HOW TO...
think and act in ways that make Adaptive IWRM practically possible

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Unilever

WATER RESEARCH COMMISSION

NO. 1
SP 116/18

WHO ARE THESE HANDBOOKS FOR?

The user-friendly series of "How to…." handbooks are aimed at staff and stakeholders in catchment management forums (CMFs), catchment management agencies (CMAs) and municipalities. The handbooks are not all written at exactly the same level of "user-friendliness", it depends on the topic, and target users.

The list below shows which groups are likely to find the handbooks most useful:

TITLE	#	CMF	CMA	MUNICIPALITIES
How to think and act in ways that make Adaptive IWRM practically possible	1		√	√
How to think about water for people and people for water: Some, for all, forever	2	√	√	√
How to establish and run a Catchment Management Forum	3	√	√	
How to manage Water Quality and Water Quantity together	4		√	√
How to engage with the challenges facing Water and Sanitation Services (WSS) in small municipalities	5			√
How to run a Green Drop campaign in a Catchment Management Forum	6	√	√	√
How to engage with coal mines through a Catchment Management Forum	7	√	√	√
How to use Strategic Adaptive Management (SAM) and the Adaptive Planning Process (APP) to build a shared catchment future	8	√	√	√
How to understand Environmental Water Quality in Water Resources Management	9	√	√	√

NOTE: Words marked with an * in these handbooks appear in the glossary at the end of each handbook.

Definition: **Adaptive IWRM:**

Using adaptive, systemic, processes and an understanding of complex social-ecological systems **to coordinate conservation, manage and develop water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems.**

A definition based on the Global Water Partnership 2000 definition of IWRM (Agarwal et al., 2000), with specific Adaptive IWRM additions (italics).
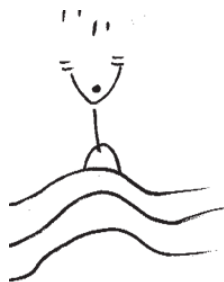
Why read this? Why is it likely to be critical for putting IWRM into practice?
This short handbook:
- provides an essential, *new* way of thinking about *practising Adaptive IWRM*.
- draws on solid research and first-hand experience.
- offers practical, realistic ways in which Adaptive IWRM can be put into action.

Who are you, the reader?
- You recognise that the piece-meal*, silo-ed* way in which water is managed is not delivering the constitutional requirements or the development goals South Africans need and want.
- You want a practical way to implement IWRM.

What is IWRM in a developmental* and constitutional context?
Adaptive IWRM recognises:
- that the economy needs to grow in order to create jobs, redress the wrongs of the past, and improve the lives of all South Africans;
- that water is an economic good* because (except for free basic water) water is priced and paid for. We need to pay for water to help cover the cost of storage and delivery infrastructure;
- that water also has more value than just money; it is essential for human well-being and development;
- that water is **finite***, vulnerable* and essential;
- that people think of water in terms of their constitutional rights of freedom, justice and well-being;
- that fair access to water is a critical aspect of social justice;
- that ethical* water governance and management are essential for sustainability;
- that good governance ensures fair access to water. Fair access is difficult because water is often in short supply and has to be shared. Sharing is contested* and vulnerable to abuses of power;
- that water is a *shared public substance of value* – so everyone must participate in making decisions about it. This helps build a stronger democracy;
- that there is no substitute for water and we cannot manufacture it – it is found on earth only as water ecosystems, in the natural water cycle;
- that our use of water depends on sustaining the water cycle and aquatic, needs to be use and not exploitation.

ACTING ON THIS KNOWLEDGE REQUIRES **ADAPTIVE** IWRM

Note: Words marked with * appear in the glossary at the end of this handbook, together with a list of acronyms.

1   INTRODUCTION

"We cross the river by feeling the stones with our feet"
(Chinese proverb)

Most of the ideas in this handbook you already know from living your life. Here we put your everyday experience and knowledge into the language of managing water.

In the last twenty years, there has been a lot of talk about new ways to make Integrated Water Resource Management or "IWRM" work, but not nearly as much useful knowledge about how to put those ideas into practice. We now know how to use a set of ideas and ways of understanding that help us to make IWRM really work practically. We call this practical way of working: **Adaptive** IWRM.

This is the first in a series of handbooks to come out of a WRC project Practising **Adaptive IWRM** *(Integrated Water Resource Management (IWRM) in South Africa: towards practising a new paradigm* [TPNP]).* The TPNP project researchers have had experience with many different situations in southern Africa, where people have grappled* with putting the ideas of complexity* and integration into practice.

Researchers in the TPNP project used Adaptive IWRM practice to take difficult water problems forward:
1. *In the Crocodile River (West) the problem is deteriorating water quality and the threat to water resource protection.*
2.

    Adaptive IWRM facilitated recognition that no single water user can improve water quality in the river. A group of water-dependent industries, other stakeholders, researchers and the Inkomati-Usuthu CMA (IUCMA) worked together. As a result of listening and co-learning, participants became more aware of i) all fellow-user's needs, ii) upstream/downstream connections were clarified, and iii) connections were made between social, institutional and bio-physical processes.

    An outcome was a clear request for more public water quality data. At this point technical research helped. A new model that links water quality and water quantity was tested. The model delivers water quality in relation to water flow – which means the outcome of pollution and dilution together, can be made public. One barrier here was identified as the technical capacity of the managing agency. We are now working on simpler methods as well as technical training. It is important to note that the immediate response of better public information has not happened. Before the Adaptive IWRM research, the managing agency did not realise the critical importance of better public water quality information, and especially information about interconnections, for example upstream-downstream interactions. Working together built trust and we got to the point of model installation. Adaptive processes are repeated, with steps forward in each cycle. Now we see two "next steps": 1) address technical capacity in the managing agency, AND 2) look for a more simple/coarser approach to linking flow and quality.

    IUCMA noted improvement in meeting the river protection objectives and linked this to this project.

This process strongly influenced the new Water Quality Management Policy and Strategy (DWS 2017).

3. *In the Makana Municipality, the problem is low water security experienced by residents.* Adaptive IWRM enabled i) civil society research activities that focussed attention of household water supply; ii) engagement with both the municipality and the Mzimvubu-Tsitsikamma proto CMA. As a result, the first combined Catchment, Water and Sanitation Forum was formed and is supported mutually by the Mzimvubu-Tsitsikamma proto CMA and the Makana local municipality. Stakeholders including business, emerging and commercial farmers, academics, residents, and NGOs have joined their knowledge and co-developed a local catchment management strategy.

    The main outcome has not yet improved civil-society experience of water reliability – but there is now a non-statutory, participatory governance institution – the forum – to engage with statutory water institutions.

4. *In the Mbombela Municipality the problem is varying Green Drop performance by wastewater treatment works, and pollution of the river by sewage effluent.*

    Adaptive IWRM supported a group of municipalities to participate in a Green Drop Campaign that exposed underlying non-technical problems with wastewater treatment works performance. The outcome has not yet been to improve Green Drop performance. It did bring municipalities together to consider the barriers to this. The outcome highlights that technical solutions alone will not improve WWTW performance. Attention has to be paid to underlying political issues. We don't yet know how to do this – further engaged research, using political ecology, is likely to take this issue further (Palmer and Munnik 2018).

Adaptive because of complexity

It is useful to understand why the word "adaptive" is so important.

We recognise that water resources are part of landscapes that include people, who make up society, and living and non-living things that make up ecosystems. We call these interlinked systems – social-ecological systems.

Catchments include all the linkages between
- people within society,
- the different components within the ecosystem, and
- society and ecosystems.

They are therefore identified as **complex*** social-ecological systems.

All complex systems have a set of characteristics in common: all the components or elements of the systems are interconnected; the connection and elements influence each other in ways called feedbacks. The connections do not always behave in a linear* way. We need to understand the connections if we want to influence them. (Figure 1 and Table 1). When we take account of linkages in this way, in the management of catchments, that is the reason for calling the process **Adaptive IWRM.**

In the past, understanding and actions were based on the assumption that processes were linear. Actions were dictated from 'the top', and management styles were 'command and control'. Those approaches and actions have not been successful in producing equity or sustainability.

Experience shows that **before** putting ideas into practice, we need to use a **_new way of thinking_** about issues. The new way of thinking greatly influences and improves chances of success. This handbook outlines the new way of thinking in as practical a way as possible. We advise you to read this handbook, together with any or all of the other handbooks in the series, which deal with more specific aspects of Adaptive IWRM.
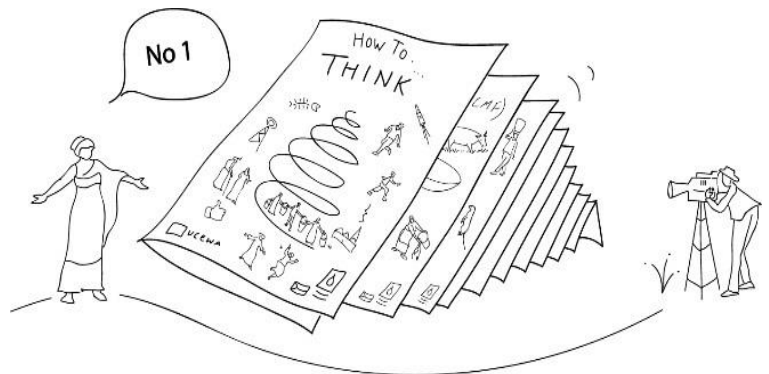
We are "navigating difficult waters without causing a shipwreck". We encourage upbeat* but realistic pragmatism*. *We are trying to practically reach IWRM goals, but the way there is difficult. However, we encourage you to be positive and practical.*

This handbook cannot possibly give readers the complete theoretical background to the new thinking; please use the Reference list for more information.

Some vocabulary and background
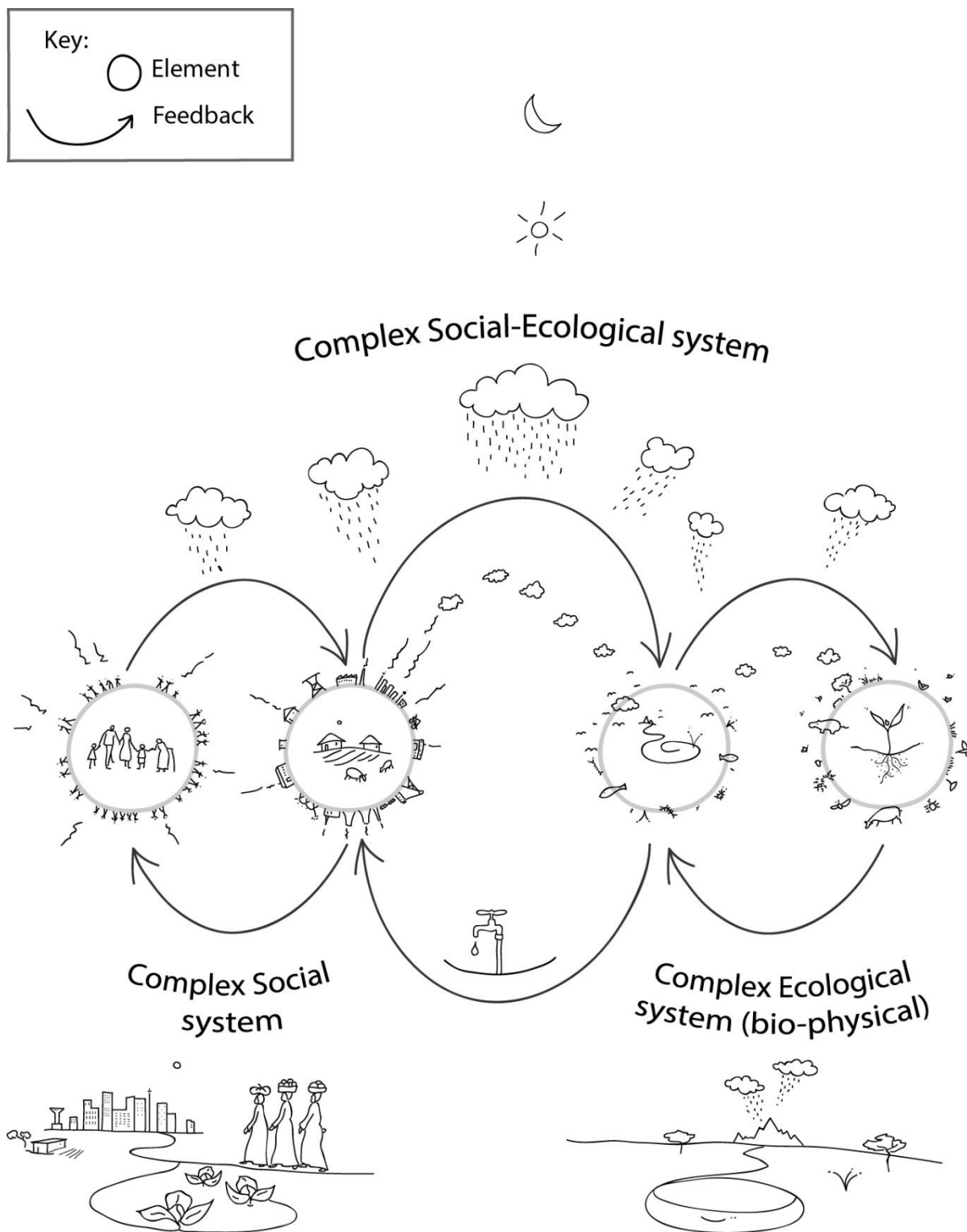
Figure1.Social systems are complex systems where the interactions and feedbacks are between people. Ecosystems are also complex systems, but the interactions and feedbacks are between the physical (such as temperature, pH, chemistry) and biological living parts of the earth. Where complex social systems interact with complex ecosystems, such as in ALL-natural resource management, the systems are called **complex social-ecological systems** (CSESs).

