

Perceptions and interpretations of environmental flows and implications for future water resource management: A survey study

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Abstract

The assessment and application of environmental flows has advanced considerably in the last ten years. To coincide with the emergence and expansion of the environmental flows concept, a survey study was undertaken aiming to identify perceptions and interpretations. The study also aimed to determine the extent to which the concept is being applied and translated into policy and practice, and the major challenges and opportunities that exist. A total of 272 responses representing 64 countries in the six major regions of the world was received. The ways in which people define and interpret the concept varied widely. The degree of application shows the growing recognition around the world of the need to consider the environmental water requirements when making decisions on water allocations. The survey allowed the opportunity for respondents to highlight what they perceived as the major obstacles and difficulties for the concept. Lack of understanding among stakeholders of the socio-economic costs and benefits associated with concept implementation, and a lack of political will were the two most common obstacles for continued application of the concept around the world. Overall, the survey delivered promising signs for the continued evolution of environmental flows within water management.

Key words: environmental flows, water allocations, river basin management, global survey, perceptions, ecological water requirements, flow methodology

Introduction

The twentieth-century saw unprecedented growth in the development and management of earth's freshwater resources. The dominant approach was to construct infrastructure in the form of dams and other impoundments, diversions, pipelines, canals and groundwater wells (Gleick 2003; Tharme 2003). This approach provided direct benefits to humans by securing a stable supply of freshwater for irrigated agriculture, hydropower generation, flood and drought protection, and domestic purposes. Combined with the increasing availability of fertilizers and pesticides and new high-yield varieties of grains, the increased supply of water fueled the so-called Green Revolution (Rijsberman, Molden 2001). Many countries were able to provide food and water security while keeping pace with rapidly growing populations.

Hydrologic alteration from dams, diversions, canals and other water developments invariably manipulates to some extent the natural flows of rivers. Awareness continues to grow of the impacts on river ecosystems and the connected floodplains, wetlands and aquifers from the "hard path" approach to water development so dominant in the twentieth-century (Gleick 2003). In response to this rising awareness, researchers, water managers, policy-makers, and other concerned groups have attempted to understand and measure the impacts, and propose ways of providing for the environmental needs of freshwater resources, alongside the human needs. These efforts have spawned a new field of scientific research that has its origins in the mid-1900s, but has only recently started to gain momentum. This field is centered on the concept commonly referred to as "environmental flows" (Tharme 2003).

The understanding that flows are critical for maintaining biodiversity and ensuring ecosystem integrity has led to a new paradigm of water resource management based on the natural flow regime (Postel, Richter 2003; Poff et al. 1997). The last decade has seen a transition from the narrow objective of prescribing minimum acceptable flows to protect valued fish species, to more comprehensive objectives that consider the spatial and temporal patterns of the

entire flow regime and the interrelationships between river flows, floodplains, estuaries and aquifers. Recent efforts have also incorporated social and economic aspects in environmental flow assessments, particularly in terms of the effects on subsistence users of rivers and floodplains (King, Tharme, Brown 1999; Brown, King 2003).

Despite advances in the recognition and understanding of the environmental needs of water systems, water resources continue to be depleted, rivers continue to show signs of drying up, and inefficient water use practices persist in agricultural, industrial and domestic sectors. In a recent study that provided the first global picture of environmental water scarcity, Smekhtin et al. (2004) estimated that 1.4 billion people live in river basins where current water use is in conflict with environmental water requirements. The basic dilemma that exists is how to continue to provide water for human needs in the face of increasing population pressures, while at the same time taking into account and allowing for the environmental needs of water. If water is reserved in some way for the environment, the availability of water for other human uses is reduced, thereby increasing competition and potentially leading to disputes and conflict.

Aims

This study is the first known attempt to gather global data on people's perceptions and interpretations of the environmental flows concept. The study aims to capture current views, definitions and interpretations of the environmental flows concept. It also aims to add to the growing volume of information regarding the extent to which the concept is recognized, implemented and being translated into water resource policy throughout the world. To encompass all views, the survey attempts to reach those areas where the concept is not recognized or applied and to examine the underlying reasons for why the concept is not being used. The study concludes by looking at people's perceptions of the major challenges and opportunities for the concept in the future.

