J. Water Resource and Protection, 2009, 3, 174-187
doi:10.4236/jwarp.2009.13022 Published Online September 2009 (http://www.SciRP.org/journal/jwarp/).

Integrated Catchment Value Systems

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Received April 22, 2009; *revised June* 1, 2009; *accepted June* 30, 2009

Abstract

Historic models of conservation are being superseded by the integration of ecological, economic and social dimensions into a simultaneously sustainable and supportive whole. This transition is evident as South Africa evolves from an apartheid history to novel governance including the equitable, sustainable and efficient use of water within an arid and increasingly climate-challenged landscape.

The concept of 'value chains', established in industrial and government thinking, has been applied to water issues. We explore and extend 'value chain' thinking to cover various important dimensions of water management, taking account of both developed-world assumptions and developing world realities.

This analysis exposes the limitations of linear 'value chains', and the need to join them up into cyclic systems if they are to protect or improve the capacity of water systems to support the sustainable livelihoods and wellbeing of people dependent upon diverse ecosystem services within catchments.

Informed by practical work by the authors in catchments within South Africa, we develop an integrated catchment value system model to support action research dialogues for the delivery of sustainable water services.

Keywords: Catchment, System, Ecosystem Services, Integrated, South Africa

1. Introduction

Recognising that historic approaches to conservation predicated upon excluding people and economic activities from biodiversity or habitat 'reserves' – so-called 'fortress conservation' – had become demonstrably ineffective and unethical, the Ramsar Convention of 1971 [1] ushered in a new era founded upon the 'wise use' of wetland resources through social and economic patterns that do not fundamentally erode the 'natural character' of ecosystems and associated biodiversity. This integration of ecological, economic and social dimensions has since become one of the central tenets of sustainable development. Growing recognition of the interdependence of these three attributes to all habitat types and landscapes was reflected in the 1980 *World Conservation Strategy* [2] and documented as a global consensus in the 1987 UN document *Our Common Future* [3].

The disconnection between social equity and biodiversity considerations is of great significance in South Africa due to its political history. Environmental racism took many extreme forms in apartheid South Africa, a significant element of which was the exclusion of black South Africans from their heritage during the construction of national parks [4]. During the apartheid regime, environmentalism operated effectively as a conservation strategy that neglected social needs [5,6]. Despite the extremely high value of South African national parks for both biodiversity conservation and tourism, they also reflect historic relations of power and privilege which have shaped South African society and which, in turn, confound simple communication of the broader value to society of ecosystems. For this reason, Cock [7] argues that the notion of environmental justice represents an important shift away from the pre-existing traditional authoritarian concept of environmentalism, concerned mainly with the conservation of threatened plants, animals and wilderness areas, broadening it in scope to also include urban, health, labour and development issues. Truly cohesive and sustainable development rests in large measure upon the extent to which all of society identifies with its dependence upon shared supporting ecosystems [8]. Brechin *et al* [9]. argue that, since the protection of nature is today a matter more of politics than ecology, social justice and biological conservation must go hand in hand if they are to flourish in the long term.

The apartheid history of dispossession produced a starkly unequal land ownership pattern and widespread rural poverty, which adds complexity and potential conflict to today's tasks of safeguarding environmental assets as well as undertaking land reform and ensuring access to water and other resources to benefit the historically dispossessed [10]. South Africa is not unique in this regard. Nature conservation and environmental concerns in the USA functioned politically as a coalition of groups with a variety of environmental interests including outdoor recreation, wildlands, open space, public health and pollution, but which largely reflected the tastes of a white political and economic elite [11]. Indeed, the history of clearances and dispossession of 'First Nations' peoples from land to be designated as National Parks in the USA closely mirrors the historic creation of National Parks in South Africa [12].

The concepts of sustainable development and environmental justice are inherently radical and subversive, overturning assumptions and vested interests implicit to prior world views. For example, industrialisation founded on economic and corporate governance models established at the outset of the European Industrial Revolution assumed a limitless pool of natural and human resources available for entraining into the production of financial capital [13]. There is also a history of resistance to allocation of water to 'Instream Flow Requirements', essential to maintain aquatic ecosystems in an intact and functioning state, as it is often seen as taking water away from supporting human needs and economic activities [14].

In the South African context, emerging sustainability and environmental justice principles challenge political assumptions and vested economic interests residual from the nation's history prior to the 1990s. Undertaking a change culture as radical as integration of the three strands of ecology, economy and society is necessarily a protracted process that remains far from complete. Robust scientific concepts are needed to guide this transition, but also a new narrative of the value of protected and restored ecosystems to support the life aspirations of all of the diverse sectors of South African society.

Many assumptions remain to be overcome about the requirements of ecosystems competing with human demands, despite the scientific reality that the many functions performed by aquatic and other ecosystems provide the basic resources and services that support human wellbeing, security and profitability [15,16]. Since the 1990s, there has been growing recognition of the many societal values provided by ecosystems. The numerous 'goods' and 'services' provided to society by the functions within wetland ecosystems were becoming increasingly recognised from the late 1980s [17–19], with societal value provided by forest, oceanic, catchment, rangeland, cropland and many other ecosystem types not long to follow [20–22]. Attempts at monetisation of these many previously unaccounted benefits led to a burgeoning of environmental economic studies, with Costanza *et al*. [15] famously quantifying the cumulative value of global ecosystem services between $US16 and $54 trillion (mean $US33 trillion) per year, largely outside the market and dwarfing the global gross national product of around $US18 trillion. Regardless of uncertainties about both this estimate and its underpinning assumptions, it had become undeniable that the social and economic value of ecosystems was both substantial and substantially overlooked in planning at all scales. Largely externalised from policy and practice, ongoing environmental degradation, not least anthropogenic climate change, threatens to undermine further progress with human development [23]. This trend is also reflected in the ongoing series of *Human Development Reports*, produced annually by the United Nations Development Programme (UNDP) since 1990 (www.hdr.undp.org).

