Perceptions and interpretations of Environmental Flows and implications for future water resource management

A Survey Study

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

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Sammanfattning
An understanding of the impacts on freshwater systems from water management and development practices and the recognition that freshwater ecosystems are dependent on various aspects of the natural hydrological variability has given rise to a relatively new field of science commonly referred to as environmental flows. 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 around the world, this survey study was undertaken aiming to identify people’s perceptions and interpretations of the environmental flows concept and its role in water management. It also aims to add to existing knowledge of the extent to which the concept is being applied, how it is being translated into policy and practice and the major challenges and opportunities that exist for continued understanding and implementation. The survey was distributed to a range of people representing different water-related sectors and regions around the world. A total of 272 responses representing 64 countries in the six major regions of the world was received. The responses were compiled and analysis of aspects of the respondents backgrounds as well as the questions were conducted using the computer statistical program SPSS. Representation of specific groups, particularly water user groups, and specific regions in the survey however was low, demonstrating possible limitations of the survey distribution method as well as the lack of concept awareness and application in many parts of the world. The ways in which people define and interpret the concept varied widely. The degree to which the concept was applied shows the growing recognition around the world of the need to consider the environmental water requirements when making decisions on water allocations. Despite the growing recognition many areas do not yet apply the concept. The survey allowed the opportunity for respondents to highlight what they perceived as the major obstacles and difficulties for the concept within their respective areas. 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 the continued adoption and application of environmental flows around the world. Overall, the survey delivered promising signs for the continued evolution of environmental flows within water management. There was widespread opinion that the concept of environmental flows was an essential element in the efforts to achieve sustainable management of water resources.

Nyckelord
Environmental flow, water management, global survey, perceptions, ecological water requirements
Abstract

An understanding of the impacts on freshwater systems from water management and development practices and the recognition that freshwater ecosystems are dependent on various aspects of the natural hydrological variability has given rise to a relatively new field of science commonly referred to as environmental flows. 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 around the world, this survey study was undertaken aiming to identify people’s perceptions and interpretations of the environmental flows concept and its role in water management. It also aims to add to existing knowledge of the extent to which the concept is being applied, how it is being translated into policy and practice and the major challenges and opportunities that exist for continued understanding and implementation. The survey was distributed to a range of people representing different water-related sectors and regions around the world. A total of 272 responses representing 64 countries in the six major regions of the world was received. The responses were compiled and analysis of aspects of the respondents backgrounds as well as the questions were conducted using the computer statistical program SPSS. Representation of specific groups, particularly water user groups, and specific regions in the survey however was low, demonstrating possible limitations of the survey distribution method as well as the lack of concept awareness and application in many parts of the world. The ways in which people define and interpret the concept varied widely. The degree to which the concept was applied shows the growing recognition around the world of the need to consider the environmental water requirements when making decisions on water allocations. Despite the growing recognition many areas do not yet apply the concept. The survey allowed the opportunity for respondents to highlight what they perceived as the major obstacles and difficulties for the concept within their respective areas. 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 the continued adoption and application of environmental flows around the world. Overall, the survey delivered promising signs for the continued evolution of environmental flows within water management. There was widespread opinion that the concept of environmental flows was an essential element in the efforts to achieve sustainable management of water resources.
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1 The emergence of a new concept in water resource management

1.1 “Water in the right amounts in the right places at the right time…”

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 (Rosegrant, Cai & Cline 2002; Rijsberman & Molden
2001). Many countries were able to provide food and water security while keeping pace with
rapidly growing populations. Billions of people benefited and humans no longer were forced
to rely on the variability and unpredictability of nature’s water supply (Gleick 2003).

The mentality that pervaded during this time was one that saw dams and other water
infrastructure as symbols of progress demonstrating the ability of humans to control nature
(McNeill 2000; McNeill 2000). Starting in the USA, but quickly spreading around the world,
the building of big dams and the control of rivers was seen as “fundamental to economic and
social advancement” (Postel & Richter 2003, p1). Management objectives aimed to maximize
supply and minimize waste and any water that flowed to floodplains, wetlands, groundwater
aquifers or to the sea was viewed as a wasted resource (Arthington & Pusey 2003). The well-
known quote from Winston Churchill in 1908 (cited in McCully 2001) illustrates this
perception clearly.

One day, every last drop of water which drains into the whole valley of the
Nile ... shall be equally and amicably divided among the river people, and the
Nile itself ... shall perish gloriously and never reach the sea.

There have been a number of studies on the extent of river modification resulting from human
water developments over the past century. A study undertaken by two Swedish scientists,
Dynesius and Nilsson in 1994, stated that 77 percent of the total discharge of the largest river
systems in the northern third of the world (USA, Canada, Europe and the former Soviet
Union) is affected by dams, reservoirs, diversions and irrigation (Rosenberg, McCully &
Pringle 2000; Postel & Richter 2003). It has been estimated that hydrologic alteration has
affected 60 percent of the world’s rivers, including over 85 percent of the rivers in the USA
and 60 to 65 percent of the rivers in the European Union (Tharme 2003). Further estimates
show that approximately 50 percent of accessible global freshwater runoff has been
appropriated by humans, with projections of 70 percent appropriation by 2025 (Rosenberg,
McCully & Pringle 2000).

\[^1\] McNeill 2000, p150.
Hydrologic alteration from dams, diversions, canals and other water developments invariably manipulates to some extent the natural flows of rivers. Moreover, many flood and drought control projects were specifically designed to compensate for the extreme fluctuations in river flow that accompanied high rainfall events, spring snowmelt and extended dry periods. In many countries, dams built to supply water for irrigation often created high flows during the summer growing seasons, when the natural flows were typically at their lowest. Hydropower dams release water according to peak electricity demands, sometimes resulting in huge and sudden daily fluctuations. These and other types of dams, diversions, canals and levees serve to even out the flow and flatten the peaks of a river’s natural hydrograph to provide a stable and secure supply of water (Postel & Richter 2003).

There is considerable evidence worldwide that river ecosystems have changed as a result of modification of the flow regime from river regulation (Poff et al. 1997, McCully 2001, Tharme 2003, Postel & Richter 2003, Bunn & Arthington 2002, Brown & King 2003). Rivers are defined in this study in line with the definition provided by King and Brown (2003), who describe a river in terms of the complete river ecosystem comprising many interdependent nonliving and living components (see Box 1). King and Brown (2003, p10) continue by saying “rivers are dynamic systems, sculptured by their flows, with dependence on different-sized flows at different times of the year for the inundation of various channel features and the completion of plant and animal life cycles.”

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). The delay in space and time of realizing the impacts from river manipulations is an important consideration. For example, the effects from dams are often only realized downstream or after years or decades from when the dam was constructed (McCully 2001). In response to 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).

**Box 1:** Main components of a river ecosystem

<table>
<thead>
<tr>
<th>Nonliving components</th>
<th>Living components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel, source to sea</td>
<td>Riparian, fringing and aquatic plants</td>
</tr>
<tr>
<td>Banks</td>
<td>Fish, including marine fish that use estuaries</td>
</tr>
<tr>
<td>Floodplains</td>
<td>Aquatic invertebrates</td>
</tr>
<tr>
<td>Linked lakes and wetlands</td>
<td>Aquatic mammals</td>
</tr>
<tr>
<td>Estuary</td>
<td>Water birds</td>
</tr>
<tr>
<td>Linked groundwater</td>
<td>Amphibians and aquatic reptiles</td>
</tr>
<tr>
<td>Linked near-coast marine environment</td>
<td>Microorganisms</td>
</tr>
<tr>
<td>Sediments</td>
<td></td>
</tr>
<tr>
<td>Water chemistry and temperature</td>
<td></td>
</tr>
</tbody>
</table>

(adopted from King and Brown 2003, p10)
1.2 The environmental flows concept and a new way of thinking

The origins of the environmental flows concept can be traced to work undertaken in the 1940s in the western USA, following the recognition that a loss of flow in rivers was responsible for reduced numbers of game-fish species, notably salmon (King, Tharme & Brown 1999; Arthington, Tharme, Brizga, Pusey & Kennard 2004). The focus on the impacts of flow alterations on specific economically valuable species continued on an ad hoc basis until the 1970s. It was at this time that documented methodologies emerged that coincided with the peak dam-building period and new environmental and freshwater legislation in the USA (Postel & Richter 2003; Tharme 2003). The most prominent of these methods was the Tennant Method, devised by Donald Tennant after years of collecting data on biological and hydrological characteristics of rivers across the USA. This simple and easy to use method for defining ecological flow needs became widespread not just in the USA, but up to 24 other countries, and is still being used today (Postel & Richter 2003; Arthington et al. 2004).