Methods

The method that was seen as most suitable for accomplishing these aims was a web-based questionnaire, distributed to people involved in various water and food-related sectors from all regions of the world. The questionnaire was prepared in association with researchers from Linköping University, Stockholm International Water Institute (SIWI), International Water Management Institute (IWMI) and the World Conservation Union (IUCN). The survey was distributed from May to July 2004 to contacts provided by the above organizations and through other networks and mailing lists.

It was intended that respondents should not be restricted to experts in environmental flows, but be extended to people within all water-related fields who may or may not view the concept of environmental flows as applicable or valid within their area. Therefore, the survey population consisted of people that were involved in a professional capacity in water management, water use and water research. A further aim was to collect responses from all regions of the world, with adequate representation according to country, region and development status.

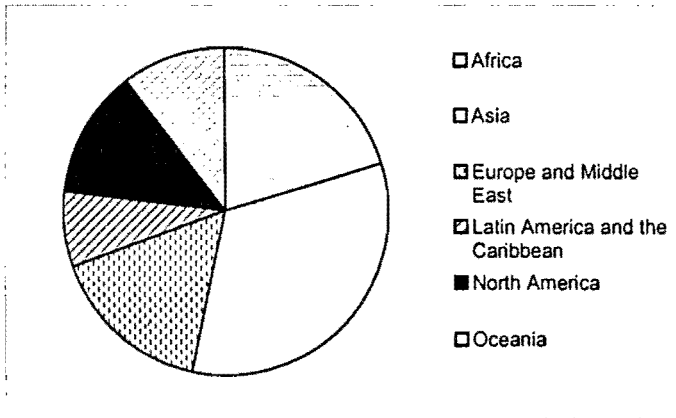
Despite the enormous potential for web-based surveys, the advantages must be balanced against significant weaknesses. Varying levels of respondent computer accessibility and literacy have the potential to affect the response rate and bias the results, particularly in a survey of this type which targeted a wide range of water sectors and regions. Other survey limitations include the inability to reach on-the-ground at local community and farming organization levels, and to gather responses from those not actively involved with or aware of the concept.

Overview of survey respondents

A total of 272 responses was received over the survey period. The response rate was roughly calculated by using the number of individual email addresses provided in the mailing lists. This number was estimated to be at least 1350 addresses resulting in a response rate no greater than 20%. Respondents represented a range of organisational types and countries. Respondents from scientific, research and academic organisations comprised the largest proportion (43% of respondents), followed by government agency representatives (28%) and NGOs (14%). Low representation from the private sector (10%), inter-governmental agencies (4%) and the media (<0.1%) were encountered.

A total of 64 countries were represented in the survey. It is important to note that responses from five countries were considerably higher than all other countries. The proportion of responses from USA (31 responses), South Africa (29), Australia (26), India (25) and Sri Lanka (22), together accounted for almost half of all responses. No other country received more than 10 responses. Figure 1 shows the breakdown of respondents by the major world regions.

Figure 1. Breakdown of survey respondents according to region of the world



Concept definition

"There is no universally agreed definition of environmental flows," Smakhtin et al. (2004, p1) stated in their global-scale assessment of environmental water requirements. Results of the survey confirmed that a variety of different terms are used around the world. The most commonly used terms include *environmental flows*, *minimum flows*, and *instream flows*; however, a total of 57 terms were recorded across all regions. The 57 terms identified in the survey relate to the concept of environmental flows; however, the terms are not all defined in the same way. In fact, there are crucial distinctions to be made between how several terms are defined and interpreted. The reason behind the diversity of terms most likely lies in the original context in which concern over hydrological alterations was raised around the world and the subsequent evolution in research and practice.

A common view within water management over the last century has been that any water allowed to flow to downstream wetlands, floodplains and the sea, or seep into underground aquifers was a wasted resource. The terms *wasted water*, *surplus water*, *spare water* and *residual water* are legacies of these views and continue to be used to a limited extent today, as the survey showed. A shift in the conceptual view began in the USA in response to the decline in economically important fish species due to reduced flows in many major rivers. The recognition of the need for a minimum amount of water to remain in a river for the benefit of

important game-fish species gave rise to terms such as *minimum flows*, *in-stream flows* and *fish flows* (Postel, Richter 2003, Acreman 2001).

