Integrated, adaptive and domanial water resources management

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Abstract[1]

Arising from concerns that integrated and adaptive water resources management (I/AWRM) may not be sufficiently tailored to certain kinds of environments, this article examines their design through a governmentality framework, positing that I/AWRM could be enhanced by increasing accountability and local appropriateness through citizen's actions that address and are situated in three types of domains – spatial 'holons', hydrological regime 'phases' and problem-solving 'tasks' – an exercise termed 'domanial'. As explained in the paper, the geo-economic scope of this paper are countries as in Sub-Saharan Africa where climatic variability and widespread irrigation dominates river basins that in turn have limited capacity for well-financed administration commonly seen in Europe. The need to recognize irrigation in adaptive water management is born from the great proportion of freshwater depleted by the sector and its effects on water shortages and behaviors in other sectors. Because of these characteristics, there is a risk that in irrigated semi-arid environments, IWRM (with a regulatory emphasis on managing water use to effect water allocation between sectors in large river basin units) or adaptive versions of IWRM (emphasizing iterative refinement and wider system complexity) will not engender satisfactory outcomes.

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Introduction

Although adaptive water resources management (AWRM) may be distinguishable from integrated water resources management (IWRM) by the degree to which AWRM is adaptive in practice, their *intended* broad objectives and modalities are similar enough for them to be variations on a single theory of adaptive, integrated water resources management (A/IWRM). Thus it is possible to argue that AWRM – explorative, iterative and cognizant of wider complex human, climate and ecological systems (Pahl-Wostl and Sendzimir 2005) – is captured within a wider IWRM family (Mitchell 2004; GWP-TAC 2000; Radif 1999; Allan 2003).

Nevertheless, despite the IWRM paradigm subsuming different versions, the notion that adaptive water resources management might have special qualities raises key *process* questions that illuminate our theorizing of water management. What clearly distinguishes adaptive water resources management from integrated water resources management to lead to improved results? Or put another way, are the only differences between adaptive and integrated water resource management those of on-going adaptation and a wider, more complex set of reference systems? Pertinently, how does AWRM claim to deal with complexity? The analysis here argues that in certain kinds of environments and complexity (that first need to be recognized) we should 'design in' mechanisms for delivering the aspirations of A/IWRM. It proposes to do this by breaking complexity into domains.

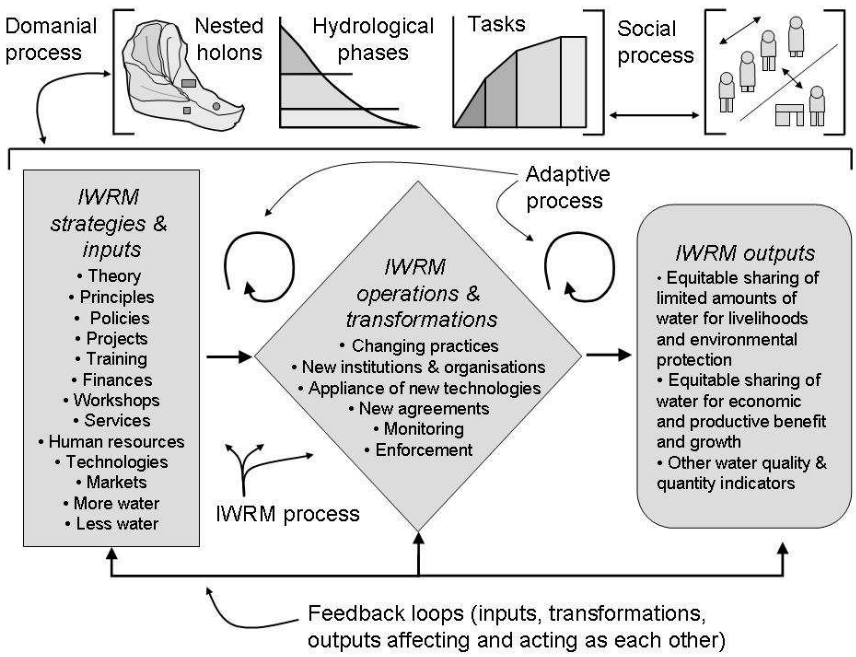
A theory of domanial water resources management (DWRM) is generated from the social co-management of three types of 'domains'[2]. This concept is generated from the starting point – where does water resources management (WRM) take place? To answer this, the paper contrasts two countries, United Kingdom and Tanzania, with different water systems; the former constructed from highly-regulated and self-regulating domestic, urban and industrial consumers mediated by financially well-off representatives, agencies and water companies, while the latter is constituted from a disparate array of relatively poor irrigating and domestic users who access water largely from a dynamic environment directly and therefore from each other with much less mediation from intermediary organizations. As explored in the paper, these differences result in separate kinds of complexity to be addressed in different ways.

