

Review

Making a case for systems thinking approach to integrated water resources management (IWRM)

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While definite benefits could be gained from integrating the management of natural and human systems, taking into account the effects of human activities on the environment, the task of operationalising and implementing this approach in practice represents an enormous challenge. Some limitations highlighted include the definition of IWRM itself, where it appears to be broad, all-encompassing and impressive, but contains “lofty phrases” that have little practical importance for either present or future water management practices. This paper makes recommendations to uptake and incorporate the systems thinking approach (STA) in IWRM decision making processes, an approach envisaged to be more participatory and also process-oriented. Incorporation of socio-economic dynamics is also recommended, with a suggestion that the biophysical relationships like interactions in a basin between water, the human population and settlements should be analysed to the extent possible.

Key words: Operationalising IWRM, socio-economic dynamics, South Africa, systems thinking approach.

INTRODUCTION

IWRM and the economic interdependence

The last two decades have seen a call for increased integration in water management, driven by recognition of the limits of a fragmented organisational approach and an

increased understanding of the interconnected nature of water related issues. The following documents: Agenda 21 chapter 18 (United Nations, 2004b), summary report of the Bellagio report (WSSCC, 2000), Rio Declaration principles 15 and 16 (United Nations, 1992), MDGs (United Nations, 2008) and the Johannesburg Declaration 3 (United Nations, 2004a) are examples.

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At a global scale the Brundtland report (United Nations, 1987) warns of many forms of development which erode the environmental resources upon which they must be based. For example too much water and non-renewable resources of high quality are taken from the eco-system and returned to the eco-sphere as pollution (Gumbo, 2005). Compatibility of environmental and economic objectives has thus been lost in the pursuit of individual or group gains, with very limited regard for the impacts on other sectors. There is pursuance of blind faith in science's ability to find solutions and an ignorance of the not too distant consequences of today's decisions. Institutional rigidities are alleged to add to this myopia. One such important rigidity which is echoed in the Brundtland report (United Nations, 1987) is the tendency to deal with one industry or sector in isolation, failing to

Abbreviations: DWA, Department of water affairs; DWAF, department of water affairs and forestry; IWRM, integrated water resources management; K9, monitoring point on Klip River; L1, monitoring point on Leeuspruit River; MDG, millennium development goals; MWB, Midvaal water board; M3, monitoring point on Mooi River; NWA, national water act; PPP, polluter-pays principle; RWB, Rand water board; SWB, Sedibeng water board; S4, monitoring point on Suikerbosrant River; T1, monitoring point on a stream from Webb's farm; VR, Vaal River; Vs3, monitoring point on Vals River; V1 - V19, monitoring points along the Vaal River; WRC, water research commission; WSSCC, water supply and sanitation collaborative council.

recognize that the strategy for sustainable development is to integrate economic and ecological considerations in decision making.

For river basins, their sub-basins or the recharge areas of groundwater, various water uses may compete or even be in conflict with each other, thus creating management problems, particularly if water is scarce and/or its quality is deteriorating. Knowledge about economic development patterns becomes important for understanding how water management problems may worsen in the future (United Nations, 2007). A few of these problems identified at a catchment level include the effects of excess nutrients, suspended and bottom sediments, heavy metals and other chemicals in surface/groundwater on drinking-water purification and use; as well as the impacts of mining activities on water resources.

Yet in conventional economic appraisals the water industry has concentrated on economic efficiency defined almost entirely in allocative terms, the key issues being the efficiency with which available water resources are allocated between users and with which factors of production are invested in new facilities. In the spirit of IWRM the link with economic operations has not been so obvious, highlighting the economic and social good of water as a resource (Liu et al., 2003).

The United Nations status report by Young et al. (2008) tracks progress towards full implementation of IWRM and highlights thorny issues where developed countries have advanced on almost all major issues, but that there is still much room for further improvement. For developing countries there has been some improvement in the IWRM planning processes at national level but more needs to be done to implement the plans. Insufficient alignment and cooperation between the policies of different government departments and the practices of different water use sectors that impact on water are pointed out by Funke et al. (2007), as huge impediments to the limited successes in IWRM, so far. Van der Zaag (2005), though, argues that the implementation of IWRM is a 'must' because systematically pursuing IWRM constitutes a path of short-term risk that leads to long-term security, which supports the current and future environmental and developmental needs to manage water resources in a holistic manner.