A second conceptual shift beginning in the 1980s in South Africa and Australia resulted in the expansion of the concept from focussing on a single feature of river systems to incorporating multiple aspects (Hirji, Panella 2003). This expansion accompanied the increasing recognition of the vital role of the entire natural flow regime in ecosystem structure and functioning. *Environmental flow*, *ecological reserve*, *environmental water allocation* or *requirement*, *environmental demand* and *compensation flow* are terms used across different regions and by different groups to broadly define the water that is set aside or released to meet the environmental needs of flowing water systems. The variety of terms reflects the variety of ways that awareness of the flow regime and its influence on ecosystems and biota has been raised in different regions. It also reflects the rapidly developing nature of this field of research.

Environmental flows can be considered as the definitive term for describing the direction in which this branch of science is currently heading. The holistic approach to environmental flow assessment is not just restricted to in-stream processes, but encompasses all aspects of a flowing water system, including floodplains, groundwater aquifers, and downstream receiving waters such as wetlands, terminal lakes and estuaries. This approach also considers all facets of the flow regime (quantity, frequency, duration, timing, and rate of change), the dynamic nature of rivers, water quality aspects, and social and economic implications (Brown, King 2003; Arthington, Pusey 2003).

Concept interpretation

To explore how people involved in water management currently interpret the environmental flows concept, the respondents were asked which aspects they considered the concept to encompass. A total of 103 respondents, or 38% of the total, selected all five components of the flow regime (quantity, timing, duration, frequency, and rate of change) as being part of the environmental flows concept. These five components comprise the elements of the natural flow regime that Poff et al. (1997) drew attention to as the fundamental scientific principle behind the ecological integrity of flowing water systems. In their 1997 article, Poff et al. (p769) stated that the recognition of the importance of the flow regime in maintaining ecosystems had been virtually ignored in a management context. The evidence from the survey suggests that progress has been made over the last few years in the acceptance of the role that the entire flow regime plays in water management.

Social aspects related to environmental flows highlight the link between river flows and livelihoods and the direction in which the concept is currently headed. The human dimension is increasingly being considered as part of the holistic approach to the environmental flow assessment. Holistic methods of flow assessment are attempting to incorporate and estimate the effect of different flow regimes on issues such as aesthetics, social dependence on riverine ecosystems, economic costs and benefits, protection of important cultural features and recreation (King, Tharme, Brown 1999). Over half of the respondents in the survey indicated that they considered social aspects as part of environmental flow assessment and implementation.

A related interpretation of the concept surfaced through a reference provided by one survey respondent, and was mentioned as part of a stakeholder workshop conducted on environmental flows in Tanzania. The interpretation included the concern that the concept of environmental flows would be considered by many as purely aimed at saving endangered aquatic species for their own sake. Outcomes of the workshop mentioned the difficulty in convincing people that environmental flows also encompassed socio-economic benefits to people, by providing ecosystem goods and services and livelihood security to local

communities. The participants in the workshop suggested that the term *environmental flows* should be changed to the more appropriate *flows for people and the environment* (IUCN 2003).

The various aspects that were identified by respondents in their interpretation of environmental flows, show that the concept continues to evolve and is shifting from the traditional view of minimum quantities of water to a more comprehensive and holistic interpretation. As this field of research continues to evolve and spread into new areas, it is expected that different interpretations will continue to surface and new aspects will continue to be integrated.

Challenges and opportunities for environmental flows in water management

In this section, focus will be given to several key issues that emerged from the responses to the survey: the major difficulties and obstacles for further understanding and implementing the concept of environmental flows; areas of common concern; and potential opportunities for the future. The survey generated considerable interest and it appears that it provided an ideal opportunity for respondents to voice their opinions on various issues related to the concept and also the state of water resource management within their area. This aspect of the survey allowed for a unique insight into what people involved in water management considered as the most urgent needs and fundamental problems associated with the concept.