To explore I/AWRM theory it is necessary to consider the institutional design factors that drive the implementation of IWRM in developing countries. This begins with the premise that IWRM has two major dimensions;

[2] Domains are; nested sub-units of the basin termed holons; parts of the hydrological regime termed phases; and tasks of work to be completed.

an upper level as a strategic planning model and a second level as a model of operationalization (Mitchell 1990, 2004). Figure 1 captures these, left and middle respectively, leading to 'outputs' on the right hand side. A problem observed in developing countries where IWRM is being promulgated is that operationalization is taking time and is not necessarily leading to intended results (Biswas 2004). This should not be seen as a failure of 'operators' but more of four characteristics of the upper strategic level of IWRM as currently constructed, explored below.

Fig. 1 Integrative, adaptive and domanial components of WRM



Firstly, in adopting IWRM plans, I contend that its operationalization is 'theory-facing' rather than 'problem-facing', or put another way the strategic level is insufficiently context-aware. Both strategic and operational levels too readily adopt *principles* of water management (such as water as an economic good) without identifying how those same ideas are expressed by users themselves to solve local problems[3]. Secondly, the upper

[3] For example, in Southern Tanzania, local users developed a land-based, village levy of about 10 dollars per hectare deemed more appropriate in reducing water consumption than the flat charge applied through a World Bank supported national water policy (SMUWC, 2001).

IWRM strategic model, regardless of context, tends towards a regulatory model of dealing with basin-scale complexity, constructed from a mix of measurement, licensing and pricing. Although IWRM purports to be participatory, it does not see devolution and subsidiarity as a means of dealing with complexity at the basin scale. Thirdly, IWRM utilizes *high level* dissemination processes such as workshops, articles and papers and training of water officers that are relatively ineffective in transforming local user practices. Fourthly, IWRM fails to address the *complexity associated with irrigation*. This arises partly out of jurisdictional gaps between Ministries of Water and Agriculture because often irrigation is viewed as the provision of water to a crop rather than as a multi-faceted system, and partly because irrigation is seen as one sector amongst many, rather than as a determinant of wider basin behavior and water competition.

It is an analysis of IWRM either through existing integrated regulatory frameworks managed by professional water officers at the basin level or by forms of localized democratic and polycentric management or by mixes of the two (Lankford and Hepworth 2006) that suggests a need to explore alternative forms of governmentality or environmentality (Agrawal 2005) of water resources management.

Identifying domains where water is managed

This paper addresses the adaptive management of natural resources to enhance resilience to change arising from economic and population growth, technological transformations and climate change. Adaptive management is "an approach to managing natural resources that encourages learning from the implementation of policies and strategies" (Allan and Curtis 2005, 414; Kashyap 2004). In addition, addressing complexity and uncertainty distinguishes adaptation in IWRM (Pahl-Wostl and Sendzimir 2005). Although accommodating iterative learning and complexity appears sensible, it is necessary to question whether IWRM *applied adaptively* (i.e. inside Figure 1) will resolve the concerns outlined above or whether it is possible to more thoroughly explore the underlying arrangements or governmentality for adaptive and integrated water management.

It is also possible to consider adaptive management via a results perspective (the right hand box of Figure 1); that for poor people the access, predictability, acceptable quantity and quality, and affordability of small amounts of water to meet daily livelihood and environmental needs are provided to levels deemed locally acceptable. These are about livelihood 'protective volumes' implying a micro, household dimension. At the higher end of the sufficiency scale when more water is available, good water management is about equitably sharing of 'productive and consumptive' volumes to provide for economic growth, which in turn provides investments in many kinds of economic activity which can further reduce sensitivity to drought. Greater utilization of more water is reflected in macro dimensions of the economy.