The Tennant Method and similar ones that arose to protect particular species, focused primarily on minimum acceptable flows and the effects on fish. A major assumption of designing flows to protect target fish populations and habitats was that it would ensure maintenance of the river ecosystem as a whole (Arthington et al. 2004). A second assumption was that flows that occurred during other times were adequate if they exceeded the minimum value, and all higher flows were available for human use and abstraction (King et al. 1999). Despite these assumptions, these early methods served a far more important purpose in highlighting the impacts on river ecosystems from hydrological alterations that were occurring primarily as a result of the dam construction boom. These early attempts also paved the way for a vast array of methods that continue to evolve today (Arthington et al. 2004).

In other countries, the identification of and attempts to quantify environmental flows appeared later. According to King, Brown and Sabet (2003), South Africa began addressing the problems associated with increasing water demands in the 1980s. In Australia, although public concern was initially raised in response to proposed hydropower developments in the early 1970s, research into environmental flows did not advance until the late 1980s (Arthington & Pusey 2003; Schofield, Burt & Connell 2003). Tharme (2003, p400), in a global assessment of the development and application of environmental flow methodologies, states that other countries such as Brazil, Czech Republic, Japan and Portugal initiated the process of estimating environmental flows later, and many parts of the world, particularly the developing regions, remain “poorly advanced.”

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).
The 1990s saw tremendous advances in the assessment of environmental flows. A multitude of environmental flow methodologies have been developed around the world, with extensive work being undertaken in South Africa, Australia and the USA. In Tharme’s study (2003), up to 207 different approaches to environmental flow assessment have been used in up to 44 countries. Methodologies ranged from simple look-up tables using hydrological data to holistic approaches to expert panels. In recent years, increasing attention has been given to the development of guidelines, manuals and practical advice aimed at creating awareness and building capacity among stakeholders involved in water resource management. For example, IUCN (Dyson, Bergkamp & Scanlon 2003) has recently released a guide for understanding environmental flows and provides technical, policy and practical advice for implementing flows into water resource planning. Implementation of the environmental flows concept and translation into policies, laws and practice is occurring on a global scale and its introduction into new basins and countries continues. The study of environmental flows is a rapidly developing field (Smakhtin, Revenga & Döll 2004).

1.3 The water for people and nature dilemma and the role of environmental flows

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. Evidence of water over-use and water scarcity continues to mount in all regions of the world (Rosegrant et al. 2002). The result is a global water crisis and a considerable amount of research has been aimed at understanding the causes, effects and potential future consequences related to this crisis (Gordon 2003). According to estimates, the population will approach eight billion by 2025, and the water demands to keep pace with this growth will undoubtedly increase over this time (Rosegrant et al. 2002). Many areas of the world are experiencing growing water scarcities, which impinge on the ability to provide water for even basic human needs. The challenge to provide enough water to meet human needs alone over the next quarter century is momentous.

Water scarcity is not just related to human needs. Over-use and over-allocation of water for human purposes reduces the amount and affects the variability of water in rivers and other water systems. Environmental water scarcity leads to the decreased capacity of freshwater ecosystems to provide the full range of goods and services and can result in irreversible degradation of ecosystems and species extinction. In a recent study that provided the first global picture of environmental water scarcity, Smakhtin 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. A further complication is that the human water needs follow a pattern that is often at odds with the natural patterns and variability of rivers and other water courses. 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 (Smakhtin et al. 2004).
Determining an appropriate balance between water for people and water for nature has been a contentious issue within national and international circles, exemplified by discussions during the Second World Water Forum in The Hague in 2000 (Rosegrant et al. 2002). People concerned with “water for food” stressed the need for an increase in water consumption for agriculture over the next 25 years to meet the needs of a growing population. In contrast, people concerned with “water for nature” stressed that a significant amount of water needs to be reallocated from agriculture to meet environmental needs. This central paradox is captured in the key conclusion from the Global Water Partnership’s Framework for Action (cited in Rijsberman & Molden 2001):

On the one hand, the fundamental fear of food shortages encourages ever greater use of water resources for agriculture. On the other, there is a need to divert water from irrigated agriculture to other users and to protect the resources and the ecosystem. Many believe this conflict is one of the most critical problems to be tackled in the early 21st century.

The environmental flows concept recognizes that there are needs of freshwater systems to maintain their ecological integrity and to continue to provide goods and services to society. This implies that rivers, wetlands, aquifers and other water systems require a certain fraction of water at sufficient quantities and times to ensure their integrity is not undermined. It is unrealistic and undesirable in many cases to return rivers, wetlands and estuaries to their natural state (Schofield, Burt & Connell 2003). Environmental change is an inherent part of socio-economic development and modification of the landscape for production of critical resources is unavoidable (Gordon 2003; Falkenmark 2003). The objective in implementing environmental flows is not to return rivers or any other water system to their natural state. Rather, the flow concept aims to estimate the environmental needs of aquatic ecosystems so that these needs can be considered alongside the social and economic needs when decisions are being made with respect to water use and allocations. Recognising the trade-offs between and associated costs and benefits of the environmental, social and economic concerns will enable decision-makers and policy-makers to make informed choices regarding water use.

Attempts to address the water for food and water for nature dilemma must consider the options and opportunities that exist in searching for a sustainable balance. There are many ways to reach a balance in how water is allocated and used by the different water sectors and the environment. The focus does not have to be on how much water is to be reallocated or “lost” to different sectors, which may lead to conflict and disputes. An alternative approach is to determine in what ways the different sectors can increase their water use efficiency and productivity. By increasing the productivity of water in different sectors, the water that is saved allows it to be used in other ways deemed appropriate by society. The values that society places on the different uses of water ultimately determines where the water is allocated. One role of the environmental flows concept is to assist in identifying and assessing the values that society places on water, by addressing the needs of ecosystems and recognizing that meeting these needs provides many tangible and intangible benefits to people.
1.4 A survey study on environmental flows

A number of smaller-scale surveys on environmental flows have been conducted within specific countries or regions. For example, Scatena (2004) conducted a survey to look at the extent of in-stream flow practices in the Caribbean and various informal and formal surveys have been conducted in different regions and river basins in Australia (Arthington & Pusey 2003; Murray-Darling Basin Commission 2002). 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. The method that was seen as most suitable for accomplishing these aims was a questionnaire, distributed to people involved in various water and food-related sectors from all regions of the world. The timing of the survey study coincides with the rapid emergence and evolution of the concept within water management policy and practice in many countries around the world. The diverse experiences and experiments in environmental flows have resulted in the adoption of various terms, definitions and interpretations across different regions and different water sectors. This new field of research and science has seen areas and organizations around the world attempt to identify, understand, quantify and implement environmental flows for rivers, groundwater systems, estuarine and coastal systems, lakes, wetlands and floodplains.

At the same time, however, many parts of the world remain unaware and unconvinced of the need and importance of considering environmental water requirements. To encompass all views, the survey also attempted to reach those areas where the concept was not recognized or applied and to examine the underlying reasons for why the concept is not used. The study concludes by looking at people’s perceptions of what the major challenges and opportunities are for the concept in the future.

This study primarily focuses on people’s perceptions of various issues related to environmental flows. It is hoped that information from this study will help identify key issues related to the concept and highlight where further effort and resources are required so that water professionals around the world can progress the understanding and implementation of the concept. Whether they are researchers, policy-makers, water managers, international agencies, NGOs, community groups, farmers, fishermen or any other interested party, it is vital that all views are taken into account and a constructive dialogue is established. The dilemma of providing water for food and water for nature in the context of a global water crisis requires that communication is based on an understanding of the various views and the various trade-offs that will be necessary.
2 Methods and materials

The methods adopted for this study include a survey or questionnaire-based approach. As part of the survey approach, mailing lists were compiled and discussions held between various researchers involved in the water resource management field. Database compilation and data analyses of the survey results were then undertaken following the submission of responses. A literature search of relevant articles and reports was conducted over a period of several months and included references supplied by respondents to the survey.