Major obstacles for further understanding and implementing the concept

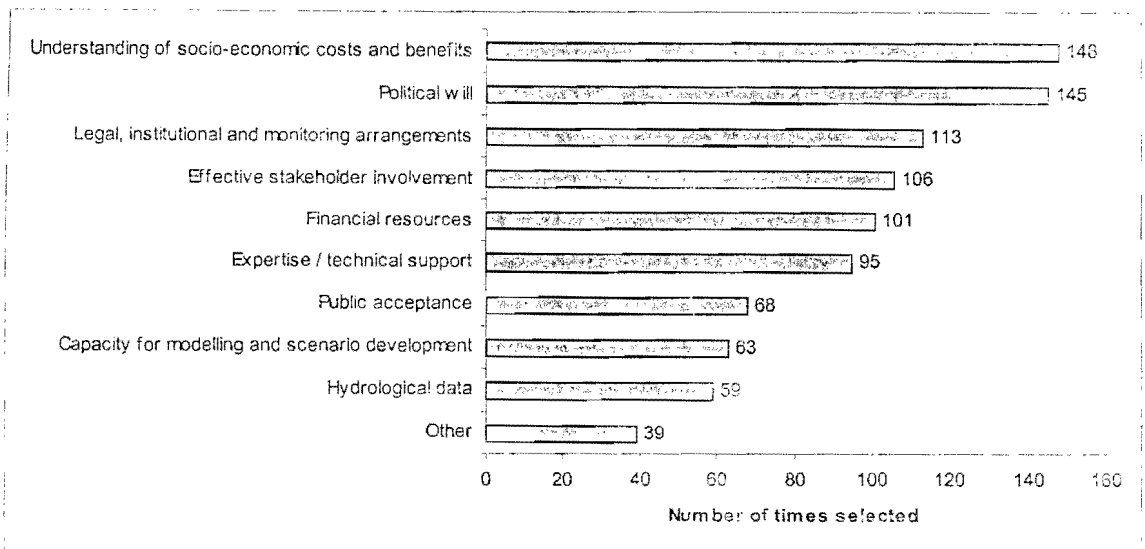
Environmental degradation of water resources continues due to limited awareness and capacity, population growth, and lack of funds.¹

Identifying the key difficulties and obstacles for assessing and implementing the environmental flows concept constituted a major aim of this survey study. By calling attention to what people involved in water management believed to be the most pressing needs and concerns related to the subject, it was hoped that this information could then be used in water management and planning, as well as decision- and policy-making. One particular question asked respondents to identify the three most critical difficulties in understanding and implementing environmental flows in their area. A list of 10 options was provided, including an option for respondents to list alternative answers. A significant number of respondents also provided further details in the additional comments section on what they perceived to be the major difficulties as well as major needs in terms of the concept.

Figure 2 presents the results of the question aimed at identifying the major difficulties and obstacles for the concept. The two obstacles identified by respondents to be most critical were the lack of understanding of the socio-economic costs and benefits and lack of political will. Other obstacles that were commonly identified by the respondents included legal, institutional and monitoring arrangements, effective stakeholder involvement, and expertise and technical support.

Figure 2. The major difficulties and obstacles for understanding and implementing the environmental flows concept according to the survey respondents.

¹ Quote from respondent 134



While much research has focussed on the ecological benefits associated with implementing an environmental flows program, it appears many stakeholders remain unaware or unconvinced of the associated social and economic costs and benefits. Maintaining or restoring ecosystem integrity was the main impetus behind the establishment of the environmental flow concept and there are many examples of improved ecosystem health following the implementation of an environmental flow program (King, Thorne, Brown 1999). The holistic approach to environmental flow assessment has started to integrate the social and economic implications of different environmental flow scenarios, while more information on the range of benefits and costs is being generated. Hirji and Panella (2003, p668) claim that "understanding the range of benefits and services provided by the ecosystems supported by the various environmental flows is the fundamental development concern with environmental flows." The ecosystems dependent on environmental flows provide many vital social and economic services and benefits, such as fisheries, nutrient removal, water supply, and forest products with a direct link between environmental flows and human well-being.

Identifying and then communicating the direct and indirect benefits of implementing environmental flows to people is a critical requirement at present. The ability to demonstrate to key stakeholders and decision-makers the benefits that their community will receive as a result of taking into account the environmental water requirements, was identified by many respondents as essential in their area. This was particularly the case where water scarcity existed and over-allocation for consumptive uses was occurring. A clearly defined list of the costs and benefits, both short- and long-term, associated with implementing environmental flows and a list of the possible consequences if flows are not established may indeed provide a good start. As one respondent recommended, an intensive information campaign should be undertaken on the benefits associated with environmental flows.