While we have some informed ideas about the inputs and outputs of adaptive water management, we appear less certain about transformations in the central kite-box of IWRM (Figure 1) or about reading the context in which IWRM sits. This is revealed by examining attempts at IWRM in Sub-Saharan Africa (e.g. Nigeria, Tanzania, Zambia) being received with mixed results. While it is possible to suggest that an adaptive style might make headway with IWRM plans, one might critically respond with the argument that if not thoroughly cognizant of on-the-ground problems, in turn driven by a theory which requires this, adaptive water resources management will be insufficiently differentiated from integrated water resources management. There is a great danger that 'learning by doing', sensible it may be, might not transcend the 'developed country' IWRM templates and principles it attempts to adapt.

I argue that developing-country IWRM, largely constructed from sophisticated basin-centered models and experiences in developed countries combined with the Dublin Principles, sets out visions and desirables that cannot inform pragmatic policies that fit current situations in much of Sub-Saharan Africa. A developed-country template of regulatory water management fundamentally misses *where* water management actually takes place in tropical and sub-tropical countries and *who* does it. Moreover, IWRM often fails to read the changes in governance systems when moving from northern country economies to those in the tropics: diversification from irrigated agriculture to urban and industrial growth; a benign political economy; greater capacity to store, purify and reticulate water; monitoring systems; iteratively developed systems of economic pricing; a longer history of water privatization and public-private initiatives; a variety of demand management tools; and well-financed water agencies and services. While aspects of these exist in countries in Africa, they are not found as comprehensively combined as in Europe.

Research in the Great Ruaha Basin in Tanzania and other SSA countries informs this analysis (SMUWC 2001; Lankford 2004; Lankford et al 2007; McCartney et al 2007). Although there is not room to describe the case study in detail, germane features of the basin are:

- An average of 25,000 hectares of small-scale irrigators leading to depletion of water and inter-sector competition between irrigation, domestic users, wetlands and hydro-power, particularly during the dry season.

- A Sub-Saharan climate that exogenously drives an unpredictable dynamic water supply and a corresponding growth and shrinkage of irrigation from 18,000 ha in a dry year to more than 40,000 ha in a wet year.
- An under-resourced basin office in terms of staff, finances, transport and hydrometrics to cope with the size and regulatory challenges of the 68,000 km^2 basin. Calculations of staff-to-area ratios show that in Tanzania it is one per 11,800 km^2, compared to one per 13.7 km^2 for the UK Environment Agency, the equivalent organization.

Although, the two countries could not be more different, the UK and Tanzania share similar water polices including terminologies, aspirations and legislative and regulatory structures (Hepworth 2007; MOWLD 2002; DEFRA 2003) yet contrast the UK's estimated 2600 irrigators using about 1-2% of freshwater (Weatherhead 2007; DEFRA 2007) with Tanzania's approximate 400,000 farmers[4] involved in water management consuming 86% of water. In 2002, irrigated agriculture was estimated to consume the largest share of water withdrawal with 4417 million m^3 while the domestic sector uses 493 million m^3 or 8% of total (TANCID 2007). Tellingly, Tanzanian water users despite being remote, rural, poor small-scale users who largely negotiate with each other, have to purchase rights denominated in liters per second from a central basin regulator (van Koppen et al 2007).

Unlike basin environments in northern Europe which are subject to oceanic temperate climates and experience predictable rates of usage from largely domestic and industrial users, Sub-Saharan basins are extremely variable. This analysis suggests that where climate drives intra/inter-annual fluctuation, government regulatory authority is so thin on the ground and irrigation shapes behavior and consumption to such an extent, certain kinds of risk and complexity arise. These relate to the mismatch between the nature of the challenge, of our conceptualizations of it and of the resources brought to bear on it. It is not clear that, despite the rhetoric, there is donor or government appetite for upping the formal regulatory budget to achieve what might be required. Leading from this, the process of reforming water management may be better promoted by closely involving the many thousands of farmers and fields in an irrigated sub-tropical basin and be suspicious of regulatory structures that treat them as abstractors of a predictable, carefully controlled and measured resource. This requires recognition at the IWRM theory and policy level in order to create structures to devolve adaptive responsibility and sustainability down to users.