If you, the reader, want to practice Adaptive IWRM, it is helpful to internalize the characteristics of complex systems – as you do so, your expectations of, and responses to, water resource issues in catchments will change – and you will become more adaptive.

Table 1: Characteristics of complex systems, related to catchments, which are complex social-ecological systems (CSESs).

Characteristic	How to recognise the characteristic in a catchment* as a CSES
Many elements	There are people, biological, physical and chemical factors in the system, for example in a catchment, a municipal area, or a national park.
Non-linear processes	The way in which one factor affects another is not always predictable. For example, an increase in a grant for municipal infrastructure does not necessarily mean improved water infrastructure; it might have a different result altogether.
Spatial and temporal scales* affect feedbacks and processes	Social learning* and the co-development of knowledge happens more quickly in smaller groups, and where trust has been built between people and organisations.
Small changes can have surprisingly large effects	The results of intervention can exceed expectations – usually because multiple positive possibilities happen to coincide*. These coincidences cannot be controlled, however.
Large interventions can have disappointingly small outcomes.	Some interventions 'fail'. In these cases, serious barriers coincide and cannot be overcome.
The context of an issue shapes the issue	Every issue arises in a context and the elements of the context interact – the issue can't be separated from its context.
The history of the context shapes the context – so we need to consider the current and historical context of issues	All current issues have a history – and the current state of the system includes a specific direction and momentum* of some processes. We need to know the history of issues because these histories influence the way we engage with the system.

Why is it useful to know these characteristics?

If you are involved in water resource – or catchment – management, you will have found 'community/stakeholder engagement' challenging in some way. Knowing about CSESs changes your expectations, for example:

- You stop seeing consultation as a waste of time and money, and start to see it as essential for sustainable outcomes.
- You are not discouraged by delays and perceived failures, because you know these are inevitable.
- You become convinced that the whole process – no matter what it is like – is an opportunity for everyone to learn: yourself, other managers, all resource users, and the wide community of stakeholders.
- You are willing to persist and persevere. You realise that this longer road is the ONLY road likely to deliver fairness, sustainability and appropriate efficiencies in the long term.

Engaged transdisciplinary* action research:
Because it is based on an understanding of complexity, TPNP research is:

- engaged – researchers connect directly with the people who experience the problem and the people who want to solve it;
- transdisciplinary – researchers bring and use a wide range of specialist and local knowledge, and pay attention to integrating new knowledge as it becomes known;
- action research: researchers learn by doing (Figure 3);
- USED not just potentially useful.

We know we cannot build huge dams and inter-basin transfers without technical expertise. In the same way, we cannot expect to engage with CSESs without understanding how these systems work. When we understand them, we are in a better position for the technical interventions to produce the results we hope for.

From seeing a 'troubled situation' to seeing a 'challenging condition'

Every one of us could write our own story of 'the state of world' or 'the state of water in South Africa'. The stories may have notes of hopefulness, but would certainly include a sense of despair. Often, we feel that we struggle helplessly with seemingly impossible problems whose causes are elusive* and where 'solutions' are scarce. "The problem is……" is often the start of a conversation, and just as often is followed swiftly by, "The solution is…….".

This sort of conversation about problems is often oversimplified and blaming, and solutions are usually draconian*, and may be disastrous for some people. People with fewer resources and little power are in a situation where they will suffer most. Yet we continue to aspire*, to dream, and to hope. Human beings have invested heavily in science and technology, and have a child-like, unreasonably strong belief that science and technology will find solutions. This belief could be wrong. We are also facing the great puzzle of how we can continue to grow and use up more and more resources on a planet that is finite.

So, this handbook series encourages the attitude that, although these conditions are difficult, we can work out ways of navigating* them sensibly.
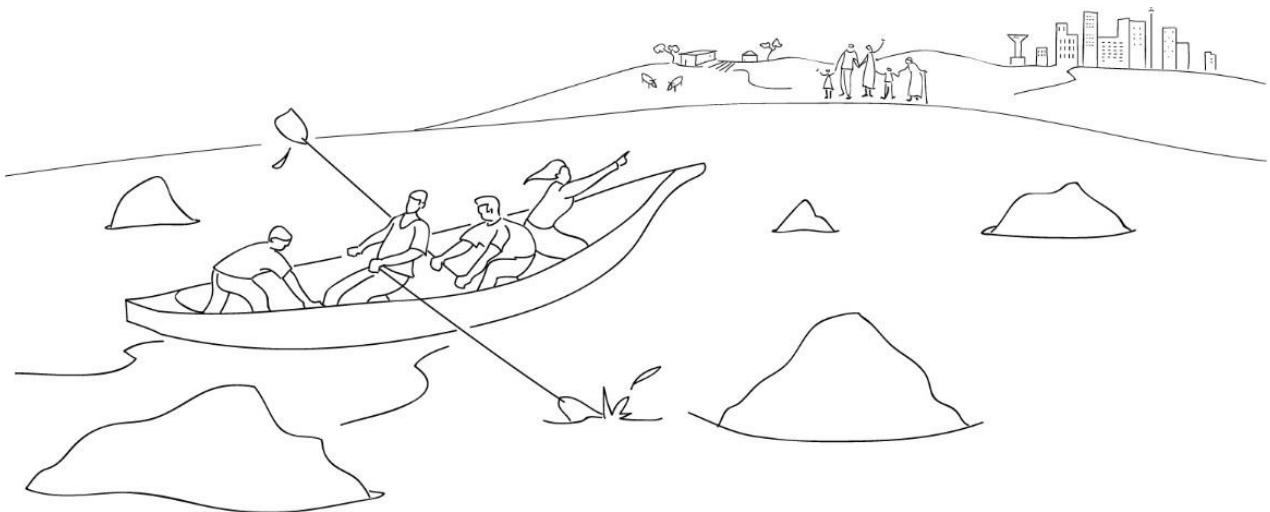
Water in South Africa

The basics:
- South Africa is a water-scarce country;
- rainfall is unevenly distributed;
- we are vulnerable to climate change;
- we have a legacy of inequity and we must use resources to restore justice and grow a vibrant economy;
- we know silo-thinking doesn't work;
- we know there are limits to the multiple connections and implications that can be accounted for; and
- we know that a good water law does not automatically become a good water experience.
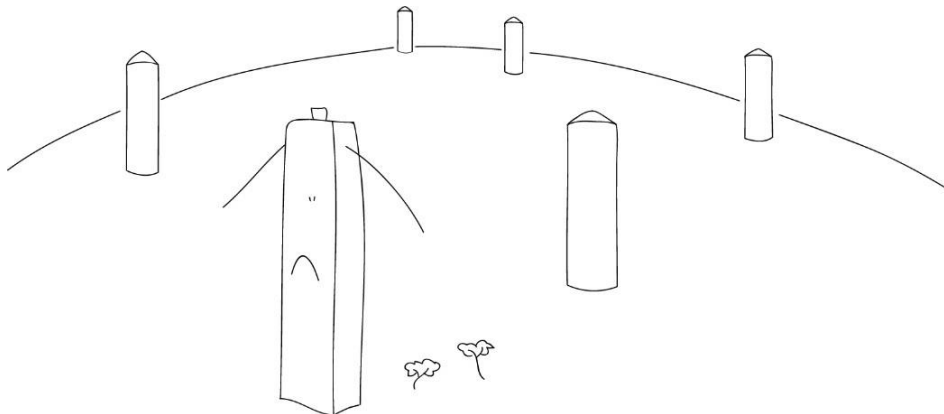
The authors of this handbook have worked in the water sector for decades. They have gathered evidence from several sources and put it together as a new and better way of dealing with water issues than the old 'business as usual' approach.
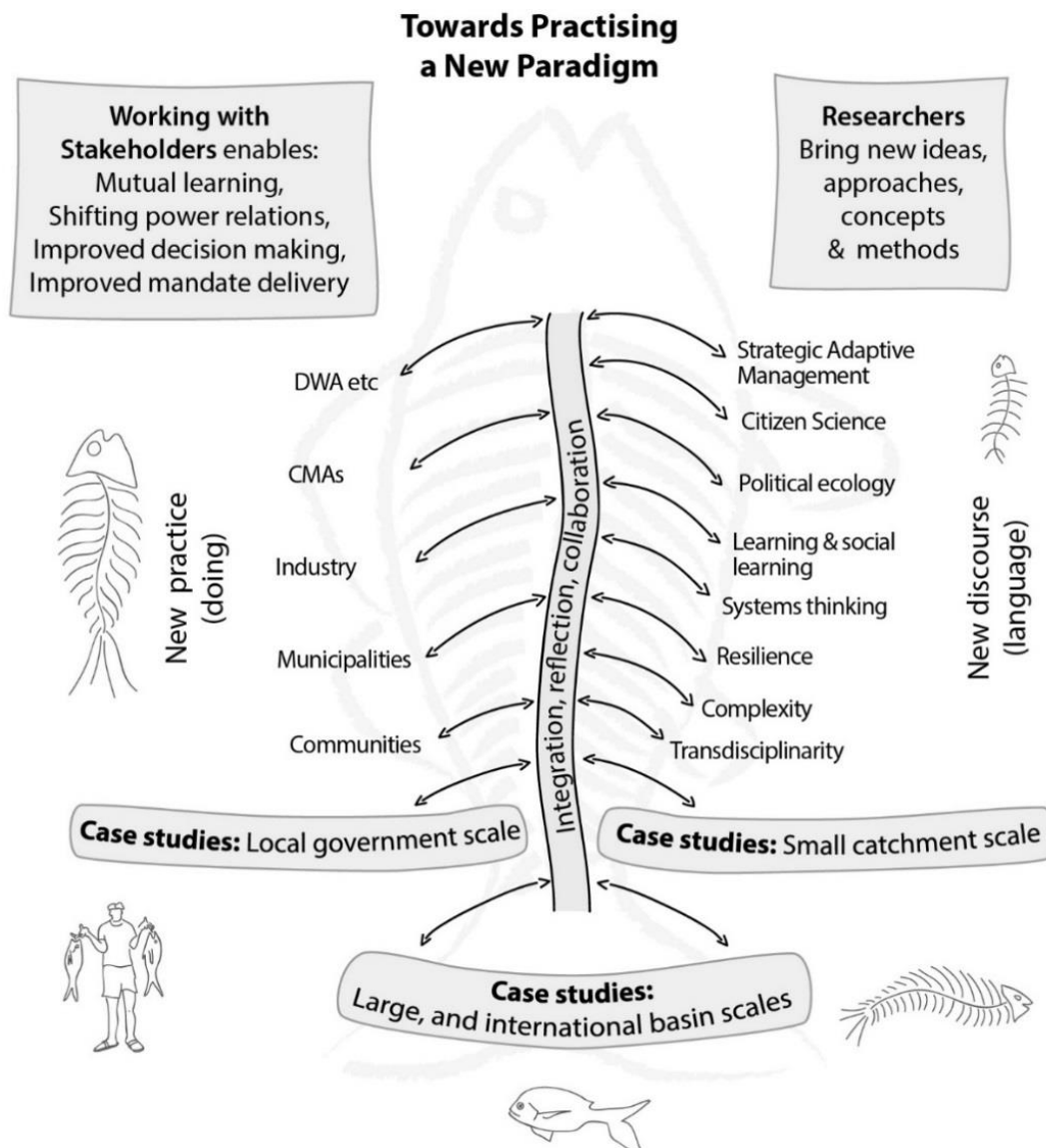
Be upbeat but realistic: this is a new and different approach with a new way of thinking, one that supports new ways of doing things.

You may have already heard much of this background 'theory' and 'talking', but now we summarise what we have learned from several situations where groups have been grappling, to actually implement the new thinking.
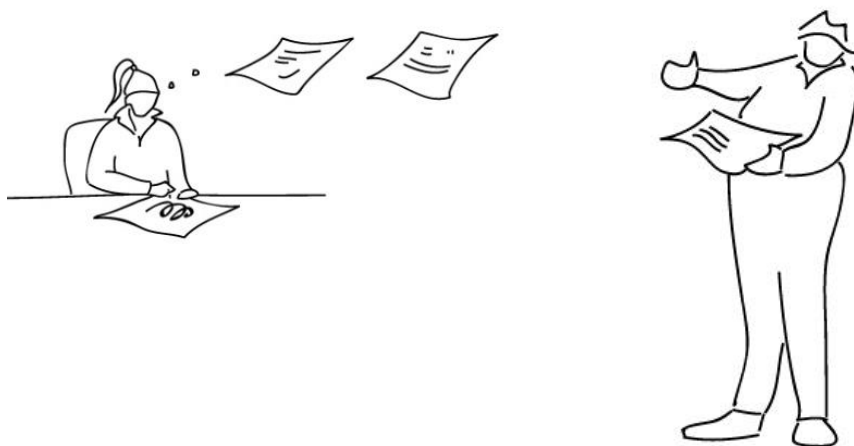
2. THE 'FISHBONE' – A CONCEPTUAL FRAMING FOR ADAPTIVE IWRM

At the start of the TPNP project, researchers created a diagram to guide the research. The diagram became known as the 'fishbone'. It brings together key perspectives that need to operate in unison in order to achieve the 'new paradigm' of Adaptive IWRM in practice.