While definite benefits could be gained from integrating the management of natural and human systems, and taking into account the effects of human activities on the environment, the task of operationalising and implementing this approach in practice represents an enormous challenge (Funke et al., 2007). The same report further argues that while the Global Water Partnership's definition of IWRM appears to be broad, all-encompassing and impressive, it however contains "lofty phrases" that have little practical importance for either present or future water management practices. The report further notes that the phrases do not help water planners or managers to solve problems in the water sector. Ultimately, Biswas

(2004) in Funke et al. (2007) considers the IWRM concept to be "unimplementable" because of the difficulty in integrating the actions of different sectors such as water and energy.

For operational reasons in South Africa, notwithstanding many other IWRM related activities, the Department of Water Affairs (DWA) had moved from broadly IWRM to primarily domestic water supply and sanitation (Jonker, 2007). The report asserts that this move was due to a lack of conceptual clarity of IWRM, although in South Africa, the concept is an important aspect of the 1998 National Water Act (NWA). This is evidenced by the establishment of Water Management Areas and other supporting institutions described in DWAF (2004). Jonker (2007) thus proposes a re-worded definition for IWRM that allows for measurement of the concept's critical components, namely, people's activities, improvement of their livelihoods and disruption of the water cycle.

South Africa is water-scarce and the provision of water should always be considered in terms of the socio and ecological economic benefits accruing from contributions by specific users, where successful implementation of the NWA 1998 is dependent on having the right tools available to support water resources decision-making and competent people to apply these tools. Futuristic systems thinking (ST) and a visionary approach are useful tools in dealing with the complex institutional environment and assessment of future reform impacts. A STA could also provide an assessment platform for the measurable activities.

The STA to integrated catchment management

Global environmental change and sustainability are characterised as the challenge of managing change in dynamic systems riddled with uncertainty (Dovers and Handmer, 1992) and for economic exchanges to become beneficial for all involved, two conditions must be met. Firstly, the sustainability of that ecosystem must be guaranteed. Secondly, the partners to the economic exchanges must be satisfied that the basis of exchange is equitable. Unfortunately for the water and economy sectors neither condition is met, hence the unsustainable situation that many developing countries find themselves in, where fresh water resources are deteriorating at an alarming rate.

Integration of disciplines

An increasing awareness of the complexity of environmental problems has triggered the development of new management approaches. Pahl-Wostl (2007) discusses the importance of focusing on the transition to new management paradigms based on the insight that the

systems to be managed are complex and adaptive. The paper provides arguments for the role of social learning processes and the need to develop methods combining approaches from hard and soft systems analysis. Many of the traditional approaches tend to strive for objectivity and are thus classified as hard systems. The STA has been proposed as a useful method of integrating disciplines based on 'reductionism' and the degree of 'subjectivity'. A reductionist approach like IWRM tends towards breaking down complex systems into simple constituents, based on the view that they can be fully understood in terms of their isolated parts. In contrast, the holistic approach recognises the tendency in nature to form 'wholes' that are more than the sum of the parts by ordered grouping, a STA. Although some systems can be studied in a reductionist manner, a truly holistic approach is, by virtue of its breadth and complexity, difficult to adopt thus in practice there is a continuum of approaches incorporating degrees of reductionism. Systems based research, as a paradigm, tends towards the holism where sustainable planning is influenced by the concept of holism, a central tenet of ST.

Examples of practical application of the STA

By way of moving towards operationalising IWRM, Moore (2004) provides an approach to ecosystem toxicity using ST, even though practical challenges are also highlighted. Stakeholder cooperation is emphasized as key to implementation of the STA towards greener production in the textile industry, a major industry contributing towards environmental toxicity. One of the approaches in this case was applying limits to success for toxicity reduction by product substitution as well as making follow-ups on a flowchart depicting an inclusive process for aquatic toxicity resolution. A bench-marked dialogue acceptable to both legal and regulatory authorities was thus created, without which the whole process could have been sidetracked by the diverse goals of multiple stakeholder groups (Moore, 2004).

From Figure 1, Chan and Huang (2004) argues that the viewpoint of sustainable development dictates that a sound growth pattern of a community should be a logistic S-curve type. Because the cybernetic thinking tends towards the idle, environments in crisis currently due to pollution and over allocation of natural resources, are already signifying signs of collapsed.

The 4 interrelated challenges

In the context of decision-making and decision support systems, targets pose 4 inter-related challenges:

- Going beyond 'end-of-pipe' solutions.
- Enhancing integration.

- Encouraging meaningful participation.
- Linking actions and measures across multiple scales.

In the process of holistic planning, stakeholders are encouraged to step outside of the boundaries of their disciplines, and to have a 'life cycle basis' view so that the implications of a project over its total time span are considered (Tippett, 2005).