'Ecosystem services', a phrase now subsuming the previous conception of 'goods' and 'services' originating from ecosystem functions, have been advanced by the Millennium Ecosystem Assessment [24] as a strategic mechanism to progressively internalize the interdependence of ecological, social and economic dimensions into sustainable human progress. Interpretation of ecosystem services and discussion of their method of implementation have been approached by various national governments, including in the UK [25,26]. This refocusing on ecosystem services is helpful in that it recognises ecosystems as the source of multiple benefits to society, in polar opposition to the prior conception of 'wildlife conservation' as a constraint on narrowly-framed capitalist social and economic progress. Notwithstanding considerable uncertainty in exactly how ecosystems 'produce' many of these beneficial ecosystem services, there is consensus that biodiversity is needed for ecosystems to function effectively and thus to deliver services [27]. By implication, management of ecosystems to maintain declining or merely a minimum residue of biodiversity is to deny opportunity to current and future generations who equally depend upon these ecosystem services to support their diverse needs. Continued degradation of ecosystems is therefore an infringement of human rights at all scales from the local to the global. Sustainable development is thus as much a moral as a biophysical imperative, dependent upon scientifically-rooted principles to ensure that its implementation is not distorted by vested economic interests [28]. Valuation of natural capital is an essential underpinning of a truly sustainable society and economy [29].

Conservationists across Africa are struggling to find a new model for the protection of species and ecosystems that is politically and economically acceptable to local communities and governments, and which effectively links conservation of biodiversity to social and economic benefits [30]. The interdependency of habitat types within drainage basins provides an integrating framework from which to apply systemic principles to ecosystem management for social and economic wellbeing [31,32].

In this paper, we consider various of the 'value chains' that have been developed in connection with ecosystems, people and economic activities. We then seek to mesh them together into a coherent system that can be used to guide practical dialogue, decision-making and sustainable development. This is undertaken in the context of catchments (drainage basins), acknowledging the limiting role of fresh water and associated services to human development across much of the globe [24,33]. In practical terms, we illustrate our thinking with instances in South Africa, where innovative new water laws [34] and attempts at their implementation create opportunities and case studies relating to novel thinking [35]. In particular, the three driving principles of South Africa's National Water Act 1998 [34] – equity, sustainability and efficiency – provide a sound basis for integrated thinking and implementation of water policies and operational reforms.

2. Value Chains within Catchments

The 'value chain' concept, ascribed to Michael Porter and first introduced in his book *Competitive Advantage: Creating and Sustaining Superior Performance* [36], arose in the field of analysis of industrial and commercial processes. Essentially, it relates to the sequence of activities that a product passes through in a chain of value-adding steps, and is widely used to identify inefficiencies, process enhancements and alternative business models. The concept is, however, of wider value in considering integrated water resource management (IWRM) and other ecosystem-based chains in that it provides a mechanism to link human utility and value (both market and non-market) to the natural processes that create and renew them. It also helps recognise that the means by which nature 'produces' the many ecosystem services from which society benefits is not limitless, and that different uses can have implications for the balance of ecosystem-provided services available to other consumers within catchments.

Given the wide acceptance of the value chain concept for considering cause-and-effect linkages in socio-environmental systems, we set out below five different 'perspectives' on water-related value chains. We then seek ways to integrate these into a coherent systems model for sustainable planning of socio-ecological catchment systems.

2.1. Perspective 1: The Basic Water Value Chain

Recognition of the ecological basis for production of diverse ecosystem services enjoyed by people within catchments is an important primary basis for sustainable and integrated management of water resources [20,24]. In its absence, an 'Industrial Revolution' mindset of water supply and demand might conceptualize the 'value chain' as flowing from rainfall to river to people and to the sea, with any 'unused' water in the river or draining to sea perceived as 'wasted'. This utilitarian model can be seen in those nations enshrining a 'large dam' culture, wherein large-scale engineering is seen as controlling and improving upon nature despite the widespread evidence that it is in reality contributing to declining ecosystems and diminution of services to populations across drainage basins [37,38]. In fact, water is not a static resource, but is in constant circulation in complex cycles at atmospheric, continental, catchment and habitat scales. In essence, it follows cyclic pathways at all these scales, in which living things play a key role. For practical management purposes, the drainage basin, or catchment, represents a pragmatic and finite management unit from which to comprehend and manage water [20,32].

Beneath the catchment landscape scale, at which important physical processes such as orographic effects may contribute to the character and hydrology of catchments, the interaction of water, sediment, solutes and energy with other non-living and living ecosystem components across a range of habitat types occurs through a range of 'ecosystem functions' [16,18]. These functions include water capture, water storage, floodwater detention, physico-chemical purification processes, regeneration of populations of fish, wildfowl, reeds, wetland trees and other vegetation, movement of particulate matter along the river systems ('sediment fluxes'), habitat formation, fluxes of plant nutrients, generation of characteristic ecosystems, and many more besides.

In turn, these functions generate the 'ecosystem services' from which society ultimately derives uses and utility [18,24], and which confer value to humanity in both its market and non-market senses [15,19,39]. The breadth of ecosystem services summarized by the MA is wide, yet itself only partial – covering 'provisioning services' (comprising basic resources such as 'fresh water supply'), 'regulatory services' (including such factors as 'climate regulation'), 'cultural services' (those that enhance human wellbeing i.e. 'aesthetic value') and 'supporting services (underpinning basic life-support processes required to sustain ecosystems such as 'nutrient cycling') – reflecting the dependence of society upon ecological processes for health, wealth creation and quality of life.

The methods by which ecosystems 'produce' their functions are not well understood [27]. However, habitat quality, quantity and location, and the representativeness of that habitat within river systems [40], are known to be important to provide the capacity for these functions as is the role of biodiversity within these habitats [27,41,42].

This basic 'water value chain', incorporating delivery from catchments through functions within habitats and their resultant services, uses and values, is illustrated below in Figure 1.

Of course, ecosystem services can be delivered by highly managed as well as natural ecosystems, although the breadth and balance of services may be altered by modification with consequences for different sectors of society [16,18,43]. In very many cases, industrial exploitation of ecosystems has tended to focus on utilization or management of just one or a few ecosystem services – for examples over-abstraction, damming of natural catchment flows to serve local utility, or waste discharge – and this inevitably comes at a cost to a wide range of other services generally to the detriment of communities sharing catchments [44]. There are, by contrast, positive examples (several reviewed by Everard, 2009) where sensitive management of critical catchment ecosystems and ecosystem functions has delivered a broad range of simultaneous benefits. These include, for example, reliable flows of high quality water, fish recruitment, landscape and tourism protection, and biodiversity gains. Some types of human intervention may therefore be protective or restorative of ecosystems and their supportive capacities. It is then necessary to look at the impacts of different types of human activities upon catchment functioning (*Perspective 2*), the potential for dialogue within society to manage impacts upon and the consequent sharing of ecosystem services (*Perspective 3*), and planned measures to deliver beneficial management consequent from various forms of social contract (*Perspective 4*). Some of these perspectives are encapsulated in some legislation aimed at sustainable catchment management, for example the EU Water Framework Directive.