Towards Practising a New Paradigm

Working with Stakeholders enables:
Mutual learning,
Shifting power relations,
Improved decision making,
Improved mandate delivery

Researchers
Bring new ideas, approaches, concepts & methods

New practice (doing)

Integration, reflection, collaboration

New discourse (language)

DWA etc
CMAs
Industry
Municipalities
Communities

Strategic Adaptive Management
Citizen Science
Political ecology
Learning & social learning
Systems thinking
Resilience
Complexity
Transdisciplinarity

Case studies: Local government scale

Case studies: Small catchment scale

Case studies: Large, and international basin scales

Figure 2: The 'fishbone' diagram'

Look carefully at the components of the diagram – especially the list of theories and ideas on the right-hand side of the 'fishbone'. Please note: this part of the handbook does NOT go through each of the conceptual* elements in the diagram, but the reference list includes further readings at different levels of detail, and a detailed explanation of the parts of the 'fishbone' can be found in Appendix A.

Instead, the handbook shares what we have learned from our practical experience. Many of the case studies show exactly the general principles explained in the handbook, so you can apply the general principles confidently, and feel sure about the insights provided by the case study examples. The handbook highlights the most common ways for avoiding frustration and delays in achieving, or failure to achieve the results you intended.

I can't help you solve your problem, but I can help you to think in a way that will help *you* to solve your problem.

This insight from the late Paul Cilliers, a leading complexity scholar, was often shared with those learning from him.

The 'fishbone' diagram illustrates an interactive* process where new ideas about complex social-ecological systems (for example, catchments) can influence the way different water sector stakeholders could manage water resources in a more integrated manner. In the **interactive** process**,** several things happen:

- mutual learning,
- a shift in power relations,
- improved decision-making, and
- improved mandate delivery.

However, these benefits emerge slowly; there are setbacks, apparent 'failures' and it is essential to persist – don't give up! The process of *learning* together is like a spiral of learning together by *doing* together. This spiral is accelerated by *being* together through reflecting together.

When everyone reflects on the process, there are greater benefits (the middle column of the 'fishbone'). Pay attention to integrating ideas, and always strive to collaborate across different 'silos'. Consciously reflecting throughout any Adaptive IWRM processes encourages new insights to emerge.
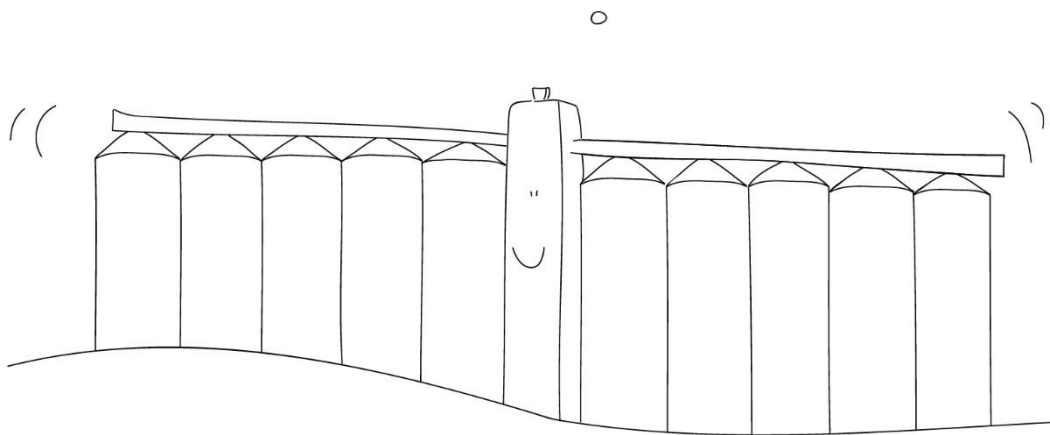
The Adaptive IWRM vision is:

- When research is done with an understanding that people in catchments are part of complex social ecological systems, and using appropriate complexity- and systems-based approaches and methods, a deeper understanding of and belief in equitable, sustainable and Adaptive Integrated Water Resource Management (IWRM) will be put into practice in South Africa.
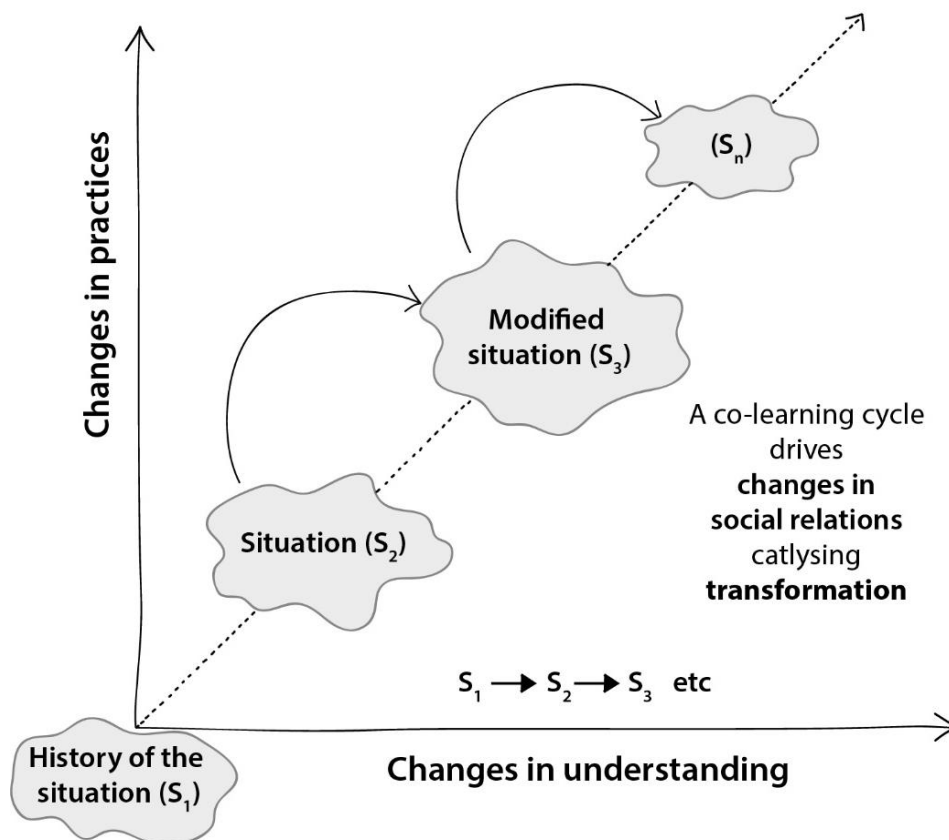
Figure 3: This diagram shows what happens when you start in a situation in a context, with a history. As you start doing things (changes in practice), your understanding changes. Different people know different things and all contribute their knowledge, understanding, and learning from actions (practices), and so the situation changes. The process of change is transformation. (Adapted from Ison, 2010)
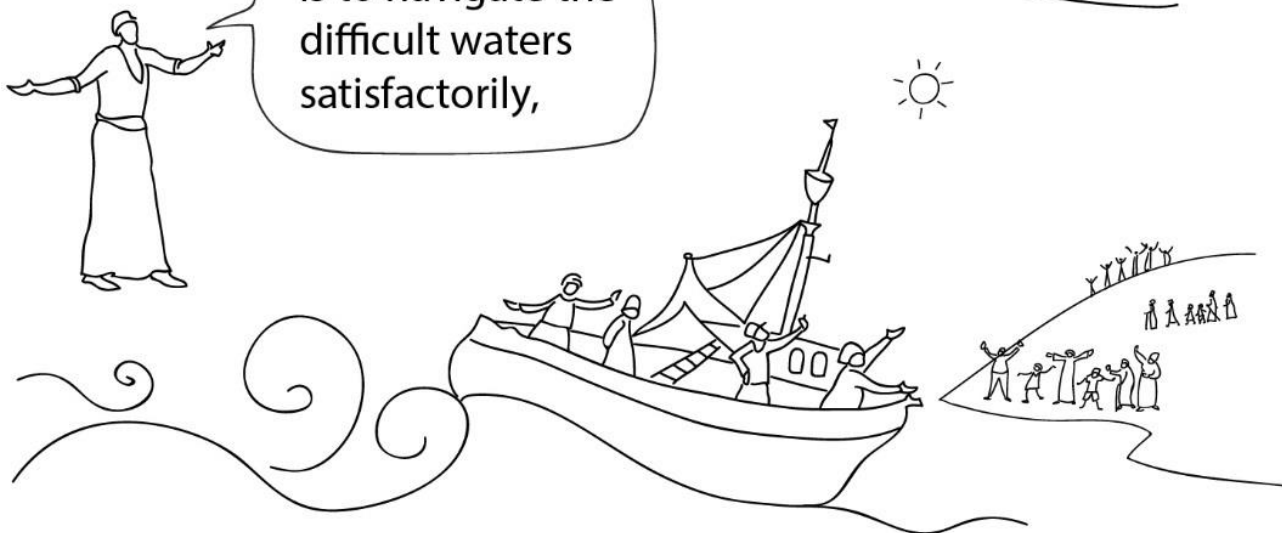

Remember the metaphor are "navigating difficult waters without causing a shipwreck"? Using complexity thinking, is a way of navigating the difficult waters of catchment management satisfactorily, rather than charting* a potentially perfect course based on assumptions that exclude surprise and adversity*.
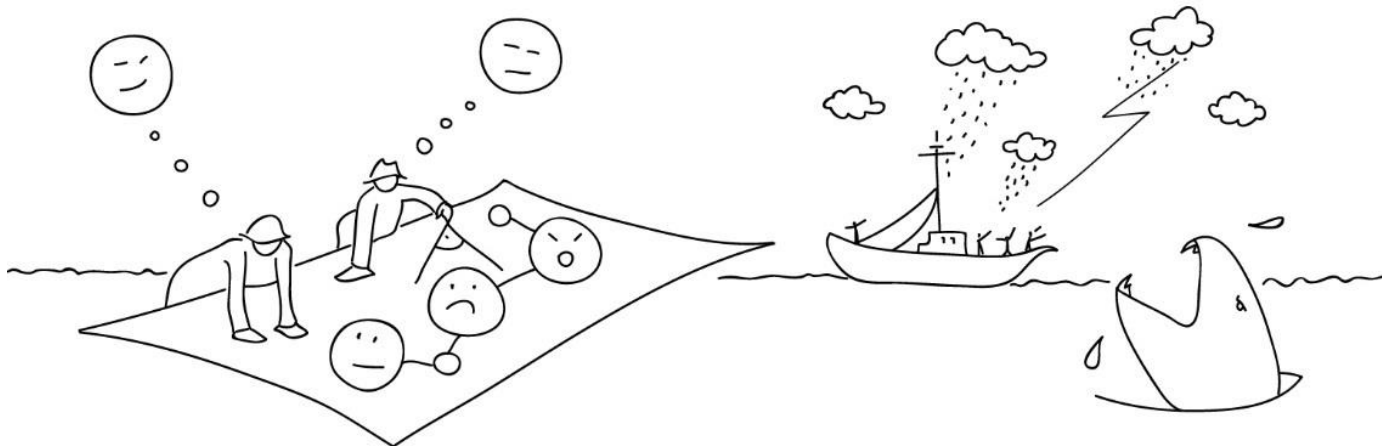
People learn to trust in practising these new ideas from reading informative material and from experience. The TPNP case study results are examples of what can be read, and are reported in detail in the TPNP final report to the WRC (Palmer and Munnik, 2018). Each case study was undertaken at a different scale because CSES processes, and therefore any interventions to improve a situation in a CSES, will be different at different scales. Spatial scales, governance*/management scales and relational scales differed between case studies:

- The Makana Local Municipality case study was conducted at the local, small sub-catchment spatial scale and the local municipality governance scale. Relational scales ranged from inter-personal to inter-institutional. Research focussed on the involvement of the local community in water security issues, because the local community indicated this was their priority water issue. Therefore, household water security was added to the issues addressed using TPNP approaches. The main recommendation was to implement programmes for households to have individual water storage tanks, either filled from municipal water when it is available, or from other local water supplies. Stored water used for drinking must be simply treated by boiling for five minutes or adding 5 ml (1 teaspoon) bleach per 20 litres water, allow to stand out of sunlight for 24 hours.