To achieve devolved adaptation two ideas are proposed; the disaggregation of water resources management into domains; and the identification of

[4] Probably a conservative estimate, calculated from 200,000 hectares of irrigation (Aquastat, FAO 2005) managed on average by one farmer per acre.

social and institutional drivers of water management reform within these domains to generate ‘balanced performance’, acknowledging that water consumption in a sub-unit cannot go unchecked but should meet wider basin concerns. Before these are discussed further, it is necessary to examine the complexity of water and irrigation management, so that its disaggregation into discrete nested problems and localities can be better understood.

Scale and complexity arising from irrigation

Water is a particularly complex natural resource to manage because of scalar dynamics. Depletion (or pollution) of water in part of a river basin affects users a great distance away – users that are logistically unable to interact with those responsible for the depletion. Solutions to solve one community’s or sub-unit’s livelihoods can deleteriously affect others. As scale increases, so do the number of interactions, divisions and drivers; e.g. land use, markets, urban growth and political and transboundary borders. Some small-scale technologies, e.g. treadle pumps, thought to be ‘sustainable’ by dint of an individual small environmental impact, can with rapid adoption cumulatively deplete water and lead to conflict.

Further levels of complexity occur with increasing areas of irrigation that drive behavior and shortages elsewhere in the basin (Lankford and Beale 2007). Consequently, irrigation systems, be they single large systems or large coalesced areas of small systems, are complex to the extent that they need to be seen as arenas where IWRM and basin management are tested. To see irrigation other than as a technology or as a sector means we can treat it more carefully than Tompkins and Adger (2004) intimate; irrigation should *not* be seen as a direct answer to drought or climate change mitigation, but as a possible magnifier of drought and conflict. Irrigation systems have feedback loops affecting efficiency, equity, adequacy and timeliness of supply. Irrigation performance is determined by main canal and in-field practices; the latter determined by farmers who, perceiving unpredictable supplies, hold onto water in turn delaying supply for others and themselves. There are institutional, organizational and livelihood factors which shape these concerns and practices and it is not easy to raise performance in an immediate sense; rather groups of farmers need to experiment with new ways of co-managing water, supported through institutional and technological change by appropriate advice and services.

Irrigation is a dynamic, behavioral system with intimately connected social, technical, agro-ecological, economic and river basin dimensions, categorically different from rainfed and rain-harvesting agriculture. Although there is a continuum of typologies in the ‘capture-control-delivery’ sense of delivery of water to crop roots, we should not “remove the artificial separation between rainfed and irrigated agriculture” (ASARECA 2006). The relationship between area and complexity is a power one since with greater unit size, the depletion of water connects users in ways that rainfed agriculture or small rainwater harvesting systems do not.

The effect of many irrigators is to make basin-scale governance much more difficult. This obligates irrigators to be more responsible than is recognized and to achieve this requires those users to connect either physically (via canal systems) or via institutional arrangements. This in turn requires a blend of disaggregation of the wider basin into smaller units, and within those units, stronger forms of connection and aggregation.

A conceptual framework for domanial WRM

A framework for social domanial water resources management is provided in Table 1. In the top, three disaggregating principles are provided for creating WRM domains; scale and space, hydrological regime and risk-based or conflict resolution approaches. Then, two social drivers are then applied to the discrete management units and objectives; participatory citizens’ action and service provision. The following sub-sections explain these.