2.2. Perspective 2: Societal Impacts upon Water Services

Humans are one of the living components of catchment ecosystems, and human pressures often significantly modify catchments at a range of scales varying from broad-scale climatic perturbations and aerial fall-out through to more direct pollution and physical modification of habitat, biodiversity and functioning at scales from the regional to the very local. Some activities alter the functioning of catchments for the express purpose of protecting human development activities (for example flood protection of urban or industrial development in floodplains) or to exploit selected catchment ecosystem services (such as soil fertility exploited by settled agriculture or alternatively dams construction to retain fresh water). One such model of societal impacts upon the 'services' provided by the water environment is contained in the (UK Government) Defra document *An introductory guide to valuing ecosystem services* [25], reproduced in Figure 2.

This 'impact pathway of policy change' model is simplistic; it can not be assumed that changes in policy will result automatically in consistent modification of practice. This is particularly so in the developing world where behavior, particularly amongst people least connected with 'first world' economic activities and their associated benefits, is often far from congruent with national policies. A practical example from South Africa is

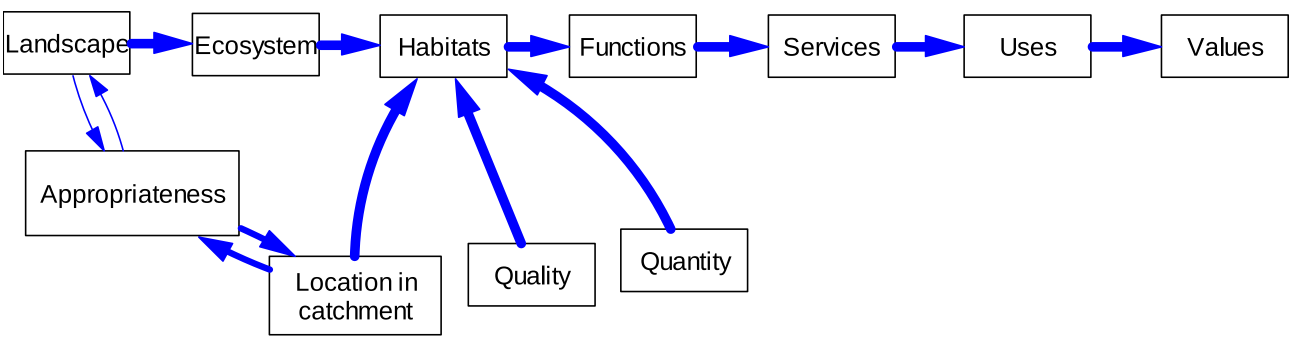

Figure 1. The basic water value chain.

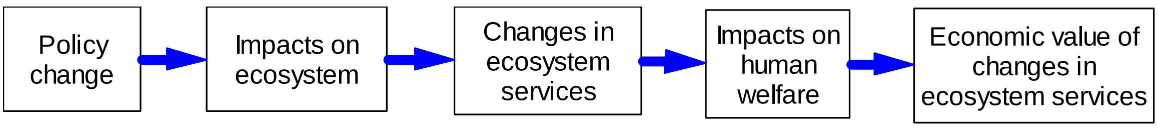

Figure 2. Societal impacts upon water services [25].

collection of fuel wood which, despite the existence of some statutory prohibitions, remains de facto practice amongst rural communities with ramifications for erosion, the hydrology of catchments and biodiversity. Other mechanisms beyond traditional regulation may be more potent in shaping the perceptions of these wider publics, and in modifying human impacts upon ecosystems with consequences for ecosystem services, human welfare and economic value. However, regulation also retains an important role as part of a broader 'package' of instruments that may contribute to modification of social impacts upon water services.

Across the world, various forms of social contract, whether traditional, voluntary or enshrined in formal regulation, have been adopted in recognition of the need to protect the 'carrying capacity' of catchment ecosystems supporting the diverse needs of catchment communities. Regulation of effluent released into catchments is now commonplace in the developed world, implemented to protect the various uses to which river reaches are put based generally upon sets of 'use-related' water quality standards [45]. Controls on catches from fisheries, harvesting of reeds, timber, birds and other catchment products, and a range of other agreements to limit impacts upon ecological integrity are commonly encountered as an expression of public agreement to protect the integrity of aspects of ecosystems of significant economic and/or cultural value. Many nations have codes of good agricultural practice as a basis for limiting the negative environmental impacts of agriculture and other forms of land use [46], intended to protect the functioning of catchments from overuse or misuse by a minority. Of course, the practical observance and enforcement of such policy measures is often at considerable variance with intentions, particularly in developing regions of the world.

Market incentives play an influential role in stimulating behaviour change. When markets ignore ecological 'carrying capacity' and the rights of downstream communities, they can accelerate erosion of essential ecosystem services. However, their potency in changing behaviour can also render them beneficial and particularly in regions where traditional regulation is less effective or largely ignored. For example, informal sectors, particularly those closest to a subsistence level and in rural communities, do not generally respond to laws, which are also often poorly enforced, but they will respond to markets. This is particularly the case where land ownership issues, historic water rights and other vested interests can confound optimal sharing of ecosystem benefits across catchments. Subsistence farmers, and other such constituencies of the 'informal economy' of catchment populations in developing countries, can represent a substantial element of catchment communities; their behaviour can have a major cumulative impact on rural catchments. Where positive incentives for behaviour change feed back to improved value and 'quality of life', markets may be a key instrument leading to either more or less sustainable behaviours. This then highlights the need to create appropriate markets to maximise the benefits of all within catchments. This principle may also apply in developed countries, with markets for ecosystem services playing a key to role in upland catchment management to secure the water supply of New York City and in the SCaMP scheme in north west England (both reviewed in this context by Everard [47]).