The importance of participation

In a reflection on lessons learnt in the twentieth century, the need for broad participation in planning could not be over emphasised, especially as participatory elements could increase the quality of public decision making by improving information management and the legitimacy of the decision process (Messner et al., 2006). Participation is thus a crucial element in IWRM, and du Toit and Pollard (2008) note that in South Africa 'participation fatigue' might eventually lead to growing frustration with the implementation of the content of the National Water Act (1998).

The STA to integrated catchment management views the interaction between parts of the catchment, including human activities and population dynamics in such a way as to avoid problems like optimising one part of the system at the expense of the whole. Recognition of equity in handling upstream-downstream impacts pro-motes a foaminess of collaboration, allowing for individual ideas to share the burden of the entire system. This assures excellent stability and adaptability – characteristics lacking in systems which insist on homogeneity and absolute efficiency. Even as the European Union-Wide Water Framework Directive enters into public policy; researchers like Collins et al. (2007) are calling for a systemic approach to managing multiple perspectives and stake holding in water catchments.

Upstream - downstream relationships

River basin management is currently based on a narrow evidence base in which science is used to inform policy principally through modelling of catchment functioning. Limitations arise because many issues cannot be understood or defined from one particular perspective alone, nor resolved by unilateral action on the part of a single stakeholder. Even when the importance of context and multiple perspectives is recognised by policy makers, they may struggle to develop a more holistic or systemic view of the interdependency between individual actions and catchment (Collins et al., 2007). Scientific understanding is essential and informative but, where sustainable management is the goal; it is most effectively seen as only part of how stakeholders understand catchments. This situation is unlikely to change unless more systemic

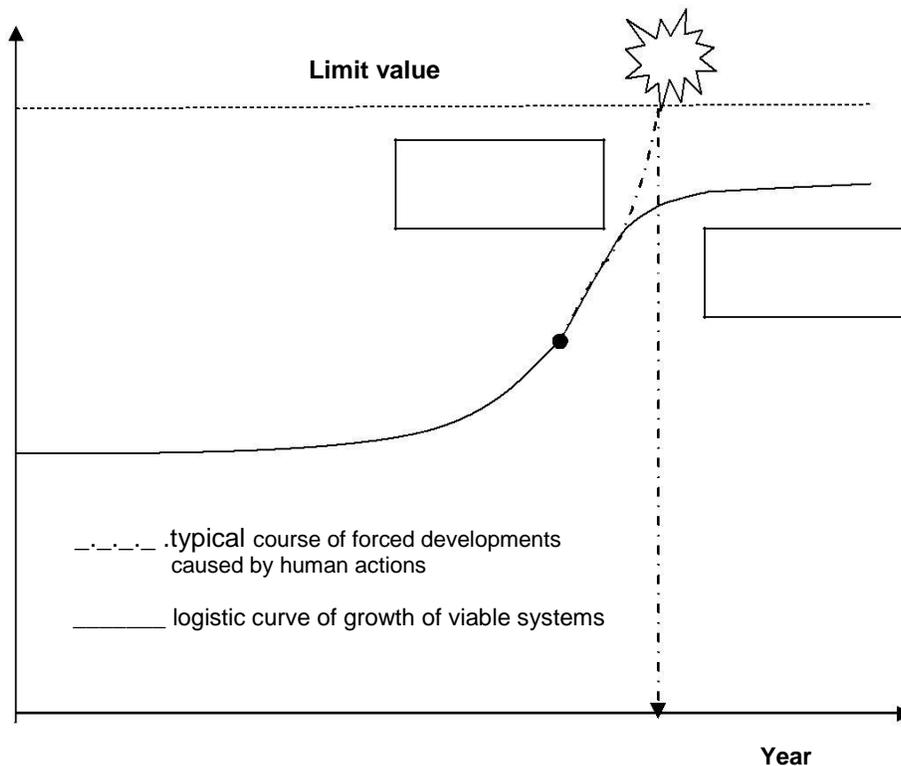


Figure 1. Logistic S-curve of sustainable development (Adapted from Chan and Huang, 2004).

approaches to managing multiple stake holding become more prevalent in policy and practice (Collins et al., 2007). Sustainable management of water requires integration, recognising the interconnections between upstream and downstream systems operating at different levels of scale. This is an endeavour in which ST could provide useful tools. Systems oriented models could enhance dialogue and facilitate work across these scales so as to increase focus on the 'whole picture' (Tippett, 2005).