2.1 Survey method

To gain an understanding of the current status of the concept of environmental flows, a survey method was proposed. This method was initially discussed with leading researchers from the organizations invited to be part of the study: Linköping University, Stockholm International Water Institute (SIWI), International Water Management Institute (IWMI) and the World Conservation Union (IUCN). The discussions focused on the types of information that could be obtained through a survey and whether the survey would achieve the desired results.

Utilizing the internet and email facilities for the survey was considered the ideal method for gathering people’s perceptions and interpretations of environmental flows. The ability to reach people involved in water management from all regions of the world and from various types of organizations is enhanced considerably through the use of electronic media. Key advantages of this method for conducting surveys over traditional mail and telephone surveys are that it easily overcomes international boundaries and brings cost and time efficiencies by eliminating the need for paper, postage, mailout and, to some extent, data entry. In addition, the sample size is easily increased when further mailouts are necessary or when reminder notices are posted (Dillman 2000). Several disadvantages and areas for caution are also associated with this type of survey method and will be discussed in Section 2.5.

Mixed-mode surveys help overcome difficulties obtaining sufficient numbers of responses using a single method (Dillman 2000). With due consideration of the associated problems, offering respondents a choice of method for completing the questionnaire can contribute to an increased response rate. It was decided for this study to allow respondents two options for completing the survey. The first was to create a web-based version of the questionnaire and publish it via a link on the email message sent to respondents. The second option was a Microsoft Word document which could be opened as an attachment by the respondents from the email message. It was envisaged that these two options presented respondents with the choice of format for which they were most comfortable using. Other advantages included accounting for the different computer systems and levels of internet access that potential respondents from around the world would invariably use.

The process of developing the questionnaire spanned three months and included a number of drafts that were continually revised as the aims of the survey evolved and feedback was received. A number of researchers around the world reviewed the drafts and provided valuable feedback and improvements for the questionnaire. A pilot questionnaire was distributed in early April 2004 to 12 people involved in water management or environmental flows. Aims of the pilot questionnaire included to see how the respondents answered the questions in order to determine possible misinterpretations, to test the Word document format for distribution, and to determine the effectiveness of the email method.
2.2 The questionnaire

The questionnaire comprised a total of seven pages and is presented in Appendix B. The first page was devoted to space for the respondents to enter details of their background. The provision of background information served two purposes. Firstly, it allowed the possibility of analysis of the results based on the respondents’ gender, age, organizational type, river basin of concern, country and region. Secondly, it allowed the formation of a database of the people involved or interested in environmental flows around the world, so that follow-up correspondence and details of the study results could be distributed.

The six pages of questions were written in English. Due to the distribution of the survey worldwide, translation into other languages would have proved beneficial in terms of increasing the response rate; however, due to lack of resources this was not possible. It was estimated that the questionnaire would take 30 to 45 minutes to complete, depending on the respondents’ knowledge of environmental flows, the level of detail provided and whether additional comments were included or not.

Following finalization of the questionnaire, the first round of distribution was undertaken in early May 2004. The questionnaire continued to be distributed over a seven week period as new contacts were compiled. Reminder notices were sent to those contacts who had not responded approximately two weeks after the initial distribution. A final call for responses was issued approximately 7 weeks from the first mailout. Responses were included in the study up until 13 July 2004. Any responses sent following this date were not able to be incorporated as part of this study; however, these responses were kept for future analysis.

The questions was divided into four sections. The first section was aimed at respondents from river basins or countries where the concept of environmental flows was not applied. Section 2 addressed concept definition and interpretation, Section 3 attempted to look at how the concept is being translated into policy and practice in the respondents’ areas, and Section 4 concluded with a look at the future of environmental flows and posed a number of questions aimed at gaining insight into respondents’ perceptions of the concept. The questions followed a number of formats. A majority of questions required the respondent to choose one answer from a number of options. Several questions enabled the respondent to choose multiple answers and other questions required a “yes/no/unsure” response. The options provided for many of the questions included an opportunity for the respondents to further explain their answer or provide alternate answers to the options provided.
2.3 Mailing list methods

The aim of the survey mailing list was to cover a range of people involved in the water management field. It was intended that respondents should not be restricted to experts in environmental flows, but be extended to people within the 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 to be sampled consisted of people that were involved in a professional capacity with 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.

Respondents for the questionnaire were selected from a number of mailing lists provided by the different organizations involved in the study. It was understood that the mailing lists provided by the organizations included contacts that have been established in the past by the organizations in relation to projects, joint research studies, clients, and other capacities. The mailing list covered people and organizations involved in aspects of water management related to *inter alia* agriculture, research, food security, international aid, fisheries, irrigation, hydrology, ecology, engineering, dams, hydropower and sanitation.

Organizations that supplied mailing lists included:
- Stockholm International Water Institute (SIWI)
- International Water Management Institute (IWMI)
- Comprehensive Assessment of Water Management in Agriculture (CA): International Water Management Institute
- The World Conservation Union (IUCN)
- SACI Waters, India
- Commonwealth Scientific and Industrial Research Organisation Australia (CSIRO)
- Global Water Partnership (GWP)

In addition to the mailing lists, a number of other methods were adopted for identifying potential respondents:
- A copy of the questionnaire and cover letter was sent to several organizations (eg. Global Water Partnership, International Commission on Irrigation and Drainage (ICID) and IUCN) which in turn forwarded the survey to their national and regional offices around the world.
- Several respondents to the questionnaire provided additional contacts that they deemed suitable for the survey and the email was forwarded to these contacts.
- To target low response areas and organizational types, searches were conducted on an internet search engine specifying particular countries and organization types.
- Links to the questionnaire were also posted on an electronic newsletter on the webpage of IWMI enabling the survey to be available to subscribers to the newsletter.
- Links to subscriber lists of several hydrology-related journals were also provided.

Due to the fact that the questionnaire was available to potential respondents via newsletters and subscriber lists, the exact number of contacts was not known. The number of directly contacted individuals also is difficult to estimate due to outdated email addresses, rejected emails, and potential computer viruses that were detected. The response rate, therefore, can only be roughly estimated for the survey (see Section 3).
2.4 Data analysis methods

Each respondent was labeled with a separate identification number, which roughly followed the order in which responses were received. The data was initially entered into a Microsoft Excel spreadsheet and then transferred to the statistical program SPPS Release 11 for analysis. Using SPSS, univariate analysis was performed on the variables provided in the respondents’ background information. Univariate analysis was used to show the distribution of respondents according to age, gender, organizational type, river basin, country, region and subregion, and development status. This type of analysis was also performed on the questions examined in the study to determine the frequency distribution of the selected answers. Univariate analysis was the method used most extensively in the study to summarise the respondents’ answers.

When considered appropriate, bivariate analysis was performed to see whether any relationships or trends existed between two variables. For example, to examine whether there was a relationship between the regions represented by the respondents and the answers to a particular question, a contingency table using bivariate analysis was produced. The contingency table was produced using the Crosstab tool in SPSS and the level of association was measured using the statistic Cramer’s V. According to Kent (2001), the Cramer’s V statistic is commonly used in survey analyses and is suitable for different numbers of variables and may be calculated on either nominal or ordinal scales.

The variables included in the results of the survey were divided into the following types:

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labelling scale:</td>
<td>Respondent ID, Name</td>
</tr>
<tr>
<td>Binary scale:</td>
<td>Gender, development status of respondent’s country</td>
</tr>
<tr>
<td>Nominal scale:</td>
<td>Organisational type, river basin, country, region, Questions 1, 2, 3, 5, 6, 7, 8, 12, 13, 14, 15, 16, 19, 20, 21, 24</td>
</tr>
<tr>
<td>Ordinal scale:</td>
<td>Questions 4, 9, 10, 11, 17, 18, 22, 23, 25, 26, 27</td>
</tr>
<tr>
<td>Continuous interval:</td>
<td>Age.</td>
</tr>
</tbody>
</table>

Due to many of the questions containing multiple options, the ability to perform bivariate analysis was extremely limited. In addition, once data was broken down according to organizational type, region or development status, the size of the datasets was reduced significantly and analysis was limited. For these reasons, analysis of the relationships between different independent and dependent variables was restricted. Results of the univariate and bivariate analyses were presented using pie charts, bar graphs and tables.
2.5 Limitations of the study

There are many limitations associated with the type of sociological research being undertaken in this study. The nature of surveys introduces many considerations in terms of how the survey is structured, the validity and reliability of the data, and the way in which results are interpreted and presented. Types of error occurring in surveys of the type conducted in this study include coverage error, sampling error, measurement error, and nonresponse error (Dillman 2000). The following section looks at these limitations and potential sources of error.