In a free market economy, wherein no such market is created for trading in 'ecosystem services', people developing 'upstream' areas of river catchments are able to benefit from the use or conversion of sensitive habitat whilst not bearing the costs of loss or alteration to functioning elsewhere within the catchment system. Correspondingly, those downstream may be unaware of the management conditions upstream that perpetuate the ecosystem services upon which their land and water uses depend [31,32,48]. However, opportunities exist within development planning and water licensing systems to require mitigation measures to address significant impacts upon ecosystem services. For example, consent for a 'water hungry' development, such as a major new factory or renewal of a water abstraction license for commercial forestry, could be granted on condition that investment was made available for upstream habitat improvement to increase the yield of water from the catchment. Even though the quantitative science is currently uncertain, we already understand the principles adequately to be confident that such a mitigation measure would also help deliver wider benefits to others within the catchment as well as being beneficial to wildlife.

This mix of formal, market and informal drivers of behaviour change with respect to the desire for more sustainable societal impacts upon water services are illustrated in Figure 3.

All of these measures – policy and perception including market signals and cultural values – have strengths and weaknesses in the effective engagement of all catchment stakeholders around a commonly-understood narra-

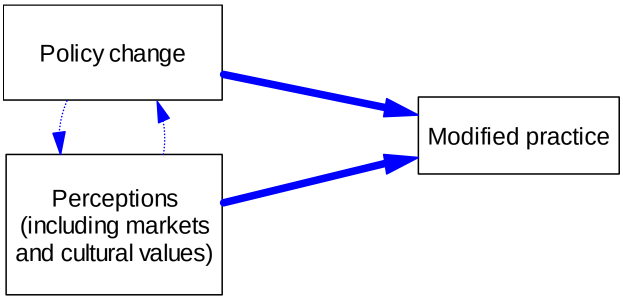

Figure 3. Societal impacts upon water services.

tive relating to water and equitable sharing of its many ecosystem services.

2.3. Perspective 3: Social Dialogue about Water

Social dialogue within catchments concerning the value of ecosystems in supporting societal wellbeing and potential is generally not expressed in technical terms such as those discussed above. Instead, social discourse generally revolves around enjoyment of the benefits of ecosystem services, or suffering from their limitation. These include, for example, services such as fresh water for domestic, agricultural or industrial uses, the vitality of fisheries, fertilisation of floodplains, flooding of developed land, the sense of place within a landscape enjoyed by a community, or the contribution of a changing river reach or forest to cultural character. Most of societal (including industrial and agri-business) identification with catchments occurs at the level of 'uses' and their resultant 'values' flowing as benefits from catchments (as already elaborated in Figure 1). These include, for example, supply of water, dilution of liquid wastes, navigation, viable fisheries (commercial or recreational), hydroelectric generation, fertilisation of floodplains, irrigation of crops, and so forth. Given the significant influence of society upon catchments, and the reciprocal shaping of social and economic patterns by catchment processes, it is legitimate to consider catchments as much social constructions as ecological ones [49]. This is manifestly the case where, for example, inter-catchment transfers and wastewater works generate new and bigger flows, or where large-scale dams alter catchment hydrology.

Identification of the catchment as a finite source of the resources that can potentially meet the competing needs and requirements of different sectors of society within catchments ('catchment communities') provides a basis for dialogue about the interdependence of different catchment uses. It also offers a platform for dialogue about options for catchment development, as all changes to the management of ecosystems and 'harvesting' of ecosystem services, both deliberate and unintended, will inevitably result in different 'winners and losers' through its influence on the suite of ecosystem services delivered throughout the catchment. Social dialogue about catchment use has to take account of the 'package' of interdependent ecosystem services occurring within a catchment, and the sharing of these services amongst the catchment community without one sector creating widespread disadvantage or long-term insecurity for others.

A simple example of this is how an off-channel fish farm may benefit a few people locally but may be detrimental to the self-sustaining river fisheries that support the needs of many other people within the catchment. A more complex example is that of a major dam designed to maximise the local provision of selected ecosystem services (primarily water supply, power generation and potentially some flood protection and/or lake fishery benefits) for clearly-articulated benefit of a chosen few people (who may be local or distantly connected by piped infrastructure). However, dam construction and operation generally tends to compromise the broader suite of other ecosystem services delivered across the whole drainage basin to the detriment of many more people dependent upon the wellbeing of fish and other wildlife stocks, fluxes of silt and nutrients along river corridors, water flows adequate to eliminate waterborne disease vectors, the natural fertilisation of floodplains for seasonal cultivation and grazing, etc. [50]. Inclusion of all constituencies within catchment communities is central to equitable social negotiation and outcomes, ensuring that those traditionally marginalised or excluded from governance decisions and shares of catchment services are given a voice. It is sometimes argued that indigenous peoples are 'closer to nature' and therefore more likely to think systemically [51]. It is generally true that traditional lifestyles are most directly dependent upon ecosystem services such as water collection from streams, fertilisation of riparian grazing, informal fisheries and so on, and that these people are therefore often the most vulnerable to the water use practices by others that erode the general 'carrying capacity' of the catchment. However, it is also true that all people dependent upon ecosystem services, including industries and municipalities remote from habitats critical to the supply of those services (such as water abstracted for mass supply from lowland rivers or dams which is dependent upon the water capture, storage and purification functions of wetland and upland areas of catchments) will be affected by degraded ecosystems.

The potentially deleterious interaction of social activities within catchment ecosystems has given rise to a great deal of historic water-related legislation in the developed world. This may particularly reflect the implications of unsympathetic uses (i.e. waste disposal, over-abstraction, over-harvesting of fish, wildfowl or other resources, etc.) for public health and other uses of river systems to which catchment communities aspire [45].

Understanding of the wide suite of uses and values stemming from ecosystem services, upon which different social and geographical sectors within catchment communities depend and which communities to a greater or lesser degree generate (via their use or abuse of the system), provides a basis for dialogue within catchments upon the relative apportionment of benefits to different sectors of society. This 'social negotiation' value chain is illustrated in Figure 4.