> Two lessons for Adaptive IWRM practice and learning:
>
> 1) The priority of your research partner/s might be different from the priority of your research funder. In this case, we adapted to include our partners' priorities.
>
> 2) In local municipalities, any intervention needs to be linked to financial processes and procurement: connect with the CFO!
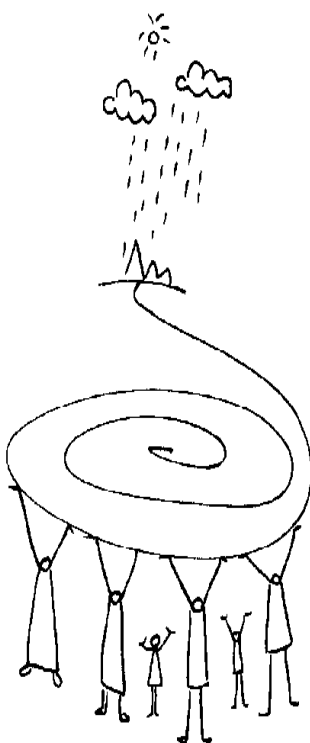
The Crocodile River (West) case study was undertaken at the small catchment* spatial scale and regional, Catchment Management Agency (CMA)* governance scale. Relational scales included the inter-personal, and inter-institutional scales. Research focussed on river water quality issues and the innovative use of the Green Drop programme to go beyond technology in addressing eutrophication and microbial pollution.

Two lessons for Adaptive IWRM practice and learning: Trust-based partnerships are essential.

1) Local municipal politics in the context of regional and national politics, plays a huge role in WWTW efficiency. WWTW workers are generally committed and interested in improvement, but political power (such as decisions to use funds granted for municipal infrastructure, particularly WWTW, for other purposes) is a barrier to effective wastewater treatment.

Action: engage with COGTA (Co-operative Governance and Traditional Affairs), and facilitate high level COGTA-DWS (Department of Water and Sanitation) partnership in prioritising WWTW efficiency.
2) Work to ensure good representation in your local CMF catchment residents.
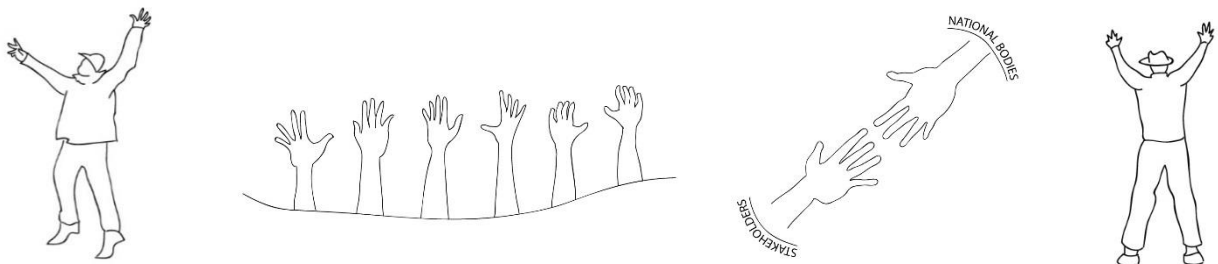
- The Olifants River associated case study was undertaken by the Association for Water and Rural Development (AWARD), at the large catchment and international basin scale. The governance scale was regional, but there was no CMA, rather a regional DWS office. Relational scales included inter-personal, inter-institutional, and international scales. The focus was on learning to practice adaptive water resource protection. Funding (USAID, $10m) and duration (7 years) of the Olifants RESILIM-O project were also at substantially larger scales. The TPNP and RESILIM-O researchers and practitioners al all practised Adaptive IWRM, and there was extensive mutual learning and knowledge exchange. The RESILIM-O project has the advantage of greater coverage and depth – and the increased time necessary to make connections and learn from them. The RESILIM-O project has its own website and publications.

Two lessons for Adaptive IWRM practice:

1) There is very little understanding of 'resource protection' among local people living in any catchment. This means that stakeholder engagement in DWS processes such as Classification, determining the Reserve, and setting Resource Quality Objectives is unevenly understood, giving greater power to stakeholders such a mining and industry, and less power to local residents, especially in rural areas.

2) It is possible to communicate meaningfully with local residents (urban and rural), about a system-based understanding of their catchment, in a process that includes both sharing knowledge with local people and learning from them. In this process, a common understanding of water-related ecosystem services and sharing ecosystem benefits made it possible for catchment residents to participate more meaningfully (www.award.org.za).
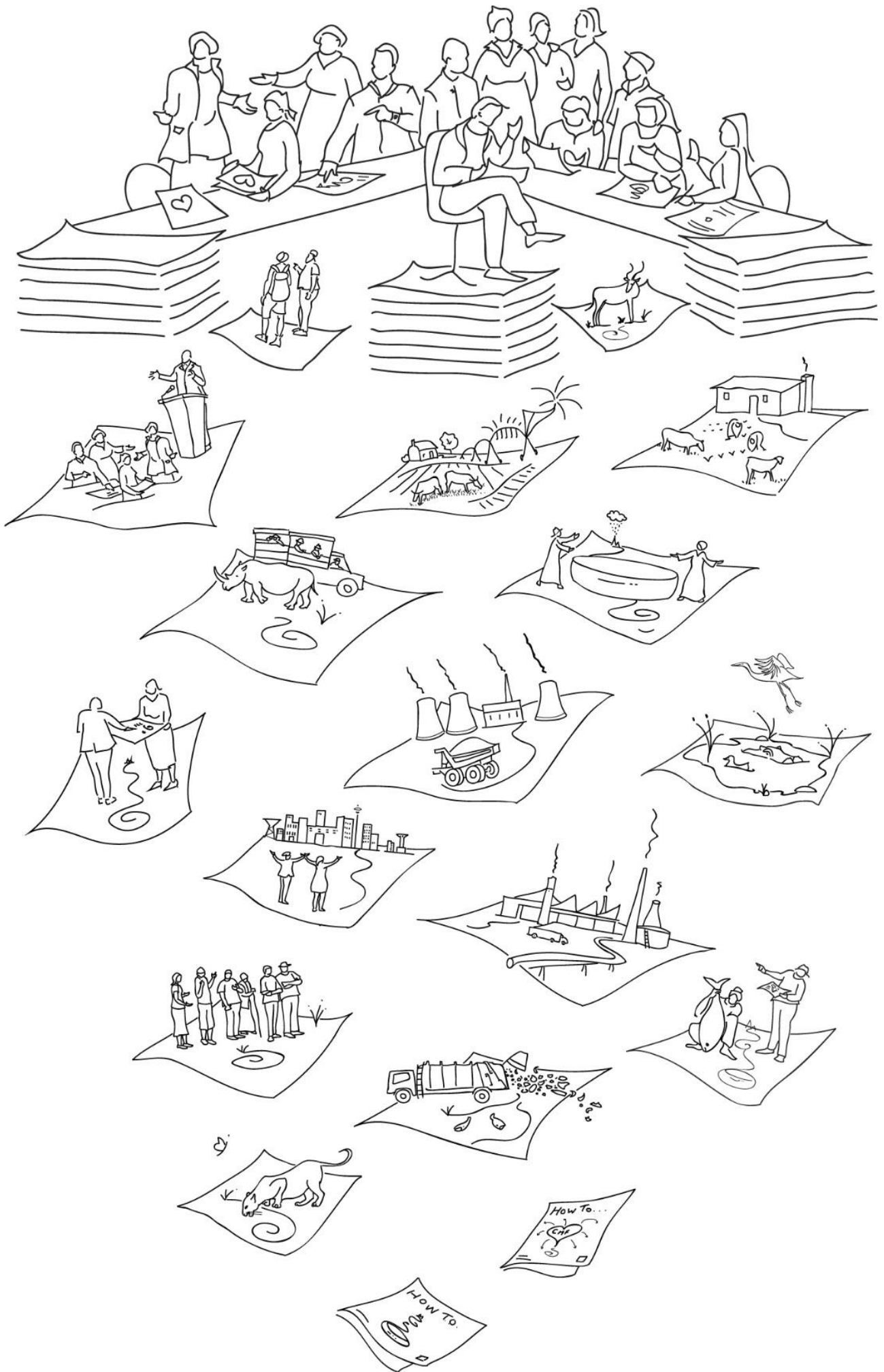
3. PRINCIPLES FOR PRACTICE

Thinking before practice
There are several core* ways of thinking that must be taken into account in practice.

The imperative of working at multiple scales*
We all live in a catchment… but what does that mean for making sure that the area of land that provides us with a home is properly cared for, and that the water in our particular catchment or sub-catchment is well managed?

Using a catchment as the unit of water (and land) management is a fairly recent idea, and there is patchy experience about how to do it effectively. Rivers are often used to define important boundaries, and rivers run through the middle of catchments. In addition, land is mainly divided up according to political and administrative boundaries without thinking about river catchments. This means in Adaptive IWRM we usually have to take account of multiple, overlapping boundaries, and a range of institutions.

In South Africa, our water law recognises that we need to manage ourselves, our resources and activities in regard to catchments. So, we have to work in very different ways from the way we worked in the past. For example, because parts of some rivers and catchments are in neighbouring countries, we need to involve those countries in water management plans and negotiations. Water governance operates differently at international, national, and regional scales.

Maps and geographical information systems (GIS) are essential tools.

There is no 'one size fits all'
Management, as well as governance, operates differently at different scales. For example, managing a river that crosses a number of international boundaries needs management practices and managers from all the different countries through which the river flows.
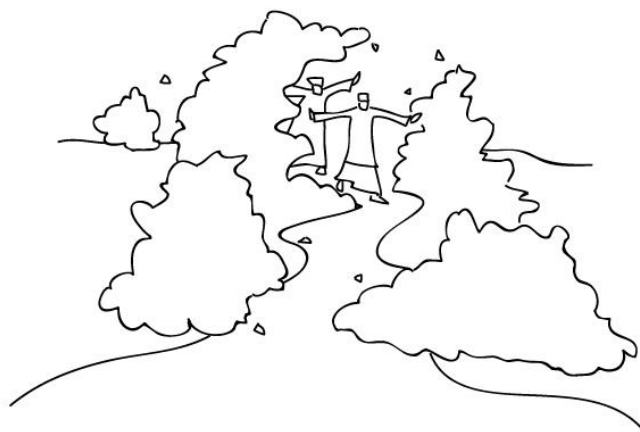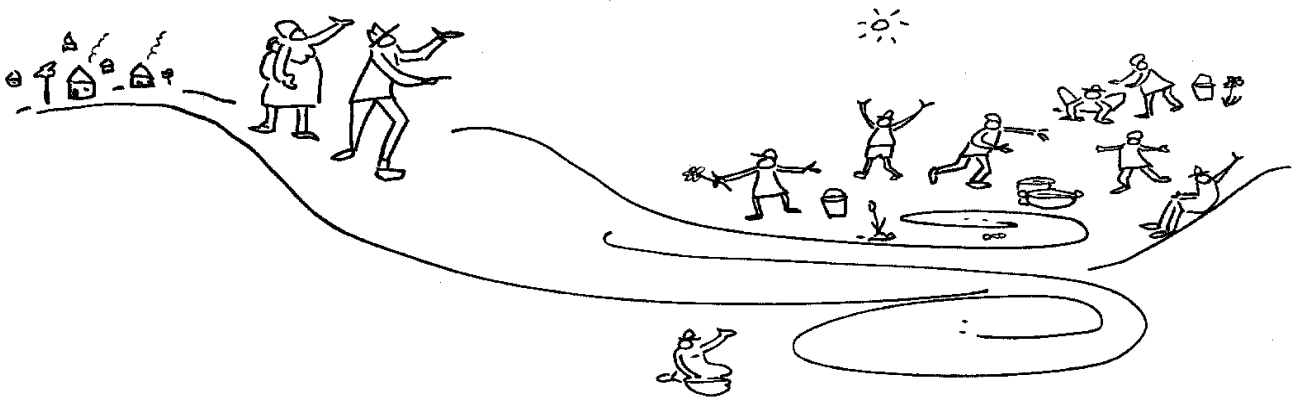
This handbook presents some of the results of work that has been done in the last twenty years in practising the new paradigm of CSESs. (See the case studies at the bottom of the 'fishbone' diagram, Figure 2.) The work was carried out at four different scales:

1. Trans-boundary level (i.e. involving more than one country);
2. Large catchments involving only one country;
3. Smaller catchments and scales where management is conducted over parts of catchment (i.e. under political or administrative boundaries), and
4. Municipal (local government) scales.

These scales are spatial and related to governance and institutions. In addition, there are relational scales that depend on the number of people involved in interacting.

Table 2 is a summary analysis of what we found when we used 'fishbone' thinking applied at these different scales. The table shows that the moderate to small catchment scale (3) has generally been the best level at which to make progress. We know from experience that obstacles at scales upward (1 and 2) and the scale downward (4, the municipal scale) will be an issue – so much so that further progress at this small catchment (3) scale will probably be limited if we cannot improve performance from the scales above and below.

This means that lessons from smaller and larger scales are less common and particularly valuable. (Look at the work done in the large-scale project RESILIM-O (http://www.award.org.za/project/resilience-in-the-limpopo-basin) and at the municipal scale by Jai Clifford-Holmes [2015]).