Lack of political will in implementing flows was one of the most common obstacles highlighted in the survey. The issue of political will was not restricted to particular areas, but was identified equally across developing and developed regions. Political support for a concept such as environmental flows is critical for its acceptance and successful implementation. Ultimately, the level of river health that will be sustained is a societal choice, driven by the values that the society places on goods and services and ethical considerations (Acreman 2001; Dyson et al. 2003). Brown and King (2003) call attention to the vital role of policy and legislation in giving legitimacy to the assessment of environmental flows in water management. By establishing a structured and transparent decision-making process that

incorporates environmental, social and economic costs and benefits, more informed tradeoffs can be made. Assessing environmental flows allows for the ecological needs to be considered alongside the social and economic needs in the decisions regarding water allocation and water use.

Common concerns regarding environmental flows

*Policy making is easy, but personal sacrifice in the face of water scarcity is difficult.*²

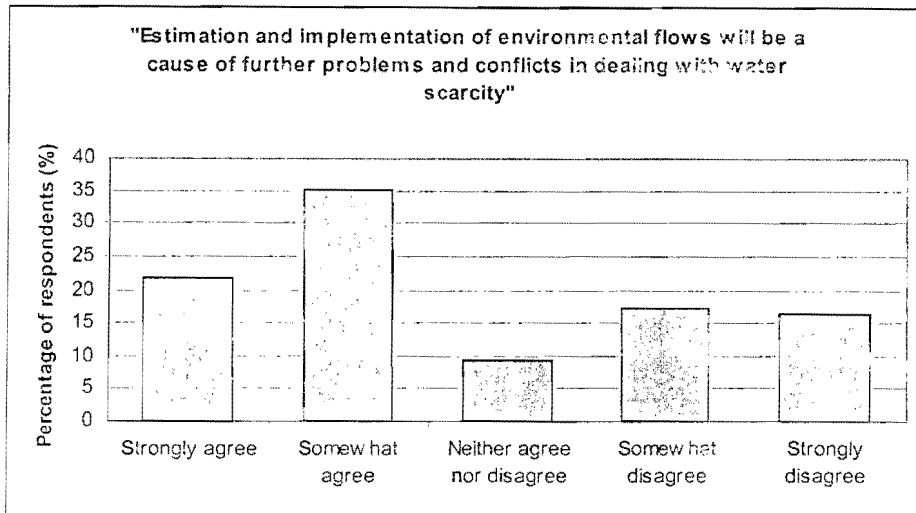
A concern raised frequently in the survey related to water allocations for environmental needs, and the implication that the amount of water available for human needs would be less, thereby increasing competition and the propensity for conflict. In many river systems around the world, allocating water to the environment will appear to many people as a threat to their water usage and livelihood security (Acreman 2001). How does one try to convince a farmer dependent on irrigation agriculture that water needs to be left in the river for the environment? Furthermore, how does one approach elected officials whose constituency is comprised of poor rural communities dependent on scarce water resources for their livelihoods? These types of questions are at the heart of the water for food and water for nature dilemma discussed in the introduction. They are also related to what many respondents saw as one of the biggest roadblocks for implementation of environmental flows – the propensity for escalating conflicts over water.

While it is recognised that providing water for ecological purposes also benefits humans directly and indirectly, the idea that water should be re-allocated away from human uses was flagged by many respondents as difficult, if not impossible, to introduce into their respective areas. This was particularly the case for water scarce regions and those respondents representing river basins where water stress is already high. In many of these areas, water is being allocated to higher valued industry and urban uses, leaving agriculture and the environment to compete for decreasing amounts of water. As a result, Molden et al. (2001, p15) predict, “the area of water stress and conflict that is likely to intensify the most is – not between cities and agriculture – but rather between nature and agriculture.”

Figure 3 shows the results of a question that asked whether the likelihood of conflict would rise as a result of introducing the environmental flows concept into new areas. As the figure indicates, a high proportion of people agreed with the statement that environmental flows indeed would lead to an increase in conflict over water. This concern over increasing conflict was also raised by many respondents when providing additional comments at the end of the survey. Some blamed the perception that environmental needs were in competition with what was considered the “beneficial uses” of water, such as for irrigation agriculture, power generation and industrial development. This perception pitted human consumption against the environmental needs – one would benefit while the other would suffer.