Recognising the spatial placements of various stakeholders along waterways and within river basins, environmental policy principles such as the polluter-pays principle (PPP) and the precautionary principle are meant to equitably internalise the pollution externalities for basin sustainability. Their actual implementation however, depends on factors like different pollution assimilative capacities of the environment, different social objectives and priorities attached to environmental protection and different degrees of industrialisation and population density, which justify differing national environmental policies (Correljé et al., 2007).

The polluter-pays and the user-pays principle are both related to who should bear the costs of environmental degradation. According to the PPP, those who cause pollution should meet the costs to which it gives rise (Correljé et al., 2007). This is because environmental

risks arising from upstream developmental decisions and actions impinge on downstream areas that have little or no influence on those decisions. In order to take account of downstream interests, the two principles may be implemented so as to set an economically and socially acceptable scenario within the basin.

Waterborne effluents as outputs from a range of activities are disposed onto land and into streams and oceans via various sewerage and drainage systems. This tends to present a scenario where an operator is also responsible for polluting the downstream outlets, compromising environmental sustainability principles. Even where these services are handled by different players like in the case of South Africa, accountability is greatly compromised by the power of economics. This approach is currently running into the law of diminishing returns in the face of complex environmental challenges as stressed by various reports regarding the critical pollution problems for South African water resources, these being externalities to water treatment processes.

Pretty et al. (2001) cautions that if such externalities are not internalised, they distort the market by encouraging activities that are costly to society even if the private benefits are substantial. Such is the case when polluted water is treated for drinking water purposes. The tradition is to internalise the cost of treatment due to pollution load by setting the tariff structures, thereby

offsetting the cost of production. This costing model is structured without any regard to the other factors like the cost of depleting the water resources itself, a cost which should ideally be borne by the user of the natural resource.

Application of the sensitivity model (SM) to study area

For South Africa examples of deteriorating ecosystems are highlighted in DWAF (2003), DWAF (2006) and Winde and Stoch (2010). The Vaal basin, which is the focus of current on-going research, is one such example. It is highly impacted by mining, industrial and domestic waste (Clout and Roux, 1997; DWAF, 2007; Gouws and Coetzee, 1997; Naicker et al., 2003; Pieterse et al., 1987; Stevn and Toerien, 1976; Winde and Jacobus van der Walt, 2004).

Various ecological problems have ensued over more than 100 years (Winde and Stoch, 2010), of which the most acute ones are growing water deficit; pollution of open and underground water; enormous over-norm water losses and exacerbation of the problem of quality drinking water supply to the population (Leendertse et al., 2008). The report further highlights that addressing these and other water environmental needs in South Africa has been quite different where the focus has been strongly on organisational, institutional and legal aspects and not so much on implementation. In the meanwhile pollution continues to be a huge dilemma which calls for workable solutions, even if those solutions are slow. A ST tool called the sensitivity model (SM) (Chan and Huang, 2004) was proposed for implementing a STA in the study area, the Upper and Middle Vaal water management areas in order to systematically tackle the huge water pollution problems currently threatening the Vaal basin. The layout as adapted from Chan and Huang (2004) is shown in Figure 2. System description to understand the major issues as well as to identify the key players was done (Dzwairo et al., 2009) and a variable set established. Dzwairo and Otieno (2010) traced some pollution pathways within the study area that were critical to understanding the impact matrix (Figure 3) as well as the available data from key stakeholders, these being DWA and three Water Boards (utilities that treat water for potable use) falling within the study area. Implementation of the tool is on-going, hopefully to be taken up by the regulator and custodian of water resources in the country.

DISCUSSION AND CONCLUSION

A holistic approach to water management is beneficial for the environment only if it takes cognizance of environmental concerns. The benefits and implications of an integrated management system for the environment cannot be over-emphasized. Several practical examples

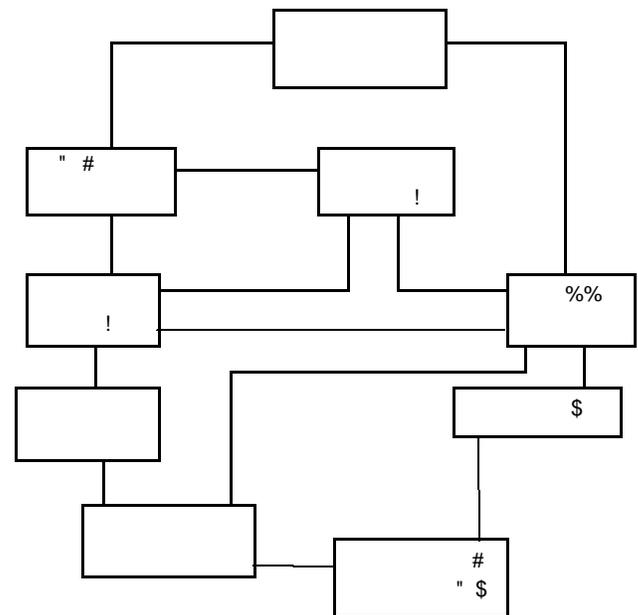


Figure 2. The procedure of sensitivity model (Source: Chan and Huang, 2004).