Table 2: A literature-based summary of progress in the practical application of new paradigm thinking: O = reasonably advanced; o = started, with some progress; x = still to engage with new paradigm thinking and practice. (This table is expanded and fully referenced in Palmer and Munnik, 2018).

SCALE ⟶ TPNP Concepts (see 'fishbone' diagram, Figure 2)	Transboundary basins/catchments (across two or more countries) E.g. Inkomati, Limpopo Rivers.	Large catchments in one country E.g. Vaal, Orange, Olifants Rivers	Smaller catchments E.g. Sabie, Crocodile, Sundays, Berg Rivers	Areas within a catchment under Local government E.g. Sundays River, Makana, Mbombela Municipalities
Complex Social-Ecological Systems (CSES) approach	O	o	O	x
Strategic Adaptive Management (SAM)	O	o	O	O
Transdisciplinary approaches	X	o	O	O
Social Learning	X	o	O	O
Systemic thinking – seeing links and interconnected functions as well as elements	O	o	O	O
Citizen science	X	o	O	O
Political ecology	X	o	O	O
Resilience thinking	O	x	O	X

Once we have accepted the reality of CSES – and we must recognise that each circumstance, through time, across space, and with particular people, is unique, with a unique context and history (Figure 3). However, for practical purposes, we also have to have some generalisations to work with. Adaptive IWRM emphasises the importance of **principles,** rather than recipes, rules or specific guides**.**

Principled practice
The difference between a recipe (or set of rules) and a set of principles is this:
- principles are generalisations that last, they endure;
- principles can be applied in different circumstances.
The context and history drive the specific way in which the principle will take its form.

A critical first step in the South African water law review was the development of primary and secondary principles. There were designed to guide implementation. Sadly, in the decades following the early democratic hopefulness, a state close to a paralysis has developed that limits decisive action towards implementing the NWA. There is a real danger that it becomes easier to review the law than to persevere with the tough task of making equity, sustainability and efficiency real. Review can be positive, for example a better linking of water resource management and water service delivery and supply. **We strongly encourage politicians, senior government official and managers to remain committed to the fundamental principles – and to use Adaptive IWRM to do so.**

The kind of national transformation required by the NWA is **revolutionary and radical**; it takes a great deal of **courage** to overcome the lack of interest. In fact, it requires re-wiring of how our brains work because, in this democracy, we have to change our thinking from the old, 'top-down' approach to policy implementation to a new thinking in which dialogue among diverse stakeholders is vital.

In the past, the water itself was the central focus of management, now we must act to manage water as a vital part of a CSES.

So, what does this mean?

> It is helpful here, to go back to the characteristics of 'complex systems' (Table 1) and see how different they are from the way we saw the 'world' in the past.

As we move into principles of what to do, how to do it, and how to check actions, we have provided tables and lists of principles. Details of derivations and applications can be found in the literature cited.

Action – WHAT you should do

Several groups of people have been working in the new, complexity-based system over the last ten years and more. Together, several of these practitioners developed a set of principles for 'new paradigm' IWRM practice (Palmer and Munnik, 2018).

Principle 1: Encourage 'learning by doing' and 'doing in order to learn'

In the past we thought situations changed because we learned new things. We thought solutions were simple and that people became aware of new knowledge and then learned new ways of acting. We thought solutions could be achieved by a 'transfer of knowledge'.

Now we understand change happens slowly, and in small steps. We need to share what we know with others who know different things, and with people who know things in different ways. As we respond and personally change, we become part of the transformation 'learning by doing' spiral (Figure 3). This kind of learning builds long and trusting partnerships between stakeholders. Managers and implementing agencies should join in with this learning, and work **with** their stakeholders, only using enforcement when co-operation fails (Roux et al., 2006).

Principle 2: Make social issues a priority

Physical and environmental scientists, and engineers, have dominated the water management scene and must now unlearn many of their traditional ways of seeing and doing things in order to accommodate the social sciences.

It is really important to co-learn and co-develop knowledge across science, social science and the humanities (like art, dance, creative writing).

Principle 3: Pay attention to the social context in which you apply your decision-making

Assigning rules and 'recipes' for doing things usually backfires because different ways of doing will achieve change towards a desired future, depending on contexts and circumstances.

Principle 4: Use values and principles to guide contextual decision-making

Because context is so important and so variable, practice and decision-making need to be guided by sets of principles and values that are developed among stakeholders. This provides the opportunity to adapt decisions and practice within the specific context. Rules, recipes and directives seldom support lasting implementation.
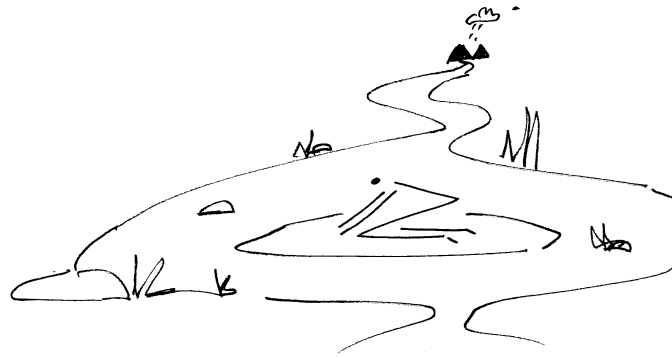
Principle 5: Make sure that decision-making promotes social and environmental justice
Change will only come if stakeholders see new opportunities to move toward a better future.

Rules are not actually easy to implement or change – and relying on rules without paying attention to justice produces social unrest.

Principle 6: Pay attention to power relations and give voice to the voiceless
In general, the powerful are happy with the way things are, and will use distraction to prevent change, while the less powerful will lose even more of their voice.

Create opportunities for the less powerful to speak and be heard. Listen.

Principle 7: Stakeholder-centred facilitation is critical
Make stakeholder input the central theme of any engagement. Do not do superficial, meaningless 'stakeholder engagement' in order to 'tick the box' of policy requirement. Do not do what is known as a DAD (Decide, Announce, Defend) or even RDDA (Research, Develop, Disseminate, Adopt). These approaches come from using outside experts to find a solution to a problem that they think the stakeholders have.

Make decisions and propose solutions based on how the stakeholders see the issues and on their capacity to solve them. Do not overvalue how the visitor, outsider, or 'specialist' sees the problem – or the solution. They probably only know parts of it.

Always build on existing strengths and opportunities before proposing something completely new.

Principle 8: Cooperatively cultivate a shared understanding of the issues at hand
Talk through the context and the problem together – sharing different ways of seeing and knowing. Use these open, trusting conversations to build a **shared** understanding of the challenges. Often stakeholders begin an engagement expecting conflict, and become disheartened and paralysed when the problem seems too huge and tangled to make progress.

This kind of shared communication encourages institutions like Catchment Management Forums to thrive.

Principle 9: Work towards a future that stakeholders desire
Conflict and paralysis* disappear when the focus is on the future, even if it is uncertain. Decide to take possible steps towards the future you desire, rather than getting lost in the mess and conflict of the present.

Principle 10: Persevere with stakeholder-based co-learning and look for ways that are as simple as possible, while taking account of everything that is important.
This is also known as 'social learning'. Citizen science is a valuable learning tool that can lead to untangling the enormous size of a problem and to overcoming apathy. Build confidence in the

stakeholder group by learning for capability (how to do and act), rather than just competency (how to know and understand).

Often specialists 'know and understand' and communicate in ways that become overwhelming for many other people.

> The 10 principles above focus on action – WHAT you should do.
> The following is a set of tried and tested principles that focus on HOW to act.
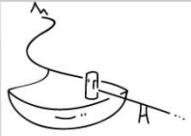
Ecosystem Services

- water supply
- waste transport, processing & dilution
- natural products
- biodiversity
- flood control
- recreation
- beauty, spiritual, cultural needs
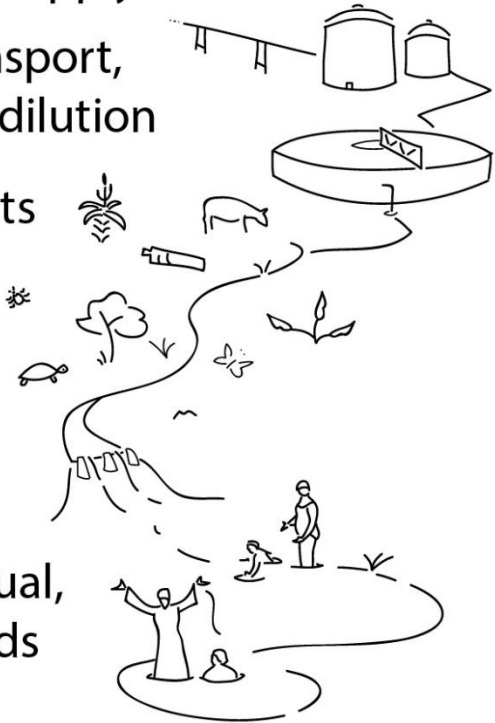
Resource Protection

Social (& Economic) and Ecological benefits

C - SES

people: society
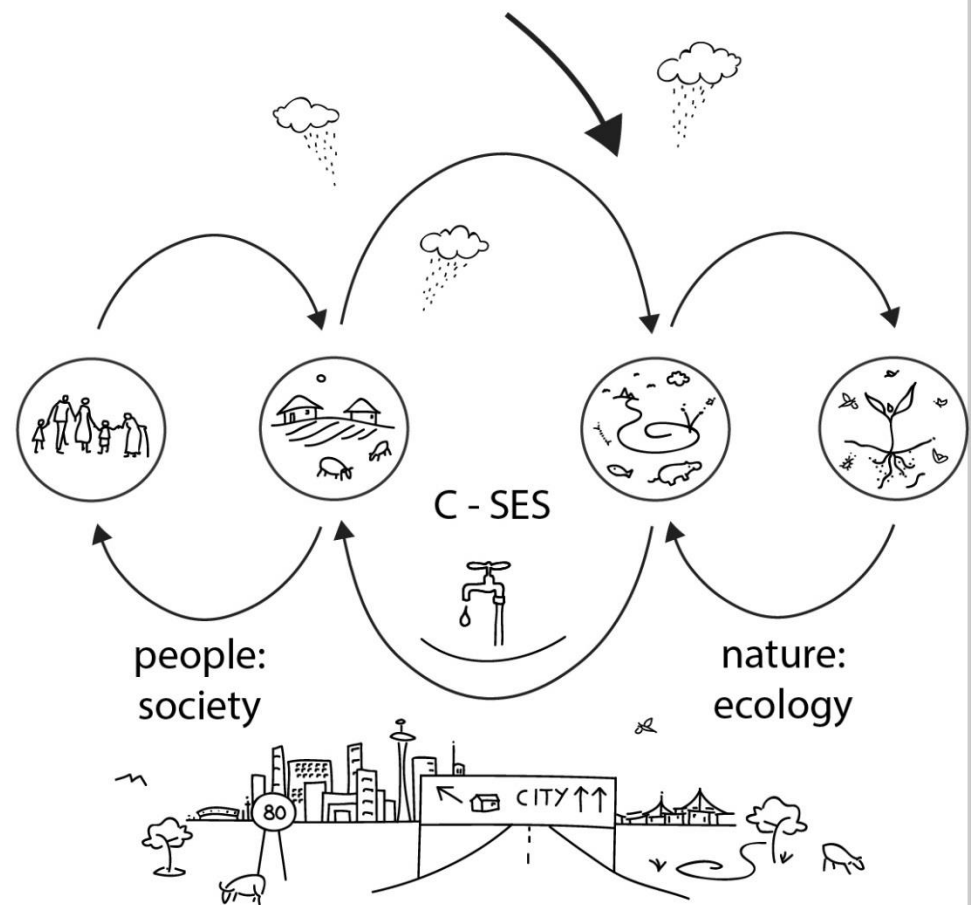
nature: ecology

Complex Social - Ecological system C-SES = people + nature

Action – HOW to action Adaptive IWRM

- Tolerate and even welcome discomfort and unresolved tensions; they are often gateways to knowledge and trust.
- Be sensitive to "Aha!" moments or insights.
- Note that irritation and conflict often signal moments of insight and a learning opportunity.
- Engage with balanced generosity; listen and share.
- Practice tolerance, build integrity and mutual trust.
- Be sensitive to 'arrivals' of both people and ideas.
- Create and use reflective opportunities.
- Manage discontinuities (people come and go, and arrangements change suddenly).
- Sustain enquiry (keep going when it is tough).
- Be conscious that everyone involved in the process is a whole, multi-dimensional person, with the potential to engage with their whole self and with many ways of knowing.

ARE YOU BEHAVING LIKE THIS?