2.5.1 Survey limitations

As mentioned in the opening sections, this study was primarily aimed at investigating people’s perceptions and interpretations of environmental flows. Therefore, the survey results were not designed to represent an exhaustive and comprehensive assessment of the concept and its use around the world. Despite the enormous potential for web-based surveys, the advantages must be balanced against significant weaknesses (Dillman 2000). 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. The different computer operating systems and equipment used around the world can also affect how the email and web questionnaires are viewed and the ability of the respondents to complete and submit. The way the questionnaire appears to the designer can differ substantially from the way the respondent views the same questionnaire, particularly in relation to margins, wrap-around text and how figures are viewed.

The two survey modes, the web version and email attachment version, allowed respondents to choose the option that suited them best. An important disadvantage of providing two options was the chance that respondents’ answers would vary according to the method used. This disadvantage was realized during this study due to respondents who used the attached Word document being able to enter multiple responses to questions which respondents who used the web version were unable to do. The web-version allowed multiple responses only when specified by the question, whereas respondents using the Word document could enter multiple responses to every question. This discrepancy had to be considered when analyzing the data.

Other potential factors influencing the response rate to the questionnaire and causing problems for the respondents include:

- length and level of detail of the survey;
- internet connection speed and stability;
- threat of computer viruses and junk or spam emails associated with mass-mailings;
- ability of respondents to easily delete or re-file the email;
- lack of personalization of the email sent to respondents;
- use of English as the only language;
- whether or not the respondents have been subjected to many surveys in the past;
- dependency on the ability of respondents to easily access, complete and submit the questionnaire.
2.5.2 Data validity and reliability

Data validity is related to whether the survey results accurately represent what is trying to be measured. In the case of this survey, a major aim was to capture people’s perceptions and interpretations of the environmental flows concept. For this particular aim, there is no right or wrong answer; however, the ways in which the results are presented needs careful consideration. For other aims such as the extent to which the concept is applied around the world and how the concept is being translated into policy and practice, caution is also needed in how the results are presented and interpreted, particularly in reference to country and regional generalizations.

Data reliability is related to the quality of the answers submitted by the respondents and also the extent to which sampling and measurement error exists. As in all surveys, data extracted is dependent on the quality of the answers provided by the respondents. The questions, therefore, need to be structured and worded in a way that minimizes the measurement error. The measurement error arises from respondents misunderstanding and incorrectly answering the questions. Despite the effort dedicated to developing the questionnaire, including obtaining advice from various experts and undertaking a pilot survey, several questions posed problems with some of the respondents. For example, respondents not familiar with environmental flows experienced difficulties in answering some of the questions and a small number of respondents provided answers that were not consistent with the question being asked. These issues had to be taken into consideration when analyzing the data.

A specific problem regarding the survey was raised by several respondents representing international organizations and whose work on water issues spanned several countries, regions and river basins. The difficulty arose when the respondents were required to provide answers according to individual countries or river basins. When analyzing the data, the individuals who represented multiple areas either had to be assigned one particular country or this aspect was excluded from the dataset, resulting in missing values being assigned for countries and regions.

Following the submittal of responses by the respondents, it became clear that some questions did not meet the criteria for categorical scale variables (Kent 2001). In particular the criterion for values to be mutually exclusive was not satisfied in several questions due to respondents choosing more than one option. In addition, options in some questions did not cover all possibilities. This means that the data was not internally reliable for a limited number of questions.

2.5.3 Results validity and reliability

One aim of the survey was to reach various segments of the water management and water user sectors around the world. This aim was not fully satisfied evidenced by the inadequate representation of people from particular organizational types, including farming groups, fishery groups, irrigation agencies and other agricultural and community based organizations from areas where little evidence of concept application existed. In addition, under-representation of particular countries and regions also occurred.
Insufficient representation was caused by a number of reasons, including:

- the coverage of the mailing lists and other distribution techniques used in the survey;
- computer access and reliability;
- language limitations; and
- lack of familiarity with the concept and inability to answer the questions in the survey.

The sampling technique used in this survey and the reliance on the mailing lists provided by several organizations involved in water management was considered sufficient in light of the resource and time constraints involved. Furthermore, the fact that particular groups and areas were under-represented also reflects the nature of the issue being studied. The distributions according to organizational type and geographic area demonstrate the nature of the environmental flows concept, which is relatively new in many areas and continually evolving. The propensity of people actively involved in the concept to respond to the questionnaire was likely to be higher than people who have limited knowledge or experience in the concept.

As the results will demonstrate, a significant proportion of responses to the survey were received from specific countries. There were various reasons for why particular countries were well represented in the survey. One reason is that these countries represented areas in which much work has been undertaken on environmental flows in the past, and therefore many people were involved in assessment and application of the concept. Another reason reflects the composition of the mailing lists, which contained contacts in countries and regions in which the organizations supplying the mailing lists were located or where work was concentrated.

The problems encountered in the survey distribution limited the ability to analyse data according to organizational type, country, region and other variables. Specifically, the ability to shed light on why people do not accept or remain unconvinced of the concept was extremely restricted. The responses received from many countries and even regions were not sufficient for allowing in-depth cross-country or cross-regional analysis or comparison. Although the dataset consisted of a sufficient number of responses for conducting analysis, the large number cannot be substituted for adequate survey coverage.

The primary purpose of the study was to capture people’s perceptions and interpretations of the concept. The subset of people involved in water management issues was considered to be appropriate for fulfilling this aim, as long as the limitations described above were taken into account. In future surveys of this kind, it is strongly recommended that to obtain datasets that are of sufficient quantity and quality, a more intensive effort within specific areas, such as countries or regions, is undertaken. An example of this type of concentrated survey technique is one conducted by Scatena (2004) on methods for setting minimum in-stream flow standards restricted to the Caribbean Basin. To conduct a survey on a global-scale like the survey in this study, it is recommended that a more thorough search for respondents from particular regions and countries as well as particular organizations and groups be undertaken. In addition, the survey needs to be very short and concise with minimal chances for misinterpretation of questions and possibly translated into other languages, such as French, Spanish and Chinese. Of course, interpreting the results in the different languages would also require more resources. Generating the maximum number of responses is not necessarily a goal of this type of survey, rather it is ensuring that equal representation is obtained across countries, regions, organizational types and stakeholders.
3 Overview of the survey respondents

The following section presents a summary of the respondents to the questionnaire based on their background details provided on the first page of the questionnaire. This section is designed to show how the respondents were distributed according to gender, age and organisational type. It also summarises the distribution according to country, region and river basin where the respondent indicated they were based or responding on behalf of in terms of water management issues. The breakdown according to development status of the country is also included. The variables organisational type, region, river basin and development status will be used in further analysis.

A total of 273 questionnaires were submitted. One response did not include details of the respondent’s background, preventing further analysis of the data. For this reason, this response was omitted from the overall dataset. This provided a sample of 272 completed questionnaires. Given the uncertainty related to the total number of potential respondents contacted (see Section 2.3), 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%.

The distributions according to gender and age of the respondents are shown in Figures 3.1 and 3.2, respectively. The two figures are included for information purposes only and are not used in further analysis of the data. In Figure 3.2, 17 respondents (6.3%) did not state their age and this is referred to as missing data.

![Figure 3-1 Gender proportion of respondents](image)

![Figure 3-2 Distribution of respondents according to age](image)
The distribution of respondents by organisational type is shown in Figure 3.3. Respondents from scientific, research and academic organisations comprised the largest proportion at 43%, followed by government agency representatives at 28%. It is obvious from Figure 3.3 that the distribution across the organisational types is not uniform. This reflects the composition of the mailing list and problems identifying potential respondents, and may be indicative of several other issues. For example, the propensity of researchers on environmental flows to respond to the questionnaire may be greater than individuals from other organisations. It can be speculated that potential respondents who may not have been familiar with or actively involved in the concept of environmental flows felt they could not adequately respond to the questions in the survey. This observation was supported to an extent by respondents with limited experience in the concept who mentioned that they had trouble answering many of the questions. This difficulty may have resulted in a number of potential respondents not completing the survey.

