Duncan Hay, Charles Breen and Bimo Nkhata look at the wicked problem of achieving water security and the difficulty of unravelling its complexity.

Standing in the centre of the city of Missoula, Montana USA, waste deep in the waters of the Clark Fork River, one can cast a fly-line at very wild trout; you can also drink the water you are standing in. A city and clean water – for many South Africans this is a revelation. Only later do we learn what securing this clean water cost – hundreds of millions of dollars in upstream mine waste rehabilitation. It seems almost inevitable – mix people and water and what do we get – a mess! This, in turn, appears bizarre. On an ongoing and escalating basis we compromise the quality and quantity of a resource upon which we are entirely dependent. People are not stupid so why do we appear to be getting it so wrong and what might we do about it?

Through the research of Nobel Prize winner, the late Eleanor Ostrom, and many others we are beginning to appreciate that the issues we are grappling with are not simple; they are complex and are particularly complex when they relate to water and aquatic systems. Water, in itself, is a complex resource – liquid, solid, vapour, flowing, falling, static, transporter, depositor – and society is equally complex with highly diverse values, needs and aspirations. Put the two together, give it a stir and the result is problems that appear intractable and are not amenable to simple or conventional solutions. This complexity is increasingly the focus of research effort funded by the Water Research Commission (www.wrc.org.za), the Lloyd's Register Foundation (www.watersecuritynetwork.org) and other agencies worldwide.

Not only has this research introduced us to new ideas but it has introduced us to a new language – the language of social-ecological systems; messy and wicked problems; common pool resources; property rights regimes; bundles of rights, collective identity, collective action and adaptive management. Let's unpack some of the ideas and their language and see where they take us.

If we are to become far-sighted and act together to find solutions we must find ways of living with this complexity; this mess full of wicked problems. At the same time we must act in ways that respect the diverse social and economic values the different groups attribute to water resources. But how might we do this?

Aquatic systems, particularly rivers, lakes and wetlands, provide a variety of ecosystem services that we use and from which we benefit. As we exercise our choice of which benefits to access and where and when to do so, so do complex patterns emerge. Just imagine drinking, bathing, washing clothes and watering cattle in or from the same pond. Our patterns of use mirror the ecological patterns we find in the pond – they are as complex and dynamic. Not only is the pond responding to physical, chemical and biological change, it is also being shaped by our changing preferences and demand. The ecological and social systems – people and the pond – are inextricably linked, each affecting the other. At the same time both are being influenced by common issues such as climate change. In complex social-ecological systems

of this nature where there are many pathways through which changes can occur, the relationship between cause and effect can be difficult to see and may take years to emerge.

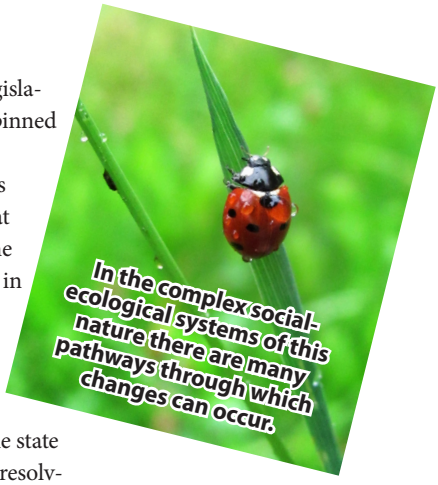
How we choose to access water resource benefits can alter other peoples' options to the extent that we might compromise the opportunity others have to access benefits. Closing the sluice gates at a dam or reservoir might improve water security for downstream irrigation farmers who require a regular supply of water for their crops. At the same time it might compromise the water security for downstream subsistence fisherfolk who rely on annual flooding to replenish the shallow lakes where they fish. How risk is experienced and how it changes in both space and time is reflected in changes to linked social and ecological systems. As this happens it affects the choices we make, and the consequences of these choices are carried forward to emerge later, sometimes with quite unexpected and undesirable outcomes.

The system is never stable; it is constantly adjusting to what is happening now and what has happened in the past. So, for management to be effective it needs to take into account this complexity, messiness and uncertainty; the wicked nature of the problems that are thrown at us. Our management needs to be adaptive – acting, reflecting, learning, refining – rather than providing blue-print type definitive solutions that might be wrong today and will certainly be wrong tomorrow.