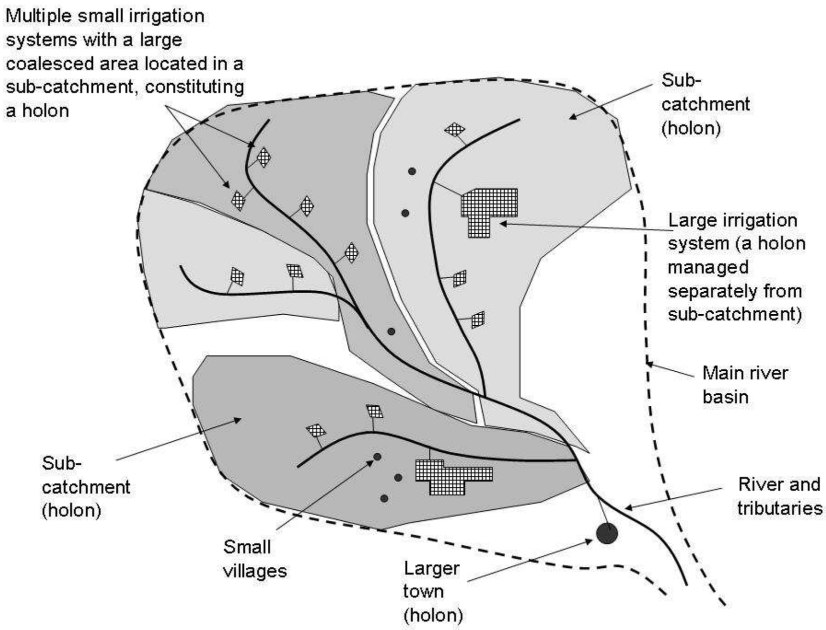
Table 1. Design for domanial water resources management

Disaggregating WRM into identified domains	**Domain nomenclature**
1. Scale and space; a spatial unit of management within the river basin chosen at an appropriate scale.	Nested sub-system or holon
2. Hydrological regime; a phase of water sufficiency from high to very low levels; bulk, medial and critical.	Phase (or state)
3. Risk based analysis or via conflict resolution; Identifying and acting on causes of particular problems.	Task
Social drivers for performance with domains	
1. Citizen’s action; formation of groups of users able to discern gaps in their knowledge and capabilities and request services accordingly.	
2. Service response and accountability; A demand responsive approach able to elicit and provide resources to fill users’ needs.	

Nested sub-systems: ‘stretched holons’

The aim is to promote success in IWRM by nesting and solving problems within sub-systems of a river basin - this stipulates a polycentric approach rather than the basin being the natural unit of management. The term 'holon' (Koestler 1967; Ashby 2003) is apt; a component or unit which is simultaneously a whole and a part (see Figure 2). The design decision is to choose holons that constitute significant and useful building blocks of the bigger river basin. Since holons nest in each other (viz; farm outlet, tertiary irrigation units, secondary units, irrigation system, sub-catchment, river basin), the holon of interest must neither be too small to result in too many units, nor too large so that internal rifts and divisions arise that cannot be managed. The 'correct' size that bridges between the micro and macro scale is dependent on the context and the holon involved but is also related to the 'working' or exercising of the holon as the next paragraph explains.

Fig. 2. Schematic of nested holons within a river basin



Likely to be a difficult and certainly site-specific decision, correct sizing is served by selecting units that meaningfully 'stretch' or exercise their water users in terms of learning about non-local effects. Thus the size and complexity of holons are slightly beyond their comfortable and normal expression – or 'stretched' – so that non-local and scalar expressions of water use can to some extent be understood by users who otherwise would not normally be faced with non-local consequences of water depletion. This is important if we are to enhance performance in recognition of the interconnected nature of water by making internal associations and agreements that are also outward-looking. Although subjective, we can explore some sensible ideas of what might constitute holons. Large single irrigation systems that have a measurable effect on their surrounds and high level of internal complexity can be treated as holons. Areas of coalesced smaller irrigation systems combined with domestic and environmental claims mean that sub-catchments and aquifers are also holons. Thus, examples are: rural towns, or districts of very large towns and cities; irrigation systems approximately 1000 ha (10 km^2) and above; aquifers approximately 200 to 2000 km^2 in size; and sub-catchments of approximately 300 to 5000 km^2.