![Figure 3-3 Number of respondents according to organisational type](image)

A total of 64 countries were represented in the survey and the complete list and relative frequencies of the responses from individual countries can be found in Appendix A. It is important to note that responses from five countries were considerably higher than all other countries. Figure 3.4 shows the proportion of responses from USA (31 responses), South Africa (29), Australia (26), India (25) and Sri Lanka (22), which together accounted for almost half of all responses. No other country received more than 10 responses. The fact that a high proportion of responses was received from a small number of countries affects the ability to conduct analysis across countries. The subset of data within these five countries is also limited, which restricts the extent to which analyses can be performed.

The reasons behind the high proportion of responses received from the five countries lie in the composition of the mailing lists and also are indicative of where work has been undertaken on the environmental flows concept in the past and awareness is comparatively high. The most comprehensive mailing lists were provided by the International Water Management Institute (IWMI) and comprised many water specialists involved in environmental flows from those countries where most work has been performed, such as South Africa, Australia and the USA. IWMI is based in Sri Lanka and therefore many contacts within the water management field have been established in the South Asia region, which may explain the high response rate from India and Sri Lanka.
Figure 3-4 Relative proportions of the five countries from where most respondents were located

Figure 3.5 shows the breakdown of respondents by the major world regions, and Figure 3.6 provides a further level of detail by classifying respondents according to subregions. As was the case with organisational types, the distributions according to region and subregion were not uniform and many areas were represented by very small datasets, preventing any opportunities for in-depth analysis. What these figures do illustrate, however, is where more information is needed in terms of environmental flows and where future surveys of this kind will need to focus on more closely.

Figure 3-5 Relative proportions of the major world regions represented by respondents to the survey (for details on regional classifications see Appendix A)
Figure 3.6 indicates that developed countries accounted for 37% of the total number of countries represented in the survey, while developing countries accounted for the remaining 63%. The classification of development status was according to the World Trade Organisation database (WTO 2004). This was an unexpected result for the survey, as most of the people involved in environmental flows and most of the work undertaken on environmental flows has occurred in developed countries, with the exception of South Africa. The high number of respondents from developing countries allowed further analysis of the extent to which the concept was expanding into new areas in the developing regions.

Figure 3.7 Proportion of developing and developed countries represented in the survey

The background information allowed respondents to indicate, if applicable, the river basins in which they were involved in water management issues. A total of 135 river basins or sub-basins were represented in the survey. Also included in this total number are areas defined by geographical or political boundaries that a small number of respondents recorded as alternatives to river basins. For example, several respondents indicated a particular city as the area in which they were involved in water issues. Another example is an area that may encompass several basins or parts thereof, such as the Arabian Peninsula.

Many of the river basins are transboundary basins, overlapping international and national borders. Thirty-two of the river basins in the survey are among the 114 primary watersheds of the world, according to classifications in the Water Resources eAtlas (WRI 2004), which includes the major transboundary river basins and other basins representative of particular
geographic areas. The 32 basins from the survey are listed below in Table 3.1, along with an indicator of Water Stress (WSI) as estimated by Smakhtin et al. (2004) in a global assessment of environmental water scarcity by basin. The countries that were allocated as “highly-stressed” in the Smakhtin et al. (2004) report represent a broad transcontinental zone from Mexico in the west to China in the east, corresponding to 1.4 billion people and 15% of the world’s land surface (SIWI & IWMI 2004). The WSI gives an indication of the pressures facing these basins from human and environmental water scarcity caused primarily by human appropriation of freshwater resources.

Many river basins were not explicitly represented in the survey; however, many of the respondents represented organisations, such as intergovernmental agencies and international research institutes, that covered broad regions encompassing projects and studies on more than one river basin. Many major river basins were incorporated in these respondents’ work and referred to in their responses to the questionnaire. Major river basins not explicitly represented in the survey included:

- Yellow River Basin, China;
- Congo River Basin, Africa;
- Tigris and Euphrates River Basins, Middle East;
- Volga River Basin, Eastern Europe and Russia; and
- Mississippi River Basin, North America.

Table 3-1 Primary watersheds and corresponding Water Stress Indicator represented in the survey
(WSI: Water Stress Indicator from Smakhtin, Revenga & Döll 2004)

<table>
<thead>
<tr>
<th>Region</th>
<th>River Basin</th>
<th>WSI</th>
<th>Region</th>
<th>River Basin</th>
<th>WSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>Amu Darya</td>
<td>Highly-stressed</td>
<td>Africa</td>
<td>Limpopo</td>
<td>Stressed</td>
</tr>
<tr>
<td></td>
<td>Brahmaputra</td>
<td></td>
<td></td>
<td>Niger</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chao Praya</td>
<td>Stressed</td>
<td></td>
<td>Nile</td>
<td>Stressed</td>
</tr>
<tr>
<td></td>
<td>Ganges</td>
<td>Stressed</td>
<td></td>
<td>Okavango</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Godavari</td>
<td>Highly-stressed</td>
<td></td>
<td>Orange</td>
<td>Highly-stressed</td>
</tr>
<tr>
<td></td>
<td>Indus</td>
<td>Stressed</td>
<td></td>
<td>Rufiji</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kapuas</td>
<td></td>
<td></td>
<td>Zambezi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mekong</td>
<td>Stressed</td>
<td>Europe</td>
<td>Danube</td>
<td>Stressed</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td></td>
<td></td>
<td>Daugava</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Syr Darya</td>
<td>Highly-stressed</td>
<td></td>
<td>Ebro</td>
<td>Highly-stressed</td>
</tr>
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<td>Yangtze</td>
<td></td>
<td></td>
<td>Po</td>
<td>Stressed</td>
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<td>North America</td>
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<td></td>
<td>Rhine</td>
<td>Stressed</td>
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<td>Columbia</td>
<td></td>
<td></td>
<td>Seine</td>
<td>Stressed</td>
</tr>
<tr>
<td></td>
<td>Rio Grande</td>
<td>Highly-stressed</td>
<td></td>
<td>Amazon</td>
<td></td>
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<td>Sacramento</td>
<td></td>
<td></td>
<td>São Francisco</td>
<td></td>
</tr>
<tr>
<td>Oceania</td>
<td>Murray-Darling</td>
<td>Highly-stressed</td>
<td></td>
<td>San Pedro</td>
<td></td>
</tr>
</tbody>
</table>

As the above results show, the survey was answered by a large number of respondents covering a wide range of organisations and countries around the world. The coverage, although not ideal as discussed in the previous section, does allow analysis of the respondents’ answers to the questions contained in the survey, albeit with a certain level of caution. The next three sections will present and discuss the results of the survey and attempt to find trends based on the aspects of the respondents’ backgrounds covered in this section.
4 Concept definition and interpretation

“There is no universally agreed definition of environmental flows,” Smakhtin et al. (2004, p1) stated in their global-scale assessment of environmental water requirements. Furthermore, there is no universally agreed terminology for the concept, with a multitude of terms adopted within and across regions. The following section attempts to present a picture of the various ways in which the concept is defined and interpreted, and to pinpoint important distinctions in terminology, definitions and interpretations.

4.1 Concept terminology and definition

It was stated in the introduction to the questionnaire that many terms are used in reference to the flow concept. The rationale for adopting the specific term *environmental flow* for use throughout the survey was that it was the most widespread term. Certainly *environmental flow* is one of the more recognisable terms used to refer to the concept; however, as the results of the questionnaire show, other terms and phrases are equally used and recognised across the regions and countries represented by the respondents.

Question 6 of the survey asked respondents to choose the most common term(s) used to define the concept within their region. An important clarification is that the respondents were asked to respond according to what they believed to be the terms used in their region, and not restricted to what they as individuals used. Respondents were also permitted to select more than one term if applicable. A list of nine terms was provided, plus an additional option allowing respondents to record alternative terms. Figure 4.1 shows the distribution according to the number of times each term was selected.