In recent years, there has been a substantial development in techniques for managing this type of social negotiation. Essentially, this requires a social space to be created and held, in which different interest groups can

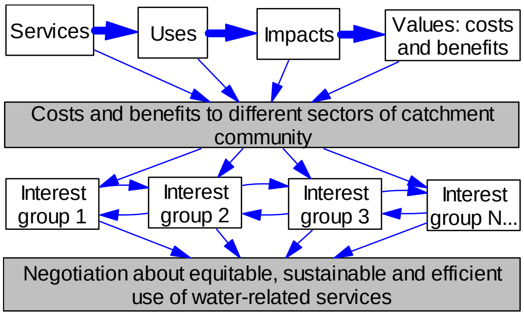

Figure 4. 'Social negotiation' value chain.

express their perspectives on the services, uses, costs and benefits that they see as flowing from (in this case) catchment ecosystems [35,49]. Within this dialogic space, interest groups are required to hear each other's perspectives and then, from a position of enhanced understanding, negotiate agreement on how these services, uses, costs and benefits are to be shared. This decision then helps determine necessary management priorities to deliver commonly-held goals.

Under traditional cost–benefit analysis, these different values and perspectives tend to be collapsed at the outset into the value set of those facilitating the dialogue and/or of more powerful interest groups [50]. By contrast, more recent forms of social appraisal have developed which employ a wide range of approaches and techniques to enable a more open or deliberative process of learning and negotiation between different stakeholders [52–55]. Some of these methods are shown in Figure 5.

2.4. Perspective 4: Protection or Enhancement of Catchment Capacity

Historic patterns of development have degraded the quality and extent of habitat types throughout the world [24], with wetlands a particularly vulnerable set of habitats readily degraded to the detriment of many who depend upon their ecosystem services [18,33]. Whilst the methods by which the functions of catchments 'produce' the diverse services of human benefit are still relatively poorly understood [27], we can at least be confident that the quality, quantity and location of appropriate habitat and representative ecosystems within catchments is of great importance [56]. It is also feasible to identify those wetland uses which are more or less sympathetic with catchment functions, providing a basis for the sustainable use of critical wetland areas [43]. For example, where orographic processes are significant in providing a source of water across catchment systems, the vitality of moist upland areas may be of fundamental importance to the hydrology of whole catchment systems (as for example in the Western Ghat mountains of Deccan India, the Pacific crest of the Andes in Amazonia, or the Drakensberg mountains as a key water capture area for South Africa.) Equally, wetland zones and naturally-inundated floodplain areas may be important for self-purification of water and flood detention in lower catchments [17,57]. These key areas of habitat provide not only nature conservation benefits but are also ultimately economically important through the various other beneficial services they produce to the advantage of wider constituencies throughout entire river catchments. The protection of

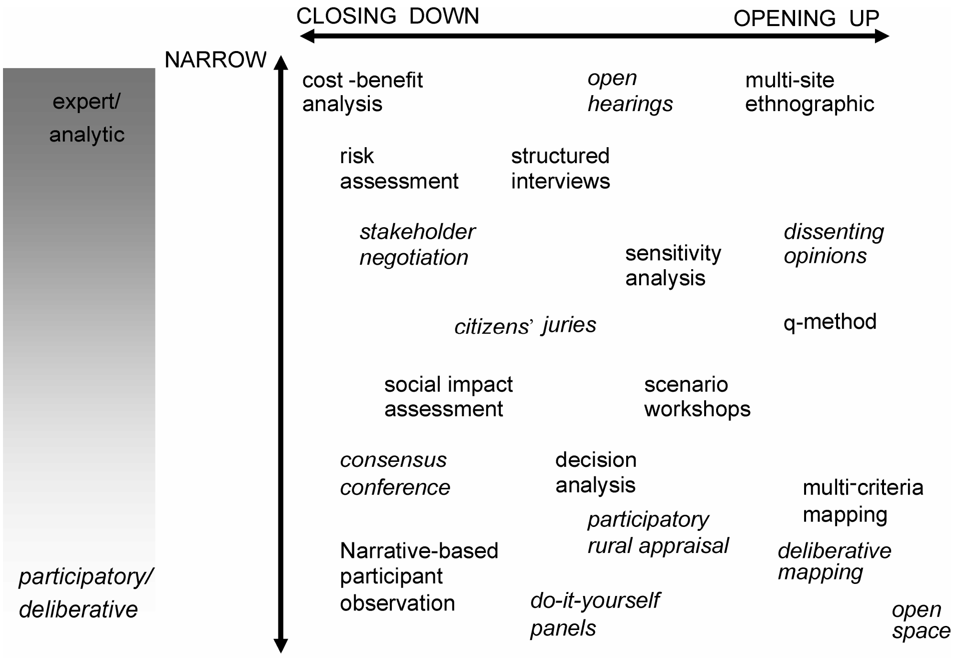

Figure 5. A schematic space for examining individual methods in appraisal design [54].

such important functional zones of catchments is therefore not a matter of altruism but represents a wise investment in the source of ecosystem services central to sustaining the diverse uses and values enjoyed by catchment communities [48].

There is a growing evidence base to substantiate the value of restoration of lost habitat critical for ecosystem functioning as a means to secure enduring benefits stemming from the supportive capacities of catchments [58]. Everard [47] reviews various schemes around the world wherein investment in restoration of critical catchment functioning has yielded economic and social benefits on a sustainable basis. This includes the famous Delaware-Catskills scheme in New York State and SCaMP in the north west of England. Although research questions remain to be answered, the cost-effective delivery of water savings within South African catchments, based upon clearance of water-hungry invasive vegetation, has been proven. (DWAF [59], and as reviewed by Woodworth [60]). An analysis of the mechanics and magnitude of water savings within South African catchments demonstrates that total incremental water use by invasive plants, controlled by the *Working for Water* initiative, account for as much as one-third of the estimated total water use in the Western Cape with the greatest percentage reduction in natural run-off a staggering 91% in the Namaqualand coast [61]. This is due largely to increased evaporative loss by invasive trees compared to native herbaceous vegetation [62] with rooting depth a key factor in depleting the water recharge of former rangelands [63]. In a study initiated to improve targeting of removal of problem species in the most impacted places, preliminary assessments of the costs, benefits and progress of South Africa's *Working for Water* programme demonstrate a considerable set of benefits associated with improved water yields [64,65] and additional benefits for further ecosystem services in other South African biomes [66]. However, one of *Working for Water*'s key strengths is its integration of ecological, economic and social goals, which have also delivered multiple additional benefits to society including employment and training for formerly excluded communities. The demonstrable success of the *Working for Water* programme is seen as influential in the decision by former US President Clinton to initiate the Comprehensive Everglades Restoration Program (www.evergladesplan.org), one of the largest natural capital restoration projects in the world. Related initiatives such as the Australian Landcare scheme (www.landcareaustralia.com.au), local projects set up by the UK's network of voluntary River Trusts (as reviewed by Everard [48]), and ecosystem service-related conservation in the catchment of Kenya's Lake Naivasha demonstrate the effectiveness of initiatives placing the functioning of catchment ecosystems at the centre of planning to improve hydrology, water quality and other functions delivering the beneficial services enjoyed by catchment communities. This feedback of societal consensus into protection or restoration of ecosystems and their services is illustrated at Figure 6.