Moving on to what we are ultimately trying to achieve – water security. The term water security conveys a sense of being safe. It is an indication of how secure and free of risk we feel about accessing our share of the benefits of aquatic systems. To feel secure we need to know that others using the resource acknowledge our right of use. Because we are all connected and need to defend our rights to use and to sanction abuse, we need to understand and identify with the system as a whole – the resource and resource users – and not only the benefits that we derive from it. Collectively we need to commit to sustaining a pattern of risk that is socially and environmentally just. When this happens the resource can be thought of as being common to all, as a common pool resource. The collective identity built through the processes of identifying with the system and developing commitment provides a foundation for collective action that is necessary for managing the use of common pool resources.

However, developing commitment to collective action is not enough – we require rules to direct this energy.

Conventionally we think of rules in terms of legislation, regulations and byelaws. These are underpinned and/or complemented by a system of rights – a property rights regime – most simply defined as a system that determines who has access to what under what conditions. This regime provides the means for social coordination and ordered rule in the delivery of benefits from aquatic resources. It provides direction, guiding our energy and initiative towards a common good. It provides the means for negotiating, constructing and ultimately defining the common good which the state must then secure. It also provides the means of resolving trade-offs in order to establish the common good. Clearly defined property rights are used by society to guide the relationships among users, managers and policymakers as they go about securing their interests, meeting their social obligations, and mediating their differences.



But how do we establish an effective property rights regime for common pool resources? Each will be context specific but Ostrom and her colleagues established seven general principles to guide us:

- The boundaries of the system (linked social and ecological system) should be clearly defined – we need to be able to define the resource and who has (or should have) access to it.
- There should be proportional equivalence between benefits and costs associated with ecosystem services – we must internalise the costs and it must be worthwhile investing in sustainable use.
- Those affected by the rules that regulate use should be included in the process of establishing the rules – governance should be inclusive and participatory.
- Those who monitor use and its consequences should be accountable to the users – those

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Bundles of Rights Associated with Positions (extracted from Schlager and Ostrom and Schlager, 1992)

Rights	Owner	Proprietor	Claimant	Authorised user	Authorised entrant
Access	X	X	X	X	X
Withdrawal	X	X	X	X	
Management	X	X	X	X	
Exclusion	X	X			
Alienation	X				

monitoring might be government or the users themselves.
- Those who disobey the rules should be subject to sanction – there must be consequences for those who disobey the rules.
- There should be affordable access to dispute resolution – it needs to be convenient and efficient.
- Resource users should have the right to self-organise and devise their own institutions without external interference – let users get on with the business of management with minimal interference.

Within a property rights regime there are number of distinct rights related to a particular property. Taking a wetland as an example: subject to certain restrictions imposed by government, the 'owner' would have rights to possess, use, access, manage, sell, lease, donate or subdivide it while someone leasing a portion would only have some of these rights. A birdwatcher, with permission of the 'owner', would only have right of access and use. So, in this context, property rights are viewed as bundles of rights to use or transfer resources, including benefits – see the table above.

These bundles of rights can be added or subtracted, shared or divided in different ways resulting in changes in the amount of benefits, and associated costs, flowing from the property. So, by defining property rights in terms of bundles allows us to better understand how different allocation systems for those rights affect our incentives structures and, in doing so, how they give effect to collective action.

Managing the use of common pool resources requires that we, the resource users, all understand, agree to and support the allocation of rights to access and use ecosystem services. In other words, agencies have to implement a property rights regime in which users are granted rights and responsibilities that encourage self-regulation within the parameters set by government. It is government's responsibility to establish the formal institutional arrangements for governance, while the various user sectors are responsible for establishing the informal institutional arrangements necessary for self-regulation. The success of formal institutions such as national policy and regulation is strongly dependent on how effective informal institutions are in ensuring compliance.

So, where is this likely to play itself out in practical terms and where might we focus our attention? In South Africa legislation has made provision for Water User Associations. This is where negotiations on water resource allocation will happen at a local level. It is particularly at this scale that effective property rights regimes will be required to ensure equitable, efficient and sustainable use. And, we cannot legislate or regulate what precise forms these property rights regimes will take place – every context is different, every situation is unique. What we need to do is provide wisdom, guidance, advice and information to assist users in working it out for themselves. This is perhaps the only way we will achieve collective action that takes account of the diversity of linked social and ecological systems in which we find ourselves.

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Papers delving further into concepts and ideas around water security

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