![Figure 4.1](image)

**Figure 4.1** Number of times (with percentage shown) that various terms were selected by respondents for defining the environmental flows concept within their region
The findings show that there are many different ways that the concept is labelled, with no one term universally adopted. No term was selected by more than 40% of the respondents as the term used in their region, demonstrating the lack of uniformity in concept terminology. The three most common terms, *environmental flow*, *minimum flow* and *in-stream flow*, showed relatively equal frequencies, and other common terms included *natural flow regime*, *ecological reserve* and *environmental water allocation*.

The option allowing respondents to record alternative terms for the concept was used by 21% of respondents (refer Figure 4.1) and produced a long list of other terms in use around the world. In addition to the nine terms provided in the questionnaire, at least 48 alternative terms were recorded by respondents, including four in other languages (see Table 4.1). It is very likely that many more terms are used in connection with the concept, particularly from countries and regions not captured within this survey. Other groups of stakeholders, particularly community groups, and farming and fishery organisations, that were not represented within the survey also would most likely have coined alternative terms related to the concept.

| Table 4-1 Alternative terms used to define the environmental flows concept |
|---------------------------------|-----------------|-----------------|-----------------|
| Base flows                      | Environmental Water Reserve | Integrated Basin Flow Management-IBFM. | River maintenance flow |
| Basic flow                      | Environmental water uses | Lean flow | Run of the river |
| Catchment flows                 | Environmentally acceptable flow | Maintenance flow | Runoff |
| Drought flow                    | Experimental flow | Maximum flow | Sanitation or sanitary flow |
| Dry season flow                 | Fish flows | Minimum balance flow | Sustainable flow |
| Ecological flow                 | Flow for ecological requirement | Minimum Flows and Levels (MFLs) | Sustainable utilization |
| Ecological flow rate            | Flushing flows | Minimum river life flow | Wasted water |
| Ecological restoration flow     | Groundwater dependent flows | Minimum surplus water | “Caudal ecologico” and “Caudales de mantenimiento” (Spanish terms) |
| Environmental protection flow   | High flows | Minimum vital flow | “Débit reservé” (French term) |
| Environmental Water Provision (EWP) | In-stream water rights | Peak flow | “Restwasser” (German term) |
| Environmental Water Requirements (EWR) | In-stream needs | Residual flow | “Sanitarny popusk” (Russian term - sanitary flow) |

Table 4.2 shows regional trends in the use of the various terms by listing the three most common terms including relative proportions. Over 85% of respondents from the Oceania region selected *environmental flow* as the term used. Approximately 62% of respondents from the African region nominated *ecological reserve*. *In-stream flow requirements* was the most common term in North America, while *minimum flow* was most common in Asia and Europe, although the differences were less pronounced. Cross-regional analysis was problematic due to the low number of total responses from some of the regions.
Table 4-2 Most common terms recorded within each region

<table>
<thead>
<tr>
<th>Region</th>
<th>Ecological reserve (63%)</th>
<th>In-stream flow (53%)</th>
<th>Environmental flow (45%)</th>
<th>In-stream flow (77%)</th>
<th>Minimum flow (44%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Minimum flow (43%)</td>
<td>Environmental flow (86%)</td>
<td>Minimum flow (57%)</td>
<td>Environmental flow (35%)</td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td>Minimum flow (31%)</td>
<td>Environmental flow (33%)</td>
<td>Other terms (29%)</td>
<td>Environmental flow (27%)</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>Environmental flow (25%)</td>
<td>Minimum flow (29%)</td>
<td>Environmental flow (29%)</td>
<td>Environmental demand (24%)</td>
<td></td>
</tr>
<tr>
<td>Oceania</td>
<td>In-stream flow (29%)</td>
<td>Minimum flow (77%)</td>
<td>Environmental flow (27%)</td>
<td>Environmental demand (24%)</td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>Environmental flow (29%)</td>
<td>Environmental flow (38%)</td>
<td>Minimum flow (44%)</td>
<td>Environmental flow (35%)</td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>Environmental flow (33%)</td>
<td>Environmental flow (38%)</td>
<td>Minimum flow (29%)</td>
<td>Environmental flow (35%)</td>
<td></td>
</tr>
</tbody>
</table>

It is important to note that although the 57 terms represented in the survey relate to the concept of environmental flows, they 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. There are many definitions that exist in the literature to define the concept. Box 2 provides a sample of how different experts around the world currently define the concept. The reason behind the diversity of terms lies in the original context in which concern over hydrological alterations was raised around the world and the subsequent evolution in research and practice. Furthermore, by briefly examining how different terms appeared can shed light on how attitudes towards the use of water resources have changed over the last several decades.

As described earlier, it has been a common view within water management over the last century that any water that was allowed to flow to downstream wetlands, floodplains and the sea, or seep into underground aquifers was a wasted resource. Related to this view of water resources, water managers within the agricultural and hydropower sectors often viewed water that flowed downstream as surplus or residual water. This water was viewed as the left-over quantity after meeting the needs of human activities, and protection of riverine environments was largely restricted to water quality issues (Arthington & Pusey 2003; Poff et al. 1997). 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 within water management and development.

A shift in the conceptual view of water resources 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). Minimum flows were often associated with limiting the abstraction of water during the dry season, to ensure that the fish species were protected during times of low flow (Brown & King, 2003). As Figure 1 shows, the term minimum flow remains one of the most commonly used terms according to the results of the survey, demonstrating the widespread influence of this first conceptual shift and the subsequent efforts in estimating minimum flows for rivers. A major distinction between the concept of minimum flows and subsequent concepts is that minimum flows often prescribed flows based on average quantities, and do not take into consideration other aspects of the flow regime (Postel & Richter, 2003). Dyson, Bergkamp and Scanlon (2003, p7) continue by saying that estimates of average river discharge for the determination of minimum flows “may be one of the least essential elements of natural flow.”
Box 2: How is the concept defined in the literature?

The lack of uniform agreement for a definition of environmental flows can be illustrated by looking at a sample of the ways in which it has been defined in the literature by leading researchers and organisations involved in assessing and implementing the concept all around the world over the last decade:

- Dyson, Bergkamp & Scanlon (2003) in the IUCN guide on environmental flows define the concept as the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated.

- The 4th International Ecohydraulics Symposium defined environmental flows as the water that is left in a river system, or released into it, to manage the health of the channel, banks, wetland, floodplains or estuary.

- Arthington & Pusey (2003) define the objective of environmental flows as maintaining or partially restoring important characteristics of the natural flow regime (ie. the quantity, frequency, timing and duration of flow events, rates of change and predictability/variability) required to maintain or restore the biophysical components and ecological processes of in-stream and groundwater systems, floodplains and downstream receiving waters.

- Tharme (2003) defines an environmental flow assessment (EFA) as an assessment of how much of the original flow regime of a river should continue to flow down it and onto its floodplains in order to maintain specified, valued features of the ecosystem.

- IWMI (2004) defines environmental flows as the provision of water for freshwater dependent ecosystems to maintain their integrity, productivity, services and benefits in cases when such ecosystems are subject to flow regulation and competition from multiple water users.

- Hirji & Panella (2003) define an environmental flow as an allocation of water with a prescribed distribution in space and time that is deliberately left in a river, or released into it to manage river health and the integrity of ecosystems sustained by the river flows.

- Brown and King (2003) state that environmental flows is a comprehensive term that encompasses all components of the river, is dynamic over time, takes cognizance of the need for natural flow variability, and addresses social and economic issues as well as biophysical ones.

The term in-stream flow emerged at the same time as minimum flows and was identified as part of an approach developed by scientists, water policy specialists and computer modellers for the US Fish and Wildlife Service. The approach was called the Instream Flow Incremental Methodology (IFIM), and was based on an array of methods and computer programs, including the “physical habitat simulation model,” or PHABSIM. This computer model allowed the calculation of minimum levels of flow based on a number of variables related to fish habitat. The tool for assessing ecological flow needs has been widely used around the world, particularly in terms of setting minimum levels of flow for dam releases (Postel & Richter 2003). The term in-stream flow is widely used today, however, it is increasingly recognised as less-comprehensive in scope than other terms that have emerged in the last ten years (Brown & King 2003).

Brown and King (2003) point to an important distinction between in-stream flows and environmental flows. In addition to releases for environmental needs, in-stream flows encompass all releases for non-environmental purposes, including for hydropower, irrigation, navigation, dilution of pollution and interbasin transfers. These releases do not constitute
environmental flows, as they do not take into account the natural variability of the flow regime. Brown and King (2003) continue by saying that the ecosystem impacts from non-environmental flows should be part of environmental flow assessments.