Four practical ways that show you are 'on track'

We have discussed the two primary issues:
- multiple scales
- principles

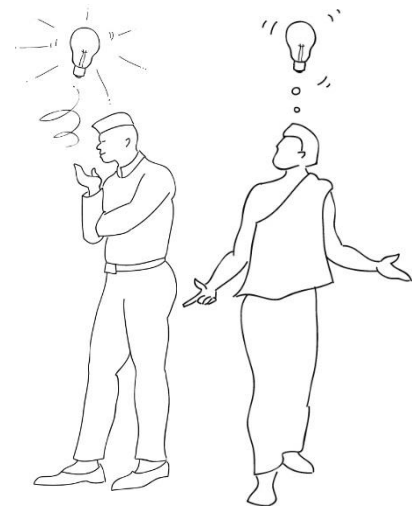There are four other essential practical checks to make sure you are on track with practising developmental IWRM. Use these as an internal checklist to make sure you are practising new paradigm IWRM. If you are not thinking and acting at least partly like this, you will probably have difficulty putting developmental IWRM into practice.

1. Each problem needs to be addressed with *enough* of the right tools by teams and/or staff that include *some* people who can use them.
Experience tells us that if we are going to put developmental IWRM into practice meaningfully, we need to use the set of potential ideas in our 'toolbox' (see 'fishbone', Figure 2). Just as different people use different tools to find their way – a compass, a map, a GPS, or asking people – and everyone will most likely get to the destination eventually, those who use more than one tool will possibly do better. So, we recommend that you use more than one of the guiding ideas. We have noticed that wherever practice has shifted towards effective developmental* IWRM, the new paradigm tools – and different combinations of these tools – are being used. You do not have to use *all* the ideas and methods – choose the ones that will serve you best.

Lessons Learned:
- It seems that using just a selection of the new ideas and practices can shift a situation toward a desired future. For example, the RESILIM-O project focuses on CSESs, resilience and social learning, whereas the Towards Practising a New Paradigm (TPNP) project produced the 'fishbone' model – and focused mainly on CSESs and transdisciplinarity. Each project or study will select appropriate tools. In IWRM, understanding a catchment as a CSES is essential.

- We found that people understand most of the 'fishbone' ideas (Figure 2) relatively easily when they are working on a particular project or at a particular site, because the various ideas/tools overlap. Often different words are used for a similar idea – so look out for these.

Common meaning usually emerges in shared conversations. While it is good to have an open mind about the value of a variety of ideas, we think it is more practical and effective to assemble a team where at least some members have a deep knowledge of the practice associated with some ideas. We have found that some specialists, with important knowledge to share, simply cannot work flexibly and adaptively, and cannot place their knowledge into systemic engaged processes. Often, they feel they are 'wasting time'. Then it is better for team members who can work in a complexity-based way to access their knowledge and bring it into the systemic understanding.

- So, you must decide how many ideas/tools (and which combination) you of want to develop for your purpose. You may land up choosing a combination of three or four where you place your main focus, and these might be determined by available expertise, or your history, as well as obviously being suitable for your particular purpose. We recommend at least two fairly different ones, to help cover the range of challenges you will face. There is more below about a likely sequence of applying the ideas, which works well.

  The reason this point of '*some* useful tools and *some* people who know how to use them' is so important, is that often developers or practitioners waste time searching for the perfect solution, or the perfect team, or get stuck in frictions between the different approaches.

A critical success factor is having at least a few 'people thinking like this', with competencies across two or more concepts or ideas, in your immediate community or project team, working at your particular scale.

But, in addition, it is true over and over again, that there are always individuals present with hidden ability in these skills, and they can be relatively easily skilled, often simply by being present and working with experienced and enthusiastic people.

Growing these 'new champions' has certainly proved possible and often surprisingly effective.

The river management section of SANParks built up an effective team of such practitioners, partly in combination with AWARD in the Lowveld, and they operate in this 'New Paradigm' manner.

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2. Encourage everyone to become comfortable with the inevitable messiness and patchiness
We grow up in a world that values perfection and often (consciously or subconsciously) emphasises the belief that is it possible to 'roll out' initiatives comprehensively across the country. In our experience this is not true, because of the contextual individuality of sites and circumstances. 'Success' in a complex world seems more related to taking account of context than to the perfection of any application.

This **does not exclude** striving towards excellence, and some standardisation of some factors across sites. It **does** mean that excellence should include defining unique contexts, and exploring which aspects are similar across sites and which are unique. We need to find sensible mixes.

Our findings showed that emphasising uniqueness and context was **motivating**, because local residents or managers tended to take pride in reflecting on what makes their situation special. Taking careful account of context can mean participants 'reinvent their own wheel'. This redundancy* – or repetition – is often a strength, and contributes to system resilience*
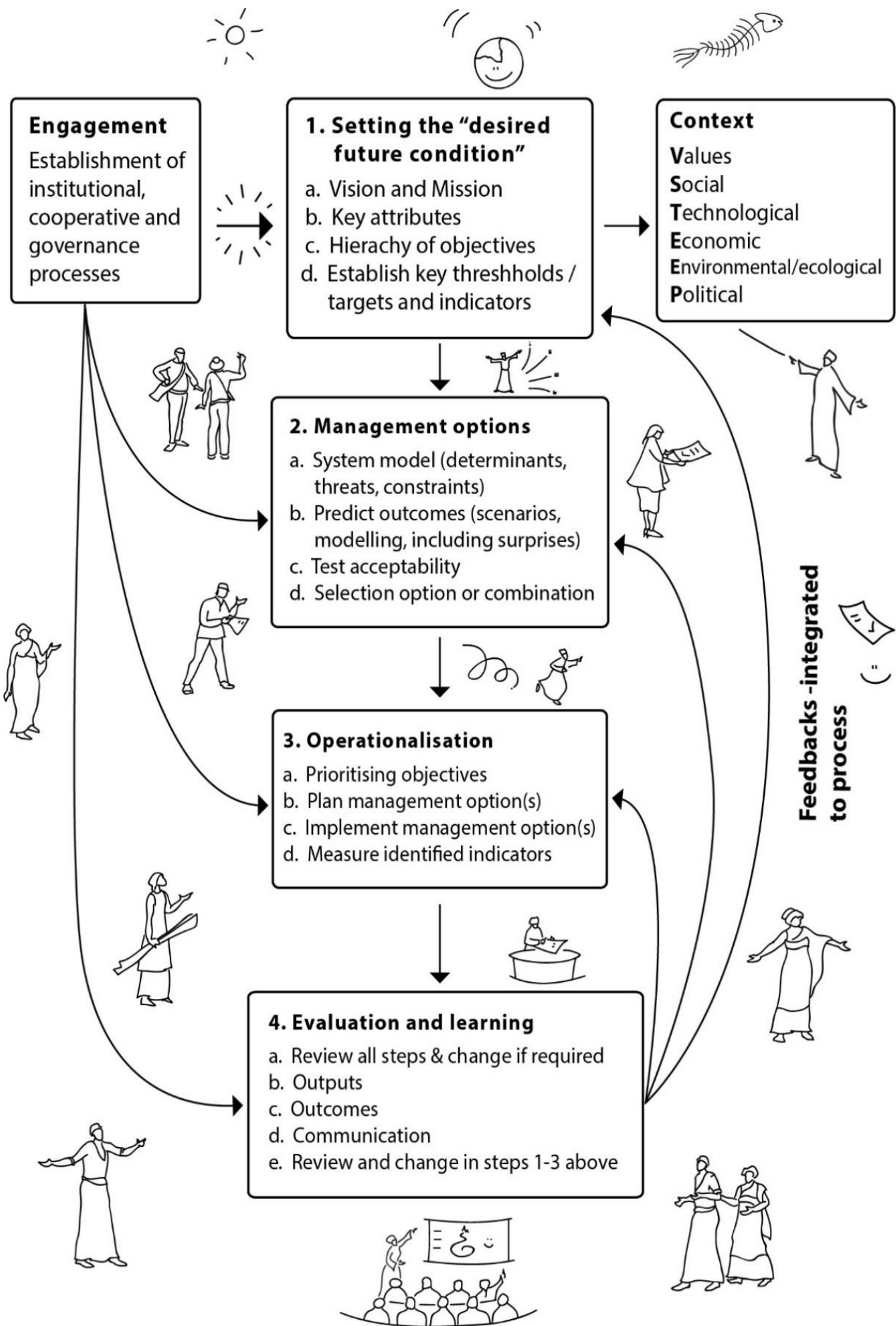
Lessons Learned:

- Because it is difficult to actually establish the behaviour that enables developmental IWRM, and because of the importance of site-to-site differences, it is reasonable to expect that the spread of such initiatives will be patchy across the country. The examples of success may be rather rare, but they are 'windows of opportunity or narratives of hope'. We are still in the early phases of new paradigm **practice**.

- Although careful preparation and thought might suggest where new paradigm ideas and practice might easily be launched and thrive, there is always the element of chance. There will be surprises and disappointments. Respond to positive surprises with opportunistic energy and imagination, and to disappointments with perseverance – and imagination. Do not let apparent early 'failures' demotivate you.

- There is a recommended sequence for establishing the new practices – but you need to use your selection of 'thinking and acting' tools to think on your feet, and your **persistence**. **Flexibility and innovation will become critical success factors**. The recommended sequence is called Strategic Adaptive Management – SAM.

- It is clear that smaller municipalities in more rural settings, as well as large metros, struggle with water service delivery. Detailed engagement with two small Eastern Cape municipalities – Makana and the Sundays River Valley revealed really different 'blockages' to improving household water security.

- Makana has been mired in the political processes of leadership, and Sundays River Valley cannot 'ring-fence'* water-related income and expenditure. The Sundays River Valley Municipality is also missing a crucial service level agreement with the local Water User Association. Both municipalities face severe limitations with aging and inadequate infrastructure. Both have begun to respond to new paradigm thinking. Both municipalities have shown an interest in new paradigm practice.

3. The recognition that a developmental sequence of events or actions is necessary – because some feedbacks are only slowly effective and the foundation stages must be in place for them to be recognised

The most uniform finding across our studies was that it *took considerably longer* (two to three times longer) than expected to introduce these ideas at a level that was viable for meaningful implementation.

Although social learning processes contributed to the longer time frames, it seemed that, if the social learning component was skimped on, there was little chance of transformative outcomes that would last. A common feature was that, although managers (or other 'practically minded' people) often wanted quick action, the project tended to produce only temporary results if the conceptual orientation steps were left out. Some conceptual steps appeared to be helpful if placed before others, even if this was unclear at the start of these initiatives.

The recommended sequence of steps follows Strategic Adaptive Management (SAM), and is illustrated in Figure 4 The supporting readings are really useful.

Engagement
Establishment of institutional, cooperative and governance processes

1. Setting the "desired future condition"
a. Vision and Mission
b. Key attributes
c. Hierachy of objectives
d. Establish key threshholds / targets and indicators

Context
Values
Social
Technological
Economic
Environmental/ecological
Political

2. Management options
a. System model (determinants, threats, constraints)
b. Predict outcomes (scenarios, modelling, including surprises)
c. Test acceptability
d. Selection option or combination

3. Operationalisation
a. Prioritising objectives
b. Plan management option(s)
c. Implement management option(s)
d. Measure identified indicators

4. Evaluation and learning
a. Review all steps & change if required
b. Outputs
c. Outcomes
d. Communication
e. Review and change in steps 1-3 above

Feedbacks -integrated to process

Figure 4: An explanatory diagram of strategic adaptive management (adapted from Kingsford and Biggs, 2012; Pollard and Du Toit, 2011; Rogers and Luton, 2011).

Lessons learned:

- Patience and perseverance are required if we are to move to even reasonably effective developmental IWRM. ***In this handbook, this is probably the single most important truth to grasp and internalise.***

- The most important of all the concepts involved is the Complex Social-Ecological System (CSES), and we recommend that is included early in any Adaptive IWRM process. For instance, transdisciplinarity initiatives worked better once CSES was included. For example, SAM is attractive as a 'practical management tool' with which to get going, and SAM procedures are built on an understanding of CSES.

- 'Rushing in' prematurely with the management actions has proved less effective than we thought. However, SAM philosophy is very firm about taking immediate action when necessary, but only for genuinely immediate priorities, at the same time, to carry out the immediate action with sufficient time for the medium- and longer-term processes to be established and continue. Even the immediate process follows (a very short set) of the SAM steps. This apparent paradox is explained by the overlapping feedbacks expected in SAM.

- The iterative*(cycling repeatedly through steps) nature of SAM, and many of the other guiding ideas, such as social learning, depends on each step feeding back to the step before, so that the next time round it can be done more effectively for the particular situation (learning by doing).

- Although this sounds philosophically sensible, it often turns out to be quite foreign to western-trained, scientific-technical people, and requires explicit attention and practice. In the early stages, people tend to wrongly self-assess themselves as 'obviously practising effective feedbacks' – **whereas explicit attention to feedbacks, and adjustments in practice, is fairly rare, and hard to establish as a habit.** Resist thinking that the cycling back to repeat and check is a waste of time. It is a VERY important step!

Check and self-examine carefully whether you really have adequate feedbacks – if you don't, your process does not qualify as adaptive (for an excellent layout of feedbacks, see Pollard and Du Toit, 2011)

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4. Making time to be pro-actively adaptive

A common context for organisations is that they hear about developmental IWRM, or adaptive management, realise it has ***real potential*** for their situation, but then find themselves ***too busy and involved in 'business as usual'*** give it a fair try (and remember how long it takes).

This barrier of finding time is made worse by the uncertainty of a new way of thinking and working.