Perspective 4 also becomes important in considering the resilience of catchments to environmental stresses, particularly in the light of increasing human demands and the stresses of climate change [67]. Ecosystem resilience was defined by Holling [68] as relating to the magnitude of disturbance that can be absorbed before a system changes its structure. Whilst the finer details of factors contributing to ecosystem resilience remain poorly understood, and there is even less consensus on how resilience is best measured, the integrity of ecosystems and their continued functioning is nonetheless perceived as a vital underpinning particularly in the light of growing environmental pressures [24]. The continuity of beneficial ecosystem services is therefore one of the key factors to be included within planning for resilient and sustainable catchments.

2.5. Perspective 5: Collective Visioning and Cooperative Governance

Rather than competing for finite and dwindling resources, shared understanding within catchment communities of the ecological basis for production of ecosystem services can provide a mechanism to promote social dialogue about a desired future. It is possible to go beyond collective bargaining about allocation of the remaining ecosystem services across catchment communities, moving instead towards mitigation or restoration to create capacity for current and future human needs. Desired catchment 'outputs' – services that deliver the uses and values enjoyed by society – may instead serve as a foundation for development of a collective vision of the future needs of the diverse constituencies within a shared catchment.

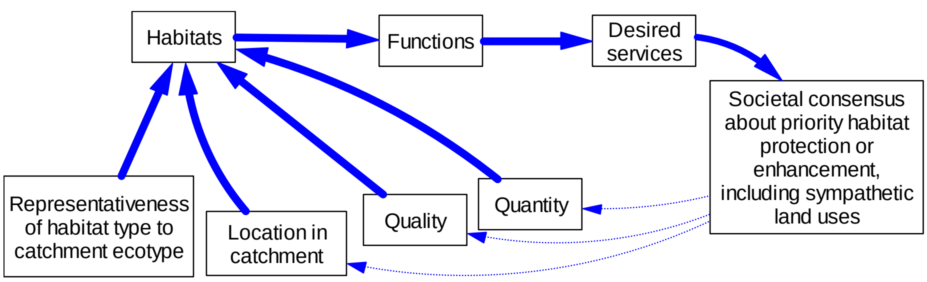

Figure 6. Protection or enhancement of catchment functions and services.

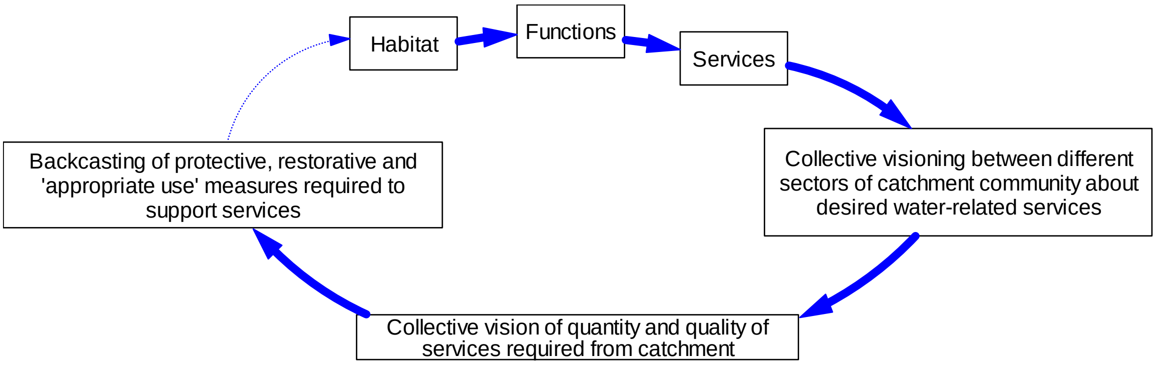

Figure 7. 'Desired future' value chain.

Where effective social dialogue can be brokered to reach agreement on a desired set of services to support the often-conflicting needs of all, catchment communities can then work 'upstream', back along the value chain, to determine the functions, and hence habitats, ecosystems and appropriate technological modifications, that can provide for them sustainably. This form of shared vision can relieve contention and conflict; indeed, cross-catchment agreements on water allocation and management can be a powerful focal point for promoting peace and overcoming historic conflicts particularly in water-stressed regions [69].

Backcasting is an effective means for achieving this, based not on the extrapolation of trends and predictable future events (i.e. 'forecasting') but instead taking as its reference point a clearly-articulated end-goal from which to work progressively towards identifying those policies, activities or trends that need to be adjusted to achieve a 'preferred' future [70]. For this to work, a common understanding is required of the underpinning sustainability principles that can lead to judgements about strategically important protection and restoration measures, and to identify the innovations that will be necessary to make 'step changes' and to found new social and economic agreements to make them work. By starting from the 'end-goal' perspective, backcasting can also help make sustainable development tractable, enabling the breaking down of sustainable development actions into 'bite-sized chunks' that lead towards a far longer-term result that is owned by catchment communities.

Running the value chain backwards, we can envisage diverse communities within a catchment getting together, for example under the aegis of a Catchment Management Agency, Water User Association or other (South African) stakeholder model, to identify the services required, the critical ecosystem functions that supply them, the productive ecosystems that these depend upon, and therefore the catchment characteristics required to support all stakeholders' needs. At this point, limitations of linear 'value chains' used in isolation begin to be exposed, with a need to join them up into cyclic systems if they are to stimulate iterative changes for progressive improvements to the wellbeing of people depending upon the diverse ecosystem services performed by catchments. This iterative investment in ecosystem-mediated collective wellbeing may best be achieved through a process of co-operative governance that matches the desired future with the habitats and functions that 'produce' the desired services. This is illustrated as Figure 7.