The minimum flow and in-stream flow concepts were limited to the protection of specific species and did not aim to maintain or restore the health of the entire river system (Schofield, Burt & Connell, 2003). It was recognised that the prescription of minimum levels of flow was not relevant in arid and semi-arid regions, where many river systems are ephemeral (Brown & King 2003). Despite the shortcomings associated with minimum flows, this concept established the need to consider the environmental needs within water management. In many rivers, it was and still is vital that a sufficient low-flow is maintained to ensure fish and other aquatic biota are sustained (Postel & Richter 2003). Examples of river dessication, which is defined as a significant reduction in rivers flows (including the complete drying out of river channels), are becoming increasingly common around the world. Lannerstad (2002) describes a number of cases of river dessication, including: Colorado River, USA; Nile River, Northern Africa; Aral Sea Basin, Central Asia; Yellow River, China; and the Murray-Darling River, Australia. Particularly with respect to river dessication, a minimum level of water is often recommended to be prescribed at which point all water abstractions should stop. The methods for determining minimum flows will continue to play an important role in the field of water management.

A second conceptual shift beginning in the 1980s in South Africa and Australia resulted in the expansion from focussing on a single feature of river systems to incorporating multiple aspects in the assessment of environmental flows (Hirji & Panella 2003). This expansion accompanied the increasing recognition of the vital role of the entire natural flow regime in ecosystem structure and functioning. Attempts to modify any aspect of the flow regime for human purposes will inevitably affect aquatic, riparian, floodplain and wetland ecosystems within a river basin.

The term natural flow regime does not refer to the same thing as other terms in Figure 1. The term implies that no modification of rivers has taken place and refers to the pre-development conditions of river ecosystems. It is neither realistic nor desirable in most cases to return rivers and other water systems to their natural state (Schofield et al. 2003). The term serves to identify the fundamental need to understand the characteristics of the flow regime when assessing the environmental flow requirements for rivers. Recognition of the role of natural flow regime gave rise to the new paradigm for river management that saw the flow regime as the “master variable” that regulates the ecological integrity of flowing water systems (Poff et al. 1997). The result was a more holistic approach to water management which considered all factors that influence the biota and ecosystem functioning of not just rivers, but also wetlands, estuaries, floodplains and aquifers.

Several terms provided by respondents and listed in Table 4.1 refer to different aspects of the flow regime. Dry season flow, drought flow, base flow, high flows, groundwater-dependent flows, flushing flows and peak flow all refer to various types of flows within the entire regime. These terms are not substitutes for the term environmental flows, but instead should be taken into consideration when determining environmental water requirements, as they represent various aspects of the natural variability of hydrologic systems.
The remaining terms in Figure 4.1 all refer to a similar concept. *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.

In South Africa in the 1990s, following the collapse of apartheid, considerable work was undertaken in rewriting laws and policies covering a wide spectrum of issues. One issue that received attention was water and the National Water Act, established in 1998, is considered a landmark in international water policy (National Water Act 1998; Postel & Richter 2003). As part of this Act, a system of water allocations known as the “Reserve” was established. The Reserve consisted of two parts – water allocations for basic human needs and water allocations for ecological needs (SIWI & IWMI 2004). The term *ecological reserve* was thus given to the water allocated to support ecosystem functions in order to conserve biodiversity and sustainably manage ecosystem goods and services. The survey revealed that this term is also used in up to 26 other countries, including many within the Sub-Saharan African region.

The term *environmental flow* appears to have originated in Australia in the 1990s (King, Tharme & Brown 1999). In response to increasing water scarcity and widespread degradation of rivers and wetlands, particularly in the socio-economically vital Murray-Darling Basin, the Australian federal and state governments developed a Water Reform Framework. The Framework recognised the environment as a legitimate user of water and sought to allocate water to freshwater ecosystems in order to sustain or restore critically important ecological processes and biodiversity (Postel & Richter 2003; Arthington & Pusey 2003). The concept of “working rivers” was introduced, which recognised the trade-offs that exist between the extent to which a river is used, or “put to work,” for human purposes and the natural state of the riverine ecosystems (SIWI & IWMI 2004). The term *environmental flows* is now widespread in the research, policy-making and public arenas in Australia, and as the survey has indicated, at least 36 countries worldwide now also use this term.

*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).
4.2 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 list of 12 aspects was provided, plus an option to include additional aspects that the respondents felt were applicable. The first five aspects in the list correspond to the five key components considered to make up the flow regime – quantity, frequency, duration, timing and rate of change (Poff et al. 1997). The remaining aspects include those that have been identified by various researchers and policy-makers as part of this evolving field. Figure 4.2 presents a bar graph indicating the number of times each aspect was selected by the respondents and includes the percentage of total respondents who chose each aspect.

![Figure 4-2](image-url) Number of respondents (including percentage) who selected possible aspects they considered to be associated with the concept of environmental flows

The quantity or amount of water within a river system was considered by 88% of respondents as a key aspect of the environmental flows concept. This was not a surprising result, as the quantity of water was the basic premise on which the concept was first developed. Timing of flows was selected by 71% of respondents, demonstrating the awareness of the important functions related to the timing of flows according to seasonal, annual and longer patterns. The remaining components of the flow regime, duration, frequency and rate of change, were selected by progressively smaller proportions of respondents.

A total of 103 respondents, or 38% of the total, selected all five components of the flow regime as being part of the environmental flows concept. These 103 respondents were distributed across all regions and organisational types, with no discernable trends. The 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 flow regime plays in water management. The proportion of respondents who selected four out of the first five aspects was approximately 52%.

Water quality as an aspect of environmental flows was selected by 70% of respondents. Water quality has traditionally assumed much of the focus in terms of water resource management. Up until the mid-1900s, water pollution was seen as the main human-caused disruption to rivers and other waterbodies (King, Tharme & Brown 1999). Many problems associated with water pollution have been recognised and huge amounts of resources and research have been aimed at addressing water quality issues around the world. The link between water quality and environmental flows has been interpreted in different ways. Some view an important role of environmental flows as being to improve water quality by diluting pollution. While providing environmental flows in rivers would contribute to controlling pollution levels to some degree, others do not consider this should be a specific goal for the concept because it may not consider the natural variability of the flows. Alternatively, it is the view of this latter group that water pollution problems should be addressed at the source. Despite these differences, the aspect of water quality is an important part of environmental flows, as evidenced in the survey results, and the link between the two has been receiving considerable attention in South Africa in recent years (Schofield, Burt & Connell 2003). In the context of Integrated Water Resource Management, it is crucial that both water quality and environmental flows are considered and integrated in water management decisions.

The aspects in Figure 4.2 related to groundwater, floodplains, geomorphology and estuaries represent some of the components of a entire river basin ecosystem that are increasingly being considered as part of the holistic approach to environmental flow assessments. As shown in Box 1, King and Brown (2003) list the nonliving and living components of a river ecosystem. As the concept moves away from the original focus on in-stream processes and more understanding of the interdependency of the components is gained, it is expected that the inclusion of these aspects as part of environmental flows will continue to grow. The survey results show that a significant proportion of the respondents already consider these components to be part of the concept.

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 (Figure 4.2). However, there is some dispute as to how social aspects are linked to environmental flows. Several respondents in the survey argued that environmental flows should only refer to flows needed to sustain a functioning river ecosystem. The socio-economic aspects of water use, they argue, are critically important and should alternatively be considered not within the scope of environmental flows but in overall water management.

A related interpretation of the concept surfaced through a reference provided by a 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 even suggested that the term *environmental flows* should be changed to the more appropriate *flows for people and the environment* (IUCN 2003).

Other aspects considered by respondents as part of the environmental flows concept are presented in Table 4.3. The diversity of the terms listed below indicates that the concept is interpreted in many different ways. Some respondents expressed great concern that various aspects listed below were not included in the options provided in the question. Many aspects listed below often were related to the specialisation of the respondents.