from Southern Africa and elsewhere make a strong case for IWRM to be an effective approach for sustainable management at river basin level. Operationalising IWRM is the huge challenge currently.

Stake holding is noted to be essential as the IWRM process should be driven by local interests and should address real needs without which IWRM cannot work. Although the immediate aim is not to be over-formulaic, it is imperative to align people in the common vision of IWRM, including sustainable environmental management. This requires strong institutional support if it is to be successful. The SM as one of many ST tools is envisaged to be adopted systematically and in phases beyond the current research in order to fill the gaps which are impediments to IWRM operationalisation in the Vaal basin. The model could incorporate a payment mechanism for natural resources through Simulation, reciprocal to pollution load as a trade-off for upstream-downstream pollution within a river basin.

It is thus recommended to uptake and incorporate the STA in IWRM decision making processes, an approach envisaged to be more participatory and also process-oriented. Incorporation of socio-economic dynamics is also recommended, with a suggestion that the bio-physical relationships like interactions in a basin between water, the human population and settlements should be analysed to the extent possible.

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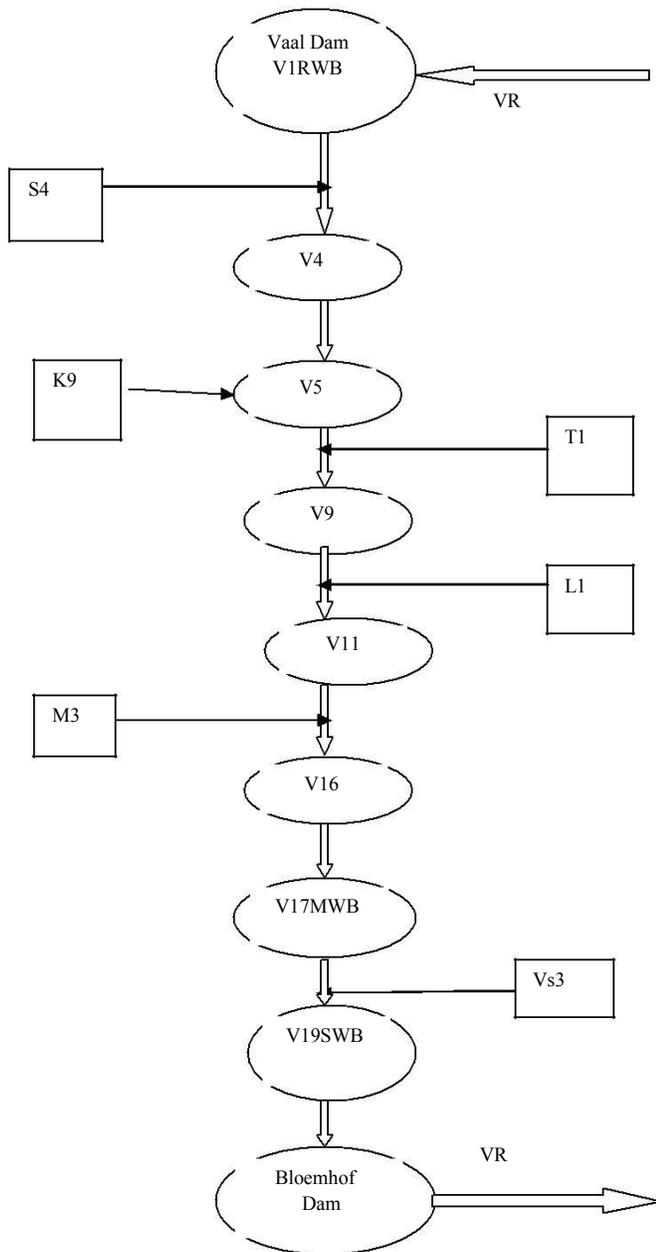


Figure 3. Layout of Vaal River (VR) monitoring points in relation to its tributaries (Source: Dzwairo and Otieno, 2010)

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