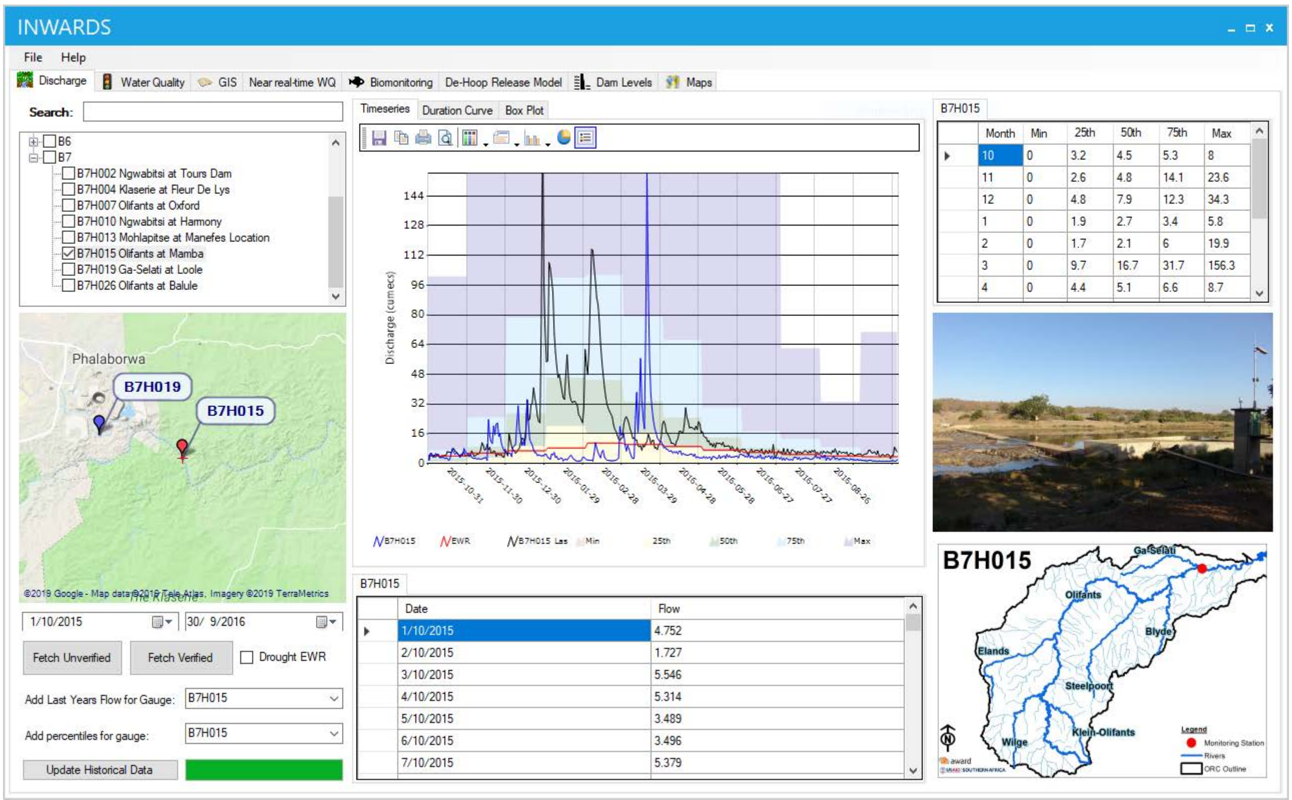

Figure 22: Screen shot of INWARDS desktop application showing the discharge interface

5.4.1.2 Flow Tracker

At the start of the work, the urgent need for a user-friendly tool for tracking compliance against the Reserve – in real-time - was highlighted. Thus, the first tool to be developed was a mobile app known as FlowTracker, which is now freely available for download. This user-friendly mobile application allows users to track river flows at DWS gauge stations and dam levels in the Olifants in real-time (Figure 24). Where available, flows are represented against the EWRs or the Reserve. This serves as an early warning system (as flows or dam levels decline) and enables rapid CME response.