Figure 3. Level of agreement with the given statement: *environmental flows will be a cause of further conflict in dealing with water scarcity.*

² Quote from respondent 23



What opportunities exist for the concept?

It is an opportune moment to provide assistance to those countries willing to take the process forward, but without the understanding or capacity to do so.³

Despite the acknowledgement of major difficulties and several key concerns, the strong interest and support shown for the concept of environmental flows by an overwhelming majority of the survey respondents was a promising sign. Almost all respondents indicated that they would support the establishment or continued expansion of the concept within their areas (97%).

The importance of public acceptance and effective stakeholder involvement for the successful adoption and implementation of the concept was raised by many respondents. Allowing the public and particularly the relevant stakeholders within an area to participate in an open forum was a key recommendation from many people. As Smakhtin et al. (2004) stipulate, the first step in overcoming the challenge of institutional barriers is to establish basin-level dialogues between users, in order to negotiate and agree on how water is to be allocated. The need to invite all stakeholders affected by water management decisions, including upstream and downstream users and countries, was identified as essential for effective dialogue on environmental flows.

To complement these public forums, it was recommended that scientists, policy-makers, NGOs, and relevant international development agencies also engage in discussions and debates to determine the most effective ways of continuing research, policy making and implementation of the concept. The lack of suitably qualified scientists and technical support was identified as a major impediment to the establishment of flows particularly in developing countries. Many of the people who answered the survey represented scientific organisations and were actively involved in research projects associated with flows. Many other respondents expressed interest in developing the concept, but were unable to do so due to a confessed lack of technical experience, insufficient funds, lack of hydrological data or even the knowledge of where to begin. According to a significant number of respondents, open sharing of information and experiences is an essential element for the instigation and advancement of environmental flows in their region. "Exchange of information and experience is key" according to one respondent.

³ Quote from respondent 60

The need for stakeholders to recognise the inherent complexities and uncertainties of assessing and implementing environmental flows was identified by many respondents from research backgrounds. Awareness is needed from all sides of the constraints of water management and the complexities of aquatic systems (King, Brown, Sabet 2003). There is no one simple answer, method or guide to providing for the environmental needs of rivers alongside the human needs. Each river system is different and each country's situation is different. The development of a quick and simple technique for determining how much water should be left in any river is not possible at present. Until more research is conducted and a greater understanding is obtained of the links between flow regimes and complex aquatic ecosystems, the implementation of environmental flows will continue largely on a trial and error basis.

Conclusions

It is the need of the hour to educate everyone of the importance of environmental flows in water management so that progress can be made towards a sustainable society.⁴

This study looked primarily at how people perceive the concept of environmental flows. The results of the survey clearly demonstrate that considerable interest in the concept exists around the world and within all water-related sectors of society. The survey itself provided an opportunity and a medium for many people to voice their opinions about the concept, as it continues to evolve and develop around the world. Allowing people to express and articulate their hopes and concerns for what is commonly seen as a central component in IWRM, is key to the success of any developing concept. The survey coincides with what appears to be an opportune moment for the concept. Efforts to assess, experiment, apply and translate the concept into policy and practice have increased significantly over the last five years.

The overall aim here is to manage water sustainably. As water scarcity increases and populations grow in many parts of the world the ability to manage water resources effectively and equitably and without jeopardising the resource base on which society depends, becomes more difficult and complex. By basing the environmental needs of rivers, wetlands, estuaries and other hydrological systems on sound science, these needs can be legitimately recognised and addressed within water management (Baron et al. 2002). Environmental flows allow the ecological requirements of rivers and other water courses to be included in the debates over sustainable water resource allocation. The concept of environmental flows can be an effective tool for identifying the wider costs of current and past water management practices. It can also be an effective tool for identifying the values to society associated with maintaining and restoring ecosystems. Environmental flows have been shown to be important not only for maintaining biodiversity and ecosystem health, but also for providing many economically valuable services and long-term benefits to society.

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⁴ Modified quote from respondent 268

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