An example from river and general environmental management in the Kruger Park.

At the beginning, there was a long period when there seemed to be no time for an entry point. Senior officials deferred any crises or issues which seemed to require adaptive handling, to other people (for example 'external' scientists who had been part of the Kruger National Park Rivers Research Programme).

But … developmental IWRM cannot be practised through a third-party organisation, especially if internal people simply have not developed the capacity to practise the new approach or change their behaviour and emphasis. In this example the new paradigm skills were not internalised in the implementing agency.

In SANParks, some external coaching and encouragement was essential, but it was only when a group of key *internal* officials realised that developmental IWRM/SAM would never get started as long as they saw the current work overload as the priority – and new practice as something that would have to wait till an opportunity after that.

What they did then was to ***re-orientate their own system*** to practically allow enough of the less important issues in the business-as-usual bundle to slide (with some obvious repercussions, as they anticipated) to free up time to begin the more proactive adaptive planning and management.

This had the predicted outcome – it helped, sometimes quickly and sometimes more slowly – reduce the large number of crisis-type situations, and once that pattern became clearer, it generally motivated staff in the organisation, and the proactive cycle grew.

Of course, there had to also be institutionalisation measures to assist this. After a while, senior management formalised the reporting and subsequent tracking of key thresholds into their regular science-management meetings. Management thus began to use adaptive cycles and feedbacks.

Crises never disappeared – in fact they keep arising partly because of non-adaptively-handled issues coming from other scales (e.g. at the national level), or from neighbours not using adaptive approaches. But at least a slice of the work over which there was more direct influence became more adaptively handled, and crisis management became less overwhelming.

Some further progress is currently being made, or is more likely to be made, as developmental IWRM at different scales starts slowly aligning and certainly as CMAs (such as evidenced by the IUCMA) become operational.   *Harry Biggs*

An understanding emerged of 'trusting where we are now', including pointers to how we can move forward more practically. This is supported by being prepared to 'think like this' at a general level.

Although much is available in the way of theory and, in some fields (such as SAM) a fair amount of practical experience, this handbook is new because it pulls together the all-important yet largely undocumented general principles of thinking developmental IWRM into practice.

For instance, although many texts talk about the necessity of multi-scaled approaches, there is very little in the way of practical experience recorded as to how to actually tackle the different scales individually, let alone jointly. We encourage you to read the more detailed WRC report that gives even more detail about the practical experiences. We encourage you to live creatively with the continual tension between reflecting, thinking and practice

DEEPENING PRINCIPLED, PRAGMATIC* PRACTICE

If you think the principles presented up to this point have become habits for you, this next section gives you a new mix of and additions to your useful habits. This will help to deepen your practice of developmental Adaptive IWRM. (This section is based on Rogers et al., 2013).

Reminder: The Adaptive IWRM way of thinking is really important if you want to change habits and move to practising developmental Adaptive IWRM. Once you really understand that principles are more useful than rules, that catchments really do operate as complex social-ecological systems – and that therefore scale, feedbacks, and the interaction between elements are system drivers are fundamental – you are on the road to practising Adaptive IWRM. Also, because there is low predictability, you must accept messiness and patchiness and still persevere towards your vision or goal – THEN the way you work will change and your practical actions will be more fruitful.

Remember: don't just rush into 'problem solving'. Assess the problem situation, act on the really urgent immediate crises, and AT THE SAME TIME start using the SAM steps and do them over and over adaptively.

Realise: a habit of mind is a pattern of behaviour that leads to productive actions. Habits of mind are seldom used in isolation but in clusters that together make up pattern of behaviour. When people are confused by dilemmas, or come face-to-face with uncertainties, their response is determined by their habits of mind.

So – try to become and remain aware of your habits of mind – and check that they support this new practice.

We offer you three broad frames of mind that each contains a set of habits of mind that are critical to leading participative planning and decision making in CSESs:
- openness,
- situational awareness, and
- respect the 'wait' or 'act' alternatives

Openness (see Text Box 1)

Change requires openness. This is difficult if your usual habit is reductionist and 'top down'. Openness includes being willing to accept diversity. People know and communicate different things in different ways. Personal and institutional openness means accepting things that do not make immediate sense to you, understanding that chance may make things unexpectedly easy – or difficult. It is helpful to hold your own strong opinions 'lightly'; do not take yourself or your opinions too seriously.

TEXT BOX 1:

- Habits of mind that promote patterns of openness in behaviour.
- Hold your strong opinions lightly and encourage others to do the same.
- Do not take yourself or your opinions too seriously.
- Be prepared to identify and accept surprises, chances, and unexpected understandings.
- Meet every person with equal respect, listen for their specific needs, knowledge, and ways of knowing.
- Be open to options that include aspects that seem to be opposite.
- Do not reject things that are not precisely clear, or that seem to include opposites.
- Seek out and respect all the various characteristics of other people, and different circumstances.
- Accept everyone you meet and work with as co-learners – not as either experts or people in competition with you.
- Encourage co-operation and consensus*: **the best way to get what you need is to help others get what they need.**

Situational Awareness (see Text Box 2)

One of the critical differences between complexity-based and reduction-based thinking is the importance of context and scale in complex systems. Issues, characteristics and interactions are different, with different outcomes in the wide range of contexts, and at different time and spatial scales. In addition – the values people hold deeply influence the ways they respond and make decisions. We use the acronym V-STEEP* (Values – Social, Technical, Economic, Environmental, and Political) (Rogers and Luton, 2011) to guide aspects of the system that need attention from us when we start to work in a new context. Exploring each of these aspects builds our awareness of the specific context. As we work, we pay attention to V-STEEP components and interactions, returning to them repeatedly through time. Practising V-STEEP awareness is a practical tool for navigating complex systems.

TEXT BOX 2:

- Habits of mind that promote patterns of situational awareness in behaviour.
- Watch out for, and decide when a change is sufficient to require re-negotiation or review.
- Remember that understanding the relationships between the parts of the system may be more important than understanding the nature of each element.
- Watch out for and embrace people and processes, then help with change.
- Take account of the time and space aspects of your system, and also be attentive to time, space and relational scales that might give different insights and perspectives.
- Be aware of the history of your system and consider how the past influences the present and the future.
- Work with other stakeholders to discover the values that will drive decision in your system.
- Scan through the principles in this handbook and decide which ones you will adopt in your system.
- Reflect often: formally, informally, individually, and collectively.

Healthy Respect for the 'Wait' or 'Act' alternative (see Text Box 3)
Leadership and decision-making in a complex system needs you to balance risks associated with practicing restraint and taking action. On the one hand, if the context requires it, you need to hold back and leave space for new ideas and opportunities to emerge. Think of trying to undo a tangled knot – it takes time (as well as trust and opportunity) to loosen the tangled problem knot. It is necessary to do it slowly and patiently (Cilliers, 2006).

The metaphor of the knot

Have you ever walked along a beach and picked up a piece of tangled fishing line? Perhaps with some seaweed and a fish hook mixed in? Have you started to pick at it – trying to untangle it? As you pull on a piece of line, it tightens somewhere else and it is hard to see where to start, and what is connected where. The first step is to loosen it, to pull patiently and persistently at the knotted pieces until a place to unravel becomes apparent.

We think of South Africa's difficult water problems as the knotted line, and we think of our research process as the loosening process. With patient and persistent engagement and investigation there is some unravelling. Opportunities arise to un-knot and deeply address problem areas. This loosening and un-knotting takes time, attention, and nimble fingers. Sometimes as we loosen we cause a new knot – which is frustrating – but that, too, has to be loosened.

Engaging with knotty and difficult problems take time, attention, engagement and all of it usually needs skilful facilitation.

On the other hand, you need the **courage** to take action in the middle of uncertainty because, in a complex system, the consequences of our actions are never completely predictable. Often it is necessary to act immediately and clearly – and then to watch and learn from the consequence.

How do you know what to do, when?

There is no simple answer to this. Experience will help you begin to feel more confident of your decisions about when to wait and when to act. Go back to the principles of 'How to act'. As you practise these, you will learn to recognise the moment for waiting and the moment for action.

You can trust yourself in the learning process because there is never an objectively 'right' decision. If you are working adaptively you will wait – or act – and then watch, communicate, listen and reflect on what happens as a result – and if the change is not in the direction of your values and the shared desired future for the system, there will always be another chance to adjust.

This pattern of working becomes adaptive leadership.

TEXT BOX 3:

Habits of mind that promote patterns of a healthy respect for deciding on when to wait and when to act.

ACTING:
- Learn from experience when to act strongly even though there is tension, uncertainty and disagreement. Encourage courage – do not be afraid of intelligent mistakes.
- Avoid doing nothing in a vacuum. Waiting needs to be active – watching for consequences. If fear is making you do nothing – then rather act.
- Have the courage to seize the 'just-do-it' moment.
- Accept that there is no one right place to start or end. Do so when it is sensible and useful.
- Have courage to take action from which you can learn. Even mistakes lead to learning.
- Push beyond discomfort – learning is uncomfortable.

WAITING:
- Avoid being too quick to make judgments and choices. Keep options on the table long past their apparent usefulness. Many will find context later in the process.
- Avoid overconfidence about being ready to take action in a data-driven 'predict and act' mode.
- Learn when to rest. Open and participatory engagement exposes vulnerabilities, requires humility, and takes energy.
- Going forward too fast leaves participants unsettled and vulnerable to defensive confusion.
- Provide participants plenty of time for questioning, healing and recovery from any discomfort.

These three frames of mind are interdependent, with openness as the foundation and most critical one because it can enable or constrain the other two frames: adequate situational awareness is not possible without openness to a diversity of perspectives, because in a complex system, you simply cannot afford a one-sided perspective. Knowing when to act and when to wait depends on your awareness of changing dynamics in the system, and it also requires openness to the unexpected.

The more specific habits of mind in the text boxes are more easily remembered and practised when grouped under these frames, but they are not confined to use under one frame. As you become more practised in their use, it becomes easier to mix them. These lists of habits are a 'living list' that is continually refined as we learn by doing. Two additional comparative tables to inform your evolving Adaptive IWRM practice are provided in Appendix B.

4. USING THE "HOW TO…." SERIES:

The other titles in the "*How to…*" series are directed at addressing specific issues – please read this *How to think and act in ways that make Adaptive IWRM practically possible* alongside of them, and go back to this to remind yourself of the underlying thinking and practice.

The *How to …* handbook series includes:
- *How to think about water for people and people for water: Some, for all, forever*
- *How to establish and run a Catchment Management Forum*
- *How to manage Water Quality and Water Quantity together*
- *How to engage with the challenges facing Water and Sanitation Services (WSS) in small municipalities*
- *How to run a Green Drop campaign in a Catchment Management Forum*
- *How to make engage with coal mines through a Catchment Management Forum*
- *How to use Strategic Adaptive Management (SAM) and the Adaptive Planning Process (APP) to build a shared catchment future*
- *Environmental Water Quality in Water Resources Management*

It is important to recognise that this handbook and the series that follows are probably only forerunners of more mature and detailed practical knowledge that will become available if this direction towards working with complex adaptive systems continues. We believe this will happen in the medium-term future because there are many kinds of situations where the approach will prove effective IF WE PERSEVERE.

We hope this series plays a helpful role in coming to terms practically with such systems.

Final message:
Treating a problem situation as a complex one, will in any appropriate developmental IWRM context, make the problem easier to shift.

GLOSSARY

address (verb) – to think about and deal with

adversity – trouble, difficulty, hardship, disaster

aspire – to have a great ambition; to work towards a great goal

attributes – quality or feature of something that is an essential part of it

bio-physical systems – systems where physical (temperature, pH, chemistry) interact with biological (plants, animals, insects, etc.) features interact

catchment – catchments are defined by a main river and its surrounding land (a primary or first level catchment), and the sub-catchments of the river's tributaries. A 'small catchment' is generally a secondary or tertiary (second or third level) sub-catchment. The river of a secondary catchment flows directly into the river of the primary catchment. A tertiary catchment river flows into a secondary tributary and so on for quaternary (four level) and quinary (fifth level) catchments. (Refer also to the *How to establish and run a Catchment Management Forum* handbook)

chart – making a map of something

charting – the action of making a map of something

CMA – catchment management agency. The purpose of establishing the catchment management agency is to delegate water resource management to the regional or catchment level and to involve local communities, within the framework of the national water resource strategy. There are nine CMAs in South Africa that govern water resource processed in nine water management areas. Each CMA communicates with several CMFs (catchment management forums) which are groups of stakeholders mandated by law to represent the interests of people who use water.