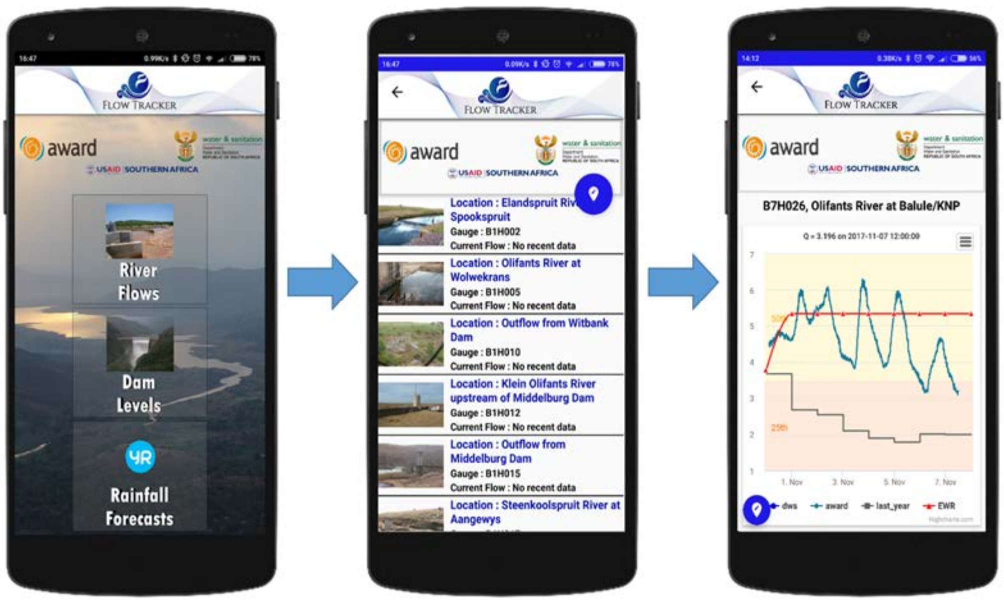

Figure 23: Android application Flow Tracker

5.4.1.3 Improved real-time monitoring network

The FlowTracker uses unverified data and at times errors can occur especially regarding calibration. Moreover, the DWS monitoring network faces severe maintenance challenges. Thus to increase the reliability of data collected, additional backup data loggers, probes, communication systems and data servers were installed alongside the existing DWS data loggers at DWS flow gauge stations. This has greatly enhanced monitoring efforts by the DWS, AWARD and SANParks. Given resource constraints, we focused on three sites in the Lower Olifants catchment in order to track compliance where the Olifants flows into KNP and the Massingir Dam in Mozambique, where flows should be met if the 'system' is compliant.

5.5 Other approaches for implementation support

AWARD used a number of other approaches to support implementation, which emerge broadly from the participatory approaches. These are discussed in various other RESILIM-O documents and summarised here for reference.

1. **Capacity development & institutionalisation**

   Almost all of the work spoke to collaborative design and learning. Our tenet is that for institutionalisation of systemic, social learning to occur (i.e. for practices, processes and tools to be embedded), stakeholders need to be involved from the start. This does not mean attendance at workshops and training events, but a facilitated process of social learning. (see Section 4.1.2).

   Thus for example, the intention behind INWARDS was for it to enable the practice of systemic water resources management. Its development was discussed, trialled and tested throughout the course of RESILIM-O. In particular, DWS staff were involved in feedback on design and use through their engagement in a three-module capacity development course. SANParks and DWS were also intimately invested and involved in using various approaches and tools based on their needs. Much of this culminated in their application during the drought crisis. *(see Resource 1: Keeping the Olifants River flowing).*

2. **Crises or vexing problems as mediating devices for engagement & action**

   The fact that people often only respond to crises is often bemoaned by many. However, the reality is that it is often problems and crises that act as catalysts for collective action regarding a 'common property' resource like water. In recognition of this, we have often designed discussions about more 'mundane' issues around a 'hot issue' like water quality and health, or the drought. If carefully considered, and supported by evidence, this can be a useful entry point. However, it must be linked to clear actions that are then tackled. Many of the participatory forums have suffered from a perceived lack of action and implementation.

3. **Partnerships & networks for collective action**

   As interest in networks for collective action and the governance of natural resources grows, demand is emerging for further guidance about how to launch and sustain these. Indeed, there is a vast literature on collective action, particularly in the community-based natural resource management (CBNRM) literature. Collective action networks are key for IWRM because, by definition, IWRM is a collective action process. As a decentralised endeavour, the co-management of water resources must be considered. Whilst the DWS supported stakeholder engagement and networks in earnest in the early 2000's, this has gradually dwindled. The envisaged success of Water User Associations as bodies to develop a shared understanding and collaborate around water has been beset by challenges of resources and perceived inaction. Consequently, in our experience, people have a very poor understanding of water resources in the Olifants (other than their own local realities) and potential strategic actions.