Phases of water management

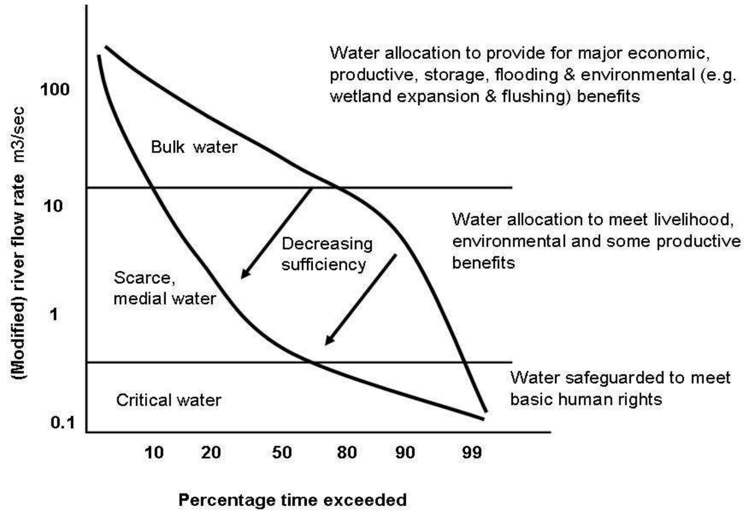
The second type of domain is a water sufficiency phase; generated by dividing a flow regime into three phases of water sufficiency (Figure 3) (Lankford and Beale 2007; Lankford et al 2007). The phases (or states) are; 'critical water' denoting very small amounts of water during droughts and dry season; 'medial water' for scarce to average flow conditions; and 'bulk water' for wet to flood conditions. For each phase it is possible to locally derive priorities and systems of allocation (markets, command and control, local community responses and other interventions). A look at the Tanzania case indicates that critical and medial water require special attention by stakeholders, but each can be addressed by relatively simple, practical and localized solutions rather than by more cumbersome formal regulatory interventions that may best be reserved for managing bulk water.

Inter-phase facilitation of users transiting from a wet phase to a dry phase is also necessary. Drought contingency plans, in defining responses to drought *locally* (enforcement, monitoring and transparency of usage of water) are important aspects of transition facilitation and management during the critical phase. Key challenges are the distribution and sharing of small amounts of surface water, requiring a shift in practices to more stringent schedules of use. Taking a nested sub-systems approach allows users to define these issues locally rather than have external protocols applied.

Risk-based and conflict resolution approaches

The third domain is work-related, designed to break large issues into more manageable objectives. Although a number of means to achieve this exist, two are proposed here and both are intended to tackle internal holon issues while recognizing external drivers and downstream obligations. Significantly because of the spatial focus invoked by the utilization of holons, problems can be addressed more pragmatically with reduced reliance on the application of global principles of IWRM (Merrey et al 2007).

Fig. 3 Phases of water management – bulk, medial and critical



The first utilizes risk-based thinking to identify component tasks and then identify which are effective in cost-benefit terms (Craft and Leake 2002; Haimes 2004) onto which other tasks can later be attached. In simple terms this is modeled in a pareto curve, a phenomenon in management also known as the 80:20 rule where 80% of the benefits may be achieved with 20% effort. An example from Tanzania exemplifies. In the Usangu sub-basin, part of the Gt Ruaha Basin, rather than attempt to manage 120 irrigation intakes to ensure downstream compensation flows, it is possible to identify approximately 15 intakes on four rivers that accounted for 49% of the intake abstraction capacity in the basin (Lankford 2001).

The second means identifies tasks via specific conflict resolution exercises. These exercises and their resulting tasks address locally relevant and socially critical concerns that might take precedence over standard water policy or regulatory principles. In the Usangu basin, local river users managed conflict by agreeing a rotational schedule for distributing water between intakes (known locally as *Zamu*, McCartney et al 2007) rather than adhering to their formal water rights.

Fostering performance – a social approach

The next section on a social approach to water management[5] echo the CAR framework (capability, accountability and responsiveness) outlined in recent Department for International Development thinking (DFID 2006, 2007) aiming for greater democratic selection and demand by water communities for services from a range of providers that in turn are professionally delivered to tackle specific hydrological phase-bound tasks within holons. The challenge in water management is to do this in ways that recognizes the scalar and depletive nature of water consumption in basins with high levels of irrigation based livelihoods.

Citizens' action and service accountability

Having determined appropriate management holons, we need to ask how they can be reformed. There is evidence from education, health programs and water and sanitation that citizens' action and participation combined with appropriate service responsiveness can generate the requisite levels of system progress (Cavill and Sohail 2004). This has been explored within a participatory governance and accountability framework (ibid), and has been termed a Demand-Responsive Approach (World Bank 1998). The approach brings water users into the process of selecting, implementing, auditing and, ultimately financing the long term delivery of water services.