Such an approach is being trialled in practice in the Inkomati water management area (IWMA) in South Africa, where the Inkomati Catchment Management Agency (ICMA) has brought together diverse stakeholders during 2007 in order to create a vision for the future of the IWMA [35], using the 'Future Search' dialogue process [55]. The nine themes of the 'common ground' vision statement produced and agreed by stakeholders at the IWMA Future Search workshop held in the Inkomati catchment in October 2007 were as follows:

- All stakeholders actively working together – improved stakeholder co-operation
- Quality of river and ecosystems improved – less pollution – greater environmental awareness
- Equitable distribution of water to all stakeholders
- Improved infrastructure for water distribution
- Capacity and skills development – emerging farmers becoming commercially empowered
- Recognition of the role and importance of the ICMA
- Improved governance and compliance with legislation
- Improved gender balance
- Job creation though tourism

This provides a strategic and consensual framework for policy and management of the catchment to maximise the benefits to all sectors of the catchment community. The framework can be used as the basis for determining planning applications, instituting catchment protection measures, targeting of appropriate restoration initiatives (i.e. *Working for Water* or the partner *Working for Woodlands*, *Working on Fire* and *Working for Wet-*

lands schemes in South Africa, amongst other options, etc.), all of which can be cross-referenced and cost-justified on the basis of delivery of ecosystem services. Given the uncertainties in the trajectory of ecosystem restoration and the untested nature of this approach, this visioning and the strategy for its longer-term delivery will need to be based on the principles of adaptive management, embedded within a cooperative governance or social learning framework [67,71,53].

Ultimately, it will be necessary to embed these innovative management approaches within River Basin Management Plans and other statutory planning frameworks. This conclusion echoes that of [72] who, having co-developed an Integrated Management Plan (IMP) for the Alfeios basin (Greece) aimed at protecting or restoring surface water and groundwater through partnerships leading to agreed goals and solutions implementation processes, identified a need for the eventual lodgement of the IMP within Greek National Plans for water.

2.6. Towards an Integrated Model

Water and the supportive ecosystem services associated with it are, of course, not merely convenient human commodities but are the basis of one of the great life support cycles of this planet. The water cycle is infinitely renewable, with its cyclic nature one of the defining features of sustainability. Therefore, to think in terms just of 'value chains' is to assess water in fragmented and utilitarian rather than sustainable terms. 'Hard' engineering solutions have a role to play in securing access to water for populations of high density relative to natural environmental 'carrying capacity' in arid regions such as South Africa. 'Softer', ecosystem-focused solutions discussed in this paper have a key role in water policy to augment and add resilience to water supply. This may include not only directly serving the needs of dependent communities distributed within catchments but also helping maximise the longevity and hence value of pre-existing 'hard' infrastructure. Protection and enhancement of ecosystem functioning delivers multiple benefits on a sustainable basis, both in terms of local use and extending the social and economic values of dams, pipes and other durable infrastructure. To develop a sustainable relationship with water and its associated ecosystem services, society has to consider its 'value chains' not in linear isolation but within the context of this greater water cycle.

Furthermore, while it has become commonplace from a reductionist perspective to view the world through separate social, economic and ecological lenses, from a systemic perspective these dimensions are fully interdependent. Every element is intimately influenced by each other, just as decisions and actions taken by a sector of society in isolation from wider consideration of ecosystem functions will have ramifications for all others within catchment communities.

For this reason, sustainable thinking and decision-making depends upon the weaving of these socially-, economically- and ecologically-based value chains into a cohesive and integrated systems model. This will then provide a basis for thinking and acting that takes account of the interdependencies between each element, forming a basis upon which catchment communities can plan and manage collectively for an equitable, sustainable and efficient future.

Some work has already been undertaken to integrate some of these value chains. For example, the document *eThekwini Catchments: A Strategic Tool for Management* [73] is a practical development planning tool that embeds an 'ecosystem services' approach into urban planning, recognising that further economic development of the city of Durban and the greater eThikwini municipality (in KwaZulu-Natal, South Africa) is limited by the environmental carrying capacity of its river catchments. The document provides planners with a graphic and simple means to determine the likely impacts of development proposals on various beneficial ecosystem services upon which the wellbeing of people and economic activities depends, making clear the relevant costs, benefits and other implications for carrying capacity in any development planning decision. A study by South Africa's Institute of Natural Resources (INR) of economic impacts on ecosystem services in the Thukela (Tugela) river catchment [74] applies a variety of methods to ascribe economic values to the wide range of current uses enjoyed by the diverse communities within various of the river's sub-catchments. The study then proceeds to evaluate marginal changes to these benefits and disbenefits as affected by a set of Instream Flow Requirement (IFR) scenarios. This reveals a significant divergence of costs and benefits, in total and across affected communities, in the sub-catchments targeted by the study.

These studies are preliminary but extremely helpful in linking ecosystem functioning with the services, uses, values and societal implications of different options for development within planning, effectively linking Perspectives 1 to 3 within this study. The *Working for Water* programme makes a major contribution to Perspective 4. The study *Payment for Ecosystem Services: Developing an Ecosystem Services Trading Model for the Mnweni/Cathedral Peak and Eastern Cape Drakensberg Areas* [58] seeks to make linkages between the restoration and management of upper catchment areas for the purposes of increasing run-off of water, yielding economic benefits to catchment communities, for which it proposes a trading model to link the beneficiaries to the currently public investment in habitat management. Thereby, the Maloti Drakensberg Transfrontier Project study seeks to link an aspect of Perspective 5 (a vision of increased water availability from the upper catchment) with Perspectives 1 to 3.

Therefore, not only are the various value chains (represented here as 'Perspectives') understood and accepted, but there is already progress towards their integration. We propose a full integration of these disparate value chains as described into an integrated catchment value system, as illustrated below in Figure 8.

We appreciate that this model is evolving and that, in particular, the relationships illustrated by each arrow may not be well understood. Furthermore, given the difficulties inherent in predicting the trajectory of ecological restoration and the uncertainties in the methods, the model must be applied in an adaptive and contextualized manner.

However, these uncertainties should not be construed as a basis for delay with integration of social, economic and ecological elements of catchment planning around a nucleus of ecosystem services. It is already abundantly clear that, without restoration of catchment functions, the net capacity of catchment services is finite, and where natural limits are over-ridden then ecosystem services and catchment integrity will inevitably decline to the detriment of the majority of catchment communities. In a water-stressed world with a growing population and the looming threat of climate change, strategic planning and implementation of integrated water resource management is a pressing priority.