Notwithstanding the difficulties of establishing and maintaining networks, we have used these with some degree of success in the Olifants. In the main this has been by galvanising stakeholders around a vexing issue (see above), running systemic social learning processes, making sure data were available and understandable by stakeholders, and mediating key actions. Interested practitioners are referred to various reports detailing these networks that were established in response to the drought, for the middle Olifants and for bringing the stakeholders from the middle and lower Olifants together. It is important to recognise that different networks may have different profiles and roles – such as technical, advocacy, or watchdog roles.

4. **Learning exchanges**

Finally we make mention of the use of learning exchanges as a way to foster interest, exposure and action. These were used in RESILIM-O as a way to expose people from the upper catchment to the lower catchment realities, to share experiences between Mozambique and South Africa and as a way for government staff to hear and understand the implications of non-compliance for civil society, for example.

6 Concluding comments

This document has outlined the systemic, social learning approaches and tools used - and the outcomes of -AWARD's efforts to build resilience in support of water governance in the Olifants River Catchment. In essence, all the approaches described here have aimed to involve stakeholders in collaboratively building a systemic picture of the catchment and issues of concern, and to reorient their praxis towards systemic, social learning and strategic adaptive management.

The 2016-2019 drought has highlighted the systemic vulnerabilities that remain in both South Africa and Mozambique. All indications are that both water quality and quantity of the catchment continue to deteriorate under drivers of change such as mining, waste-water treatment works, the spread of alien invasive plants and agriculture. Despite excellent legislation associated with the National Water Act (1998), the Olifants River is regularly non-compliant with the legal requirements for water resources protection i.e. RQOs.

Seven years on, we have a much better understanding of the potential climate change impacts from the RESILIM-O work, which will greatly exacerbate this vulnerability. Climate change is likely to profoundly affect water resources as the predicted increasing temperatures affect water storage (including in the soil) through evapotranspiration and an increase in extreme events (floods and droughts).

Securing the 'Reserve' and environmental water requirements as the basis for ensuring a viable and sustainable catchment now and into the future through systemic, integrated water resources management (IWRM) is key. Good governance is essential and the establishment and functioning of the OCMA and other stakeholder platforms is essential to institutionalize governance and practices that support water resources protection, biodiversity protection, livelihood beneficiation, climate change adaptation and transboundary arrangements. Given that the Olifants River forms part of an international system, the implications are of wider significance than for South Africa alone. Without a viable governance system, achieving water resources protection within IWRM will not be possible.

The re-orientation of water management and government to a systemic approach has had major implications for IWRM. By exploring the 'connectedness' and dynamism of the 'system' (the Olifants Catchment) we revealed, with stakeholders a number of strategic issues

- The relationships between elements of the system (biophysical, socio-political, technical) and feedbacks and emergence in the system;
- Vexing or wicked problems such as the ongoing spills, the links between upstream activities (mining) and downstream riverine health and human well-being and the need to understand feedbacks;
- The importance of practices, which mediate the relationship with water;
- Points of leverage and points to intervene such as through collaborative action;
- Strategic gaps such as the need for real-time monitoring, and how dealing with these would 'propagate' through the system (i.e. have systemic impacts);
- The projected systemic impacts of climate change;
- The need for – and highly beneficial aspects of – stakeholder engagement and involvement in IWRM;
- Clear evidence and rationale behind the need to plan strategically, as a matter of urgency
- The need for decentralised governance (such as through the Olifants CMA, Water User Associations and stakeholder networks.

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The Association for Water and Rural Development

AWARD is a non-profit organisation specialising in participatory, research-based project implementation. Their work addresses issues of sustainability, inequity and poverty by building natural-resource management competence and supporting sustainable livelihoods. One of their current projects, supported by USAID, focuses on the Olifants River and the way in which people living in South Africa and Mozambique depend on the Olifants and its contributing waterways. It aims to improve water security and resource management in support of the healthy ecosystems to sustain livelihoods and resilient economic development in the catchment.

P O Box 1919, Hoedspruit 1380, Limpopo, South Africa
T 015-793 0503 **W** award.org.za
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About USAID: RESILIM-O

USAID: RESILIM-O focuses on the Olifants River Basin and the way in which people living in South Africa and Mozambique depend on the Olifants and its contributing waterways. It aims to improve water security and resource management in support of the healthy ecosystems that support livelihoods and resilient economic development in the catchment. The 5-year programme, involving the South African and Mozambican portions of the Olifants catchment, is being implemented by the Association for Water and Rural Development (AWARD) and is funded by USAID Southern Africa.

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