Major proponents of the approach, including the World Bank have supported its uptake. Initiated by WaterAid, the aim of Citizens Action for Water and Sanitation (Ryan 2006) is to support programs to strengthen governments' accountability in service deliveries toward water and sanitation. The program puts communities in charge of their own problems and solutions, utilizing open consultation processes, the use of community scorecards, slum censuses and mapping of water and sanitation amenities.

Thus the issue is about the benefits that accrue from meaningful decision-making and institutional ability to decide and manage local priorities. The reason for this being a priority is that given a rapidly changing situation, an effective way in which provisions can remain 'up to date' is that they are constantly adjusted by people on the ground who are brought together to learn from each other and external advisors.

[5] See emerging bodies of work on social and technical approaches to water conducted by the Irrigation and Water Engineering Group, Wageningen University and ZEF, University of Bonn.

Experiences in Tanzania (Van Koppen et al 2007) suggest that it is more reasonable and effective to entrust management of water to sub-catchment decision-making networks building on already existing customary arrangements. Their tasks would be, first, regulating allocation in times of low flows, with constraints to ensuring downstream flow advised by Basin Officers, and, second, finding arrangements for dealing with the increasing demands by new users. With the right approach and institutional environment there is no reason why communities should not be able to recognize wider impacts of their water usage and connect productivity gains to conflict resolution both at catchment and irrigation system levels (Vounaki and Lankford 2006; McCartney et al 2007).

Service responsiveness

An increasingly significant debate examines how to increase the accountability, accessibility, accuracy, applicability, affordability and response times of services for the purpose of improving natural resource management (IIED 2006). This also means engaging and empowering water resource users to demand or purchase services, and to do so in a way that first asks users to critically prioritize solutions to identified problems so that services meet real gaps and not those that can be solved relatively easily by resource users. This suggests a recursive relationship between users and service providers, with the latter fostering the ability of the former to come to them as well as vice versa. The ability of productive irrigators to fund service provision would be key in the sustainability and appropriateness of services provided and may not be too difficult; one percent of the turnover of 1000 hectares of irrigated rice in Tanzania is 10,000 US dollars which could buy services related to mapping, conflict resolution, legal settlement, field trips, re-design, construction, accountancy, climate forecasting and so on.

It may also be appropriate to employ a local conditionality or 'cross-compliance' framework to offer capital, new technologies and storage against progress made with conflict resolution, institutional arrangements and financial systems. Cross-compliance defines mutual agreements for progressively implementing an agreed schedule of initiatives between two or more partners (DEFRA 2006). Cross-compliance wraps all parties in such agreements, motivating and leveraging further action out of the parties involved. For example, appropriately designed conditionalities, such as the establishment of a water user association for a holon, are attached to capital expenditure on a small reservoir.

Further discussion

The sub-sections below briefly introduce two other issues related to a nested social approach to adaptive water resources management.

Pluralist legal frameworks

A locally-nested framework implies that formal regulatory systems need to be counter-balanced with mixtures of formal and customary law, where formal statute law provides a broad framework that helps define 'equity' in the legal sense, and where customary and reflexive law (Teubner 1983) resides at the catchment, irrigation and community level to draw up agreements and protocols that bring about equity in the hydraulic sense. In addition should customary agreements not provide resolution, users could then seek to purchase legal services to resolve disputes. In addition, underlying infrastructure could be locally attuned to help users switch from formal to informal agreements and bye-laws (Lankford and Mwaruvanda 2007).

Catchment and storage infrastructure

The topic of irrigation systems rehabilitation and modernization, a complex and intransigent area, is also relevant at the catchment scale. Existing hardware for accessing water (irrigation intakes and boreholes) should be seen as distributive infrastructure at the catchment scale that facilitates or otherwise the apportionment of water as it varies in supply from bulk to medial to critical. As catchments' demand and supply rapidly change, the question of how to enhance, re-tune, remove, or build upon existing water infrastructure that facilitates water provisioning in this dynamic context becomes critical. It was clear that the standard irrigation intake designs employed in Tanzania under the 'irrigation improvement programmes' of donor agencies had widespread support with farmers, engineers and district staff. However, they encouraged upstream farmers to abstract large amounts of water (Lankford 2004). Concrete intakes could be better designed, adopting proportional flumes with high levels of transparency (Lankford and Mwaruvanda 2007). In addition, there are particularly problems in dealing with 'momentum' in uptake of or existing prevalance of technology adoption and practices.