CMF – catchment management forum

coincide – happen at the same time

coincide with (each other) – agree with (each other)

complex – make up of many interconnected parts and is therefore not easy to understand

complexity – something that has many parts and is difficult to understand

concept – an abstract idea; a plan or intention

conceptual – based on an abstract idea, or on a plan or intention

consensus – general agreement; an idea or opinion that is shared by all the people in a group

contested – fought over, argued about

context – the situation (time, place, people, circumstances, etc.) in which something happens

core – the part of something that is central to its existence

developmental – in this context, it means all people living in South Africa have fair access to the water they need to live a dignified life, and one that supports a decent livelihood. New paradigm thinking matches this because it takes into account the many factors needed to achieve this.

discourse – discussion, debate, talk

draconian – extremely harsh or severe

economic good – a commodity that can be bought and sold

elusive – difficult to find, difficult to achieve

ethical – relating to moral principles; what is the right and fair thing to do

eutrophication – too many nutrients in a body of water (dam, lake, river) usually caused by run-off from the land. It causes a dense growth of plant life, and turns water green. Eventually, everything in the water dies because there is not enough oxygen in the water.

finite – limited; there is a point at which it will all be used up

governance – the system of rules, practices and processes by which an organisation (or country) is directed and controlled. Good governance involves balancing the interests of all stakeholders

grapple – to fight with someone or something

imperative – an essential, urgent thing

interactive – people or things influencing each other

iterative – going through steps repeatedly

linear – a straight line. 'Linear thinking' means straightforward, fairly predictable thinking that does not take complexity into consideration.

microbial pollution – pollution of water by micro-organisms, such as bacteria and viruses. Untreated sewage is the most frequent cause of microbial pollution.

momentum – the strength or force something has when moving

navigate – travel [through the difficulties] very carefully and with difficulty

paradigm – a new way of looking at or thinking about something

paralysis – unable to function properly

piece-meal – little by little, not all at one time, not comprehensively

pragmatic – reasonable and logical; based on dealing with specific situations, not on ideas and theories

pragmatism – reasonable and logical way of doing things, or of thinking about problems that is based on dealing with specific situations instead of on theories and ideas

redundancy – something is redundant if it is repeated unnecessarily

resilience (system resilience) – the ability of a system to continue operating even when it is under stress

ring-fence – to protect something (assets, money) from being used for some other purpose

scale(s) – the relation between the real size of something and its size on a map, diagram or model, e.g. Is the dam drawn to scale? (i.e. it shows the exact shape of the dam, but drawn much smaller). 'Temporal scales' – time periods; e.g. a large temporal scale = a long time. 'Spatial scales – the size of the space involved; e.g. a large spatial scale = catchments that involve several countries.

silo – a tall structure, often made of concrete, for storing grain. Even though many silos may be built very close together, there is no connection between them. Government departments can be like silos that contain a lot of useful information, but do not share it with each other.

social learning – is the kind of learning where (1) the individuals involved show that their understanding of a situation has changed; (2) this change affects the society or community in which it occurs, and not simply the individual, and (3) the understanding and the change happens through social interactions between the people within the society.

synthesise – produce something new by combining different things

temporal scales – the time period in which an action occurs, e.g. daily, monthly, annually, twice a year, every century, etc.

transdisciplinary – research that involves people from different disciplines working together to create method, theories, and practices to solve shared problems

upbeat – a positive outlook

V-STEEP – Values - Social, Technical, Economic, Environmental, Political

vulnerable – able to be harmed or attacked

water resource protection – the laws and practices for protecting our water resources.

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LIST OF ACRONYMS AND ABBREVIATIONS

CMA – Catchment management agency
CMF – Catchment management forum
COGTA – Cooperative Governance and Traditional Affairs
CSES – Complex social-ecological systems
IUCMA – Inkomati-Usuthu Catchment Management Agency
IWRM – Integrated water resource management
RESILIM-O – Resilience in the Limpopo River Basin – Olifants
SAM – Strategic Adaptive Management
SANParks – South African National Parks
WRC – Water Research Commission
WWTW – Wastewater treatment works

APPENDIX A

The 'fishbone' diagram below shows a new way of thinking about these problems, and a new way of putting the solutions into practice.

Towards Practising a New Paradigm
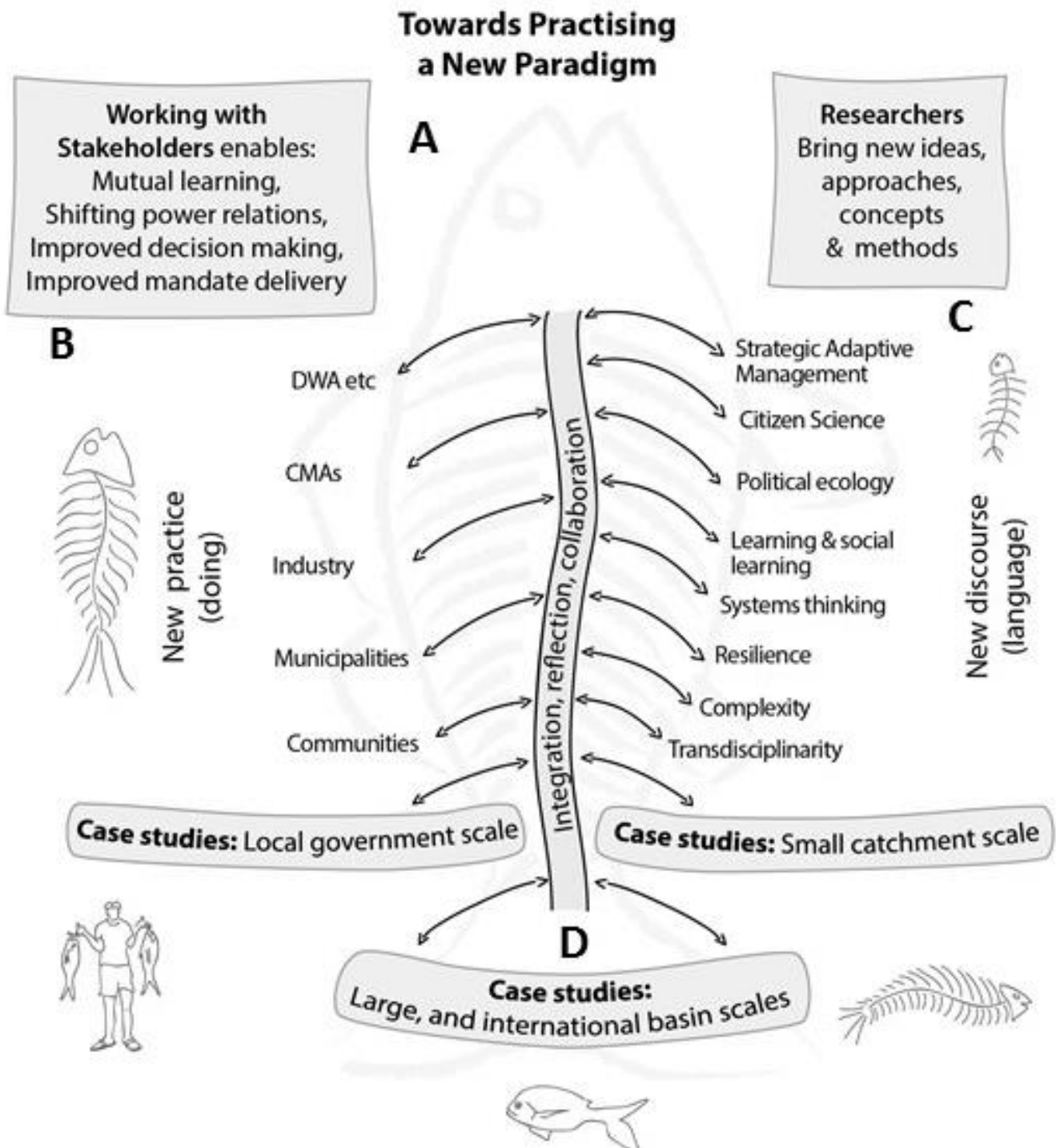
Box A – the title
Paradigm – a new, fresh way of looking at a situation.
Practising – the emphasis is on **doing** something, on carrying out the necessary actions to make the 'new way' real.

Boxes B and C
These are two groups of people involved in thinking and doing. Both are necessary; neither can achieve a solution alone.

Box B – the stakeholders are people who live and work in the catchment or municipal areas (listed on the left of the arrow: communities, DWA, industry, etc.) and who have first-hand <u>practical</u> experience of the water problems. They are in a position to put the new way of thinking into practice.

Box C – the researchers are scientists who have examined many water issues and found and tested new and different ways of thinking and talking (discourse*) about them. These new ways are listed on the right of the arrow (transdisciplinarity, resilience, citizen science, etc.)

When these groups work together ...
- they learn from each other
- they share new ideas, new approaches, concepts and methods
- power relationships change as stakeholders exchange first-hand experience, and theoretical research, and *together* create a more complete understanding
- decision-making improves because it is based on more complete information
- stakeholders are more confident about carrying out their mandate because they are better informed

Case studies
These are three situations that have been researched and from which researchers have learned much. They have been carried out at three scales*: local (case study 1), catchment scale (case study 2), and national (case study 3). See the Table for more information.

Box D – the centre
Integration – bringing together smaller components into a single system so that it functions as one.

Reflection – the process of looking inward. Very often lessons and insights emerge slowly, and quit and attentiveness is needed to recognise them. Pondering questions, and sharing insights can help: e.g. What can be done? Is that the only way to do it? Is it the best way? What would happen if ...? Should we do it differently next time? What do we need to change? Are the right people involved? Who is missing? Who is not speaking? Who is?

Collaboration – learning to trust each other, using each other's skills and strengths, and working together to protect our precious water resources.

Question
Why do the smaller arrows point both ways?
Because everyone contributes to the middle arrow (F), and everyone gains something from it.

APPENDIX B

Two additional tables that have helpful points for you to reflect on as you seek to shift your practice towards Adaptive IWRM:
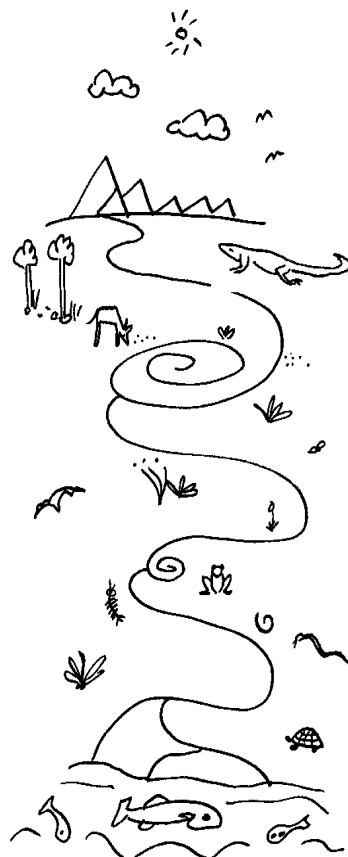
Table B.1: An 'old' (reductionist/positivist) approach compared with a 'new' (complexity-based) approach (Rogers et al., 2013)

Whose reality is real?	
The reductionist habit	**The emerging complexity-based pathway**
Cause and effect are linear and traceable.	Non-linear feedback is a mass of interconnecting interactions; causes are often not traceable.
A system is divisible into parts that can be studied or resolved independently.	The interactions between parts are as, or more, important than the parts themselves.
Parts can be categorised into like types to reduce complicatedness through generalisation.	The variability between parts is of more interest and value than the average and generalisations.
The parts and the system can be fully understood if we have the right information.	Neither parts nor the whole system can be fully understood and therefore the world is full of surprises (and disappointments).
We can isolate and complete (finish) individual tasks, decisions, solutions.	The outcome of any one task affects others. There is no definitive end to a task, or solution to a problem. Therefore, we work towards a direction, value, or vision decided by a relevant group of people – the stakeholders.
If we have the 'right' information, we can 'get it right' and tell people what to do; and – we can also 'reverse' or 'correct' something if we get it wrong.	There can be no right or wrong framing of a problem or solution. We judge outcomes in terms of values. A new state can be 'good enough' – rather than right or wrong. Often consequences cannot be reversed.
Stakeholders can expect **someone** to 'get it right' and to solve their individual and group problems.	Stakeholders must be part of the process, and we can only loosen/tweak the problem knot so as to reveal new perspectives and options.
This thinking became a habit with the industrial revolution, where uniformity of task and outcome were paramount.	This way of thinking is both more recent and more ancient. It is evident in indigenous Australian and San thinking and practice, and it emerges from complexity thinking. It is value-based.

The new style of thinking requires a complete change in styles of leadership, management and decision-making. We need to move from bureaucratic hierarchies and rules for action, to a style of 'generative leadership', in organisations that are becoming 'learning organisations' (Table B2).

Table B2: Styles of leadership (Roux et al., 2006)

	Conventional Bureaucracies	Learning Organisations
Leadership style	Primarily command and control, resulting in instructions and paper shuffling.	Primarily co-ordinate and facilitate – where knowledge grows (a leader may be a designer, teacher, steward).
Structure	Functional hierarchies. Vertical communication. Work **for** one boss (line manager).	Dynamic teams, horizontal dialogue, work across boundaries.
Culture	Planning at the top, doing at the bottom. 'This is our empire' syndrome with internal defensiveness /protection. Observe and criticise mistakes. Rather make no decision than the wrong one. View uncertainty, complexity and change as threats. We do not have capacity; Government must provide.	Driven by common vision and collaborative goal setting. Enthusiastic sharing across internal and external boundaries. Learn and adapt through experiment and critical reflection that leads to new knowledge and better decisions. Treat uncertainty, complexity and change as opportunities for learning and improvement. We have the vision and courage to innovate.