Adaptive decision-making will be required to reflect this interdependence of catchment ecosystem functions and services, reflecting the fact that human needs and uses as well as catchment condition, ecological response and climate change effects will fluctuate over time.

3. Discussion

The synthesis of ecologically-, economically- and socially-based value chains into an integrated catchment value system provides an over-arching framework for considering equity, sustainability and efficiency (the three driving principles of South Africa's National Water Act 1998 [34]) in practice. It does so not only by integrating these three themes but also by taking the finite supportive capacities of the catchment – the ecologically-based water value chain – as central to all other decisions. It thereby provides a practical basis for implementing the 'ecosystems approach' through a co-operative governance framework.

The sustainability and efficiency principles are transparent in the construction of the model, relating to balancing 'production' by the catchment ecosystem with use and sharing of water by the human population. The equity principle is also implicit within the model but is worthy of further commentary. It is in the dialogue around the integrated catchment value system that equity is enshrined in ensuing management decisions, ensuring that all sectors of catchment communities are facilitated in dialogue about a share of catchment services (Perspective 3), in the vision of catchment enhancement to maximise services (Perspective 5) and in the reward for land management to 'produce' the benefits enjoyed by others downstream as implicit in the integrated catchment value system as well as the Maloti Drakensberg Transfrontier Project [58] model. We also need to ensure an equitable distribution of management and other costs associated with modifying ecosystem services within catchments.

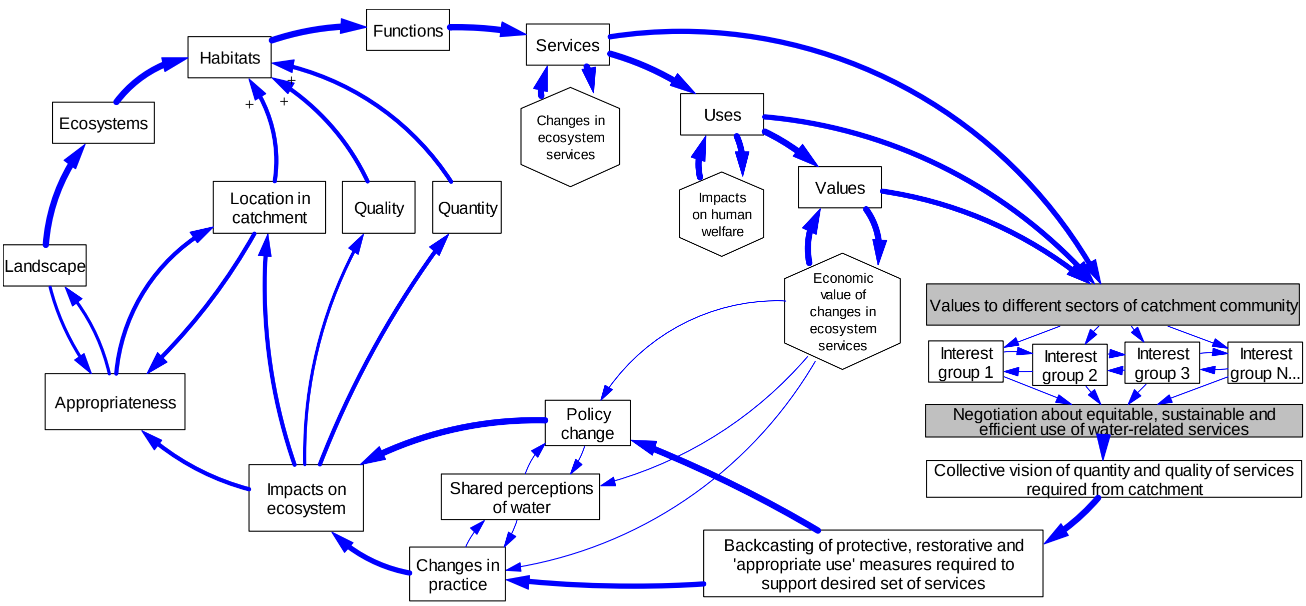

Figure 8. Towards an integrated value chain model.

It is above all important to emphasise that our work on this integrated catchment value system model arises through action research dialogue with catchment managers (staff of the ICMA and DWAF KZN (KwaZulu-Natal provincial office of the Department of Water Affairs and Forestry)), described by Colvin *et al*. [35]. This work is enabling us to develop a facilitation framework to guide practical decision-making about sustainable use of catchments. Fundamental principles of this framework are that it seeks equitable shares of access to water services and the distribution of costs, their sustainable exploitation, protection and restoration, and a basis for efficient and innovative uses that make room for all of the catchment community and the integrity of the ecosystems that 'produce' the beneficial services upon which they rely.

The model is also intended to help communicate to wider publics in catchment communities that investment in ecosystems (i.e. natural capital) is not competitive with human needs but rather provides the basis for quality of life. Catchments with diverse and representative habitats and associated ecosystem functions provide resilient and varied services supply just as, conversely, degraded catchments are compromised in their resilience and their capacity to support multiple human needs indefinitely. This has been demonstrated by improved water yields, water quality and biodiversity in landscapes managed favourably, including under South Africa's *Working for Water* and *Working for Wetlands* programmes amongst other examples, as well as through targeted agricultural improvements, more natural flow regimes instituted by sensitive water releases from dams, river habitat and wetland restoration, and a range of related measures implemented across the world.

Investment in appropriate ecosystem management and/or restoration can enhance catchment functioning, boost ecosystem services, increase societal use and utility, and deliver greater and more resilient value (both economic and subsistence) to the optimal benefit of catchment communities. All stakeholders have an interest in collaboration to protect or improve the core resource upon which their evolving and interdependent needs depend: the supportive capacities of catchment ecosystems.

If this integrated catchment value system model can be used as a basis for dialogue about allocation of ecosystem services benefits and costs, and visioning of a desired future, it may also make a contribution to 'ownership' of catchment management and societal cohesion amongst the many elements of the catchment community.

4. Acknowledgements

This publication has stemmed from various strands of work undertaken by the authors, significantly including the 'Watercourse' capacity-building initiative led by John Colvin, Mark Everard and Sam Chimbuya and funded the UK Foreign and Commonwealth Office (FCO).

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