A number of donors and countries are considering afresh dams for beneficial storage and release (World Bank 2003). Aside from climatic vagaries, benefits such as electricity generation are not always assured because although dams have operating rules developed by hydrologists and engineers, these are subject to political capture. Applying a nested and citizens' approach might usefully develop counter-balances to elite and political capture. Three other nested linkages also potentially occur.

Storage could be tied to improved water management and institutional conditionalities. In other words, stored water is released for beneficiaries provided systems are developed for managing this equitably and efficiently. Alternatively, indirect linkages could be developed; as an example from Tanzania shows, resource users explored the idea of a small storage dam for dry season domestic usage alongside agreements to share water and release water downstream during the wet season.

Secondly, a holon-based approach can be taken to extending or protecting the benefits of storage to the local environment and economy. This is not particularly new, but such projects would be in response to local requests and fit with the third point which is that investing in storage must be gauged carefully against capacity to manage that for increasing uncertainty and drought periods or insufficiency arising from increasing demand. An outcome would be that an increasing proportion of storage should be reserved for contingencies and shortages, and by taking a local frame, this could be matched more easily to rapid change within the vicinity (Lankford and Beale 2007).

Policy support

It is useful to identify some policy challenges raised by the putative A/IWRM framework if program aid dominates donor assistance, as is the case with DFID. Because of the use of spatially bounded holons, the domanial approach would require services that match one or more holons, and thus program aid would have to generate these – via geographically delineated projects. Modalities can be copied from citizens' and accountability approaches in water and sanitation funded via program aid, and some NGO's (e.g. WaterAid) have expertise in this. Nevertheless, there are risks here for donors given that domanial ideas represent new kinds of IWRM for basins and irrigation systems, requiring organizational change to a responsive mode. In addition, skills and expertise in water resources and irrigation management have not equaled progress made in water and sanitation. The prognosis for knowledge 'catch-up' is worrying; a lack of donor funding in the sector means that some University degree programs in irrigation have closed in the last 10-15 years and that relatively few training and research programs address irrigation in sufficient depth.

Other narratives in IWRM need further deliberation if policy is to be effective. A questionable one is that river basin and irrigation system management 'should be kept simple'[6] (different to the question of how to make basin and irrigation management more simple which is what this paper tackles). Furthermore, orthodoxies that appear to have a straightforward technical basis should be contested (witness the widespread belief that irrigation efficiency can be addressed by shifts to micro-irrigation or with canal lining). These brief examples indicate the need for 'systems' research of these topics and wider dissemination of findings to a professionalized body of engineers and water officers.

Although there is not the space to outline detailed policy implications, some key issues can be identified, including the shift from a largely regulatory basin-wide model of managing water to a domanial one. This would require the establishment of appropriately skilled government officers, NGO's, academics and consultants to identify stretched holons and analyze the structure, properties, behavior and social composition of these sub-systems so that risk-based approaches and conflict-based entry points can be identified to initiate citizen's actions.

Conclusions

In considering the adaptive management of basins with significant irrigation, a governmentality analysis was applied to disaggregate complexity into discrete management domains. The model, captured by the term 'domanial water resources management', is built on devolved polycentric nested holons, principally sub-catchment and irrigation systems. Using these units of co-management, the following can be considered:-

- The management of water within and transitions across water sufficiency phases drawing up objectives for each phase; bulk, medial and critical, with a particular focus on the distribution and access to small volumes of water during critical drought periods.
- The identification of key tasks via risk-based and conflict resolution approaches and utilization of conflicts to build co-operative competition and enhance productivity.
- The promotion of a social process for their management involving services that respond to collective stakeholder analyses of activities, issues, successes and problems.

[6] A refrain heard during debates at a recent DFID water policy day, 24 May 2007, DFID Head Office, London.

It should be re-iterated that a domanial approach is proposed for where regulatory approaches to river basin management, while seemingly normative within water science, may in fact be the riskier model. This is a fruitful area for research – how to raise performance in ways by using systems and livelihood approaches that are theoretically accurate, meaningful and sustainable, particularly alongside competing water management narratives (e.g. rainwater harvesting) that vie for policy-makers' attention.

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