**Table 4-3** Additional aspects mentioned by respondents to the options provided in Question 7 related to the interpretation of environmental flows

<table>
<thead>
<tr>
<th>Absence of flow</th>
<th>Environmental flow scenarios</th>
<th>Invertebrate species</th>
<th>River basin aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive management</td>
<td>Environmental Management Class</td>
<td>Land use</td>
<td>River mouth and delta needs</td>
</tr>
<tr>
<td>Aesthetic value</td>
<td>Ethical value</td>
<td>Legislation requirements</td>
<td>Salt damage prevention</td>
</tr>
<tr>
<td>Aquatic community structure</td>
<td>Existing users</td>
<td>Local community views</td>
<td>Sediment transport</td>
</tr>
<tr>
<td>Basic human needs</td>
<td>Fish spawning and survival</td>
<td>Low flow requirements</td>
<td>Site specific requirements</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Flood magnitude and frequency</td>
<td>Micro-habitat</td>
<td>Species specific requirements</td>
</tr>
<tr>
<td>Coastal ecosystem</td>
<td>Flora and fauna</td>
<td>Minimum flow</td>
<td>Spiritual value</td>
</tr>
<tr>
<td>Compensation for lost river resources</td>
<td>Flow stress-response</td>
<td>Multi-stakeholder dialogues</td>
<td>Stakeholder views</td>
</tr>
<tr>
<td>Compensation for water users</td>
<td>Flow velocity</td>
<td>Multi-year variations</td>
<td>Sustainability aspects</td>
</tr>
<tr>
<td>Links between abiotic parameters and species</td>
<td>Flushing flows</td>
<td>Natural landscape conservation</td>
<td>Target species</td>
</tr>
<tr>
<td>Cultural heritage aspects</td>
<td>High and low flow events</td>
<td>Navigation/transportation requirements</td>
<td>Technical objectives for dams and reservoirs</td>
</tr>
<tr>
<td>Desired state</td>
<td>Hydraulics</td>
<td>Public benefits</td>
<td>Tourism values</td>
</tr>
<tr>
<td>Downstream users</td>
<td>Hydrological resilience</td>
<td>Recreation</td>
<td>Wastewater discharge effects</td>
</tr>
<tr>
<td>Drinking water</td>
<td>Hydro-sociologic cycle</td>
<td>Religious value</td>
<td>Water chemistry</td>
</tr>
<tr>
<td>Economic goods and services</td>
<td>Incremental changes in streamflow</td>
<td>Resource economics</td>
<td>Water governance</td>
</tr>
<tr>
<td>Economic value</td>
<td>Industrial effluent discharge effects</td>
<td>Resource Quality Objectives</td>
<td>Water level</td>
</tr>
<tr>
<td>Ecosystem health objectives</td>
<td>Links between wetlands and groundwater</td>
<td>Resource Units</td>
<td>Water temperature</td>
</tr>
<tr>
<td>Ecosystem services</td>
<td>Intrinsic value</td>
<td>Riparian vegetation</td>
<td></td>
</tr>
</tbody>
</table>
A final alternative interpretation of environmental flows draws attention to the cultural differences between countries and the context in which the environment is considered. Highlighted in a paper on water management in the Yellow River Basin, the Chinese concept of ecological water use has a different meaning compared to what is commonly accepted in many other countries (Zhu, Giordano, Cai and Molden 2004). Zhu et al. (2004, p7) state that Chinese water managers approach environmental water requirements “with a Chinese perspective of the interrelationship between man and the environment.” In this case, the primary “ecological” use of water in the Yellow River is defined to be the flushing of sediment to control floods and limit the associated human socio-economic costs. While other environmental issues, such as ecosystem needs and biodiversity, are considered in the Yellow River Basin, the use of flows to protect against floods is not generally considered be part of the environmental flows concept in other countries (Brown & King 2003).

The latest advances within this field of research continue to expand the scope of the environmental flows concept. The extent to which the aspects in Figure 4.2 were considered as part of environmental flows and the diversity of aspects included in the Table 4.3 show that the concept continues to evolve and is shifting from the traditional view of it being about 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 included.
5 Application of the concept

There have been a number of studies and reports over the last few years which have looked at the extent to which work on environmental flows has progressed (Poff et al 1997, Tharme 2003, King, Tharme & Brown 1999, Arthington et al. 2004). The following section will aim to supplement these earlier studies by providing a current status of environmental flows as communicated by the respondents of the survey. An important point to consider when using the survey method is the varying levels of experience and knowledge that the respondents possess in terms of environmental flows. In several cases, two respondents representing the same area had different interpretations of the extent to which the concept was applied and practiced in their area.

The first question of the survey asked the respondents whether they considered the concept of environmental flows useful in their respective country or river basin, and if considered useful, whether the concept was being applied. This question was designed to gauge the respondents’ initial perceptions of the concept and the extent to which the concept is applied around the world. Figure 5.1 shows that of the 271 valid responses just over 1% (4 respondents) considered the concept as not being useful in their respective country or river basin. An aim with respect to the distribution of the survey was to reach areas and organisations where the concept was not necessarily recognised or considered valid. Given the very low representation of this subgroup, the ability to analyse and draw conclusions was impossible for respondents who viewed the concept as not useful. Targeting specific countries and regions where limited work has been conducted on the concept may deliver more data for this subset and shed more light on why the concept is not considered useful or applicable. A concerted effort to reach community groups, farming organisations and irrigation agencies is recommended for future surveys to examine why and where the concept is considered invalid or inapplicable. What can be seen from these four individual responses, however, is that they are spread across four different organisational types, in four different countries within three regions.

Almost 99% of the respondents to the survey considered the concept useful within the context of water management in their river basins or countries. This result in itself is a promising sign for the concept, particularly as a majority of the respondents represented developing countries where the concept has received little attention in the past (Tharme 2003). It may also reflect the type of people who would most likely respond to a survey of this kind. People who find the concept useful within water management would be more likely to respond to the survey when compared to people who may not be aware of the concept or view it as useful or valid. As Figure 5.1 shows, 47% of respondents (comprising 127 individuals) represent river basins or countries where the concept is not currently being applied and 52% (140 individuals) represent areas where the concept is being applied. This relatively even distribution between application and non-application of the concept provides an opportunity to compare the two datasets against other variables to see if any trends exist in the application of the concept.
5.1 The extent of concept application and non-application

Investigating the extent to which the environmental flows concept has been applied can provide an up-to-date picture of how its use has expanded throughout the world over the last several years. A base from which to examine the emergence of the concept can be provided by the global assessment of environmental flow methodologies undertaken by Tharme (2003). Using data up to 2001, Tharme reviewed the global status of the development and application of environmental flow assessment (EFA) methodologies. In her report, Tharme listed a total of 51 countries either actively applying or in the first stages of applying environmental flow methodologies.

From the results of the survey in this study, 42 out of the total 64 countries represented were identified as applying the concept of environmental flows. As in Tharme’s study, the degree to which these countries apply the concept varies considerably. In several countries where the concept has been established for over decade, such as South Africa, Australia and the USA, application has been extensive. In many other countries, application of the concept has only recently been initiated. When combined with the findings in Tharme (2003), at least 71 countries now use the concept worldwide. The countries identified through the survey represent a number of regions which have shown minimal recognition or application of the concept in the past, demonstrating the emergence of the concept over the last several years.

Table 5.1 divides the countries into three categories. The countries listed in the left-hand column include those where environmental flow work is known to have been conducted, such as Australia, South Africa and the USA. Work on environmental flows has been well established in these countries; however, there are many river basins within these countries where environmental flows has received little or no attention to date. This characteristic can be extended to all countries around the world, as there is no documented evidence of a country applying environmental flows in all its rivers, wetlands, estuaries and other water systems.
In contrast, countries where there is little or no evidence of environmental flow initiatives will experience more difficulties in establishing the concept within water management policy and practice. The middle three columns of Table 5.1 list countries in which respondents have indicated that the concept has only recently been established and evidence of application has been shown. These represent areas where the concept is emerging in terms of water resource policy and practice. The final column in Table 5.1 lists countries identified in the survey as lacking application according to the respondents. This does not infer that work on environmental flows has been non-existent in these countries; it only suggests that according to the respondents from these countries, application of the concept has been extremely limited.

<table>
<thead>
<tr>
<th>Countries where EF work is well established, yet specific areas still lack attention</th>
<th>Countries in which respondents indicated that EF work has been initiated, yet it is still in its infancy</th>
<th>Countries where little evidence of EF work exists as identified by respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Argentina</td>
<td>India</td>
</tr>
<tr>
<td>Canada</td>
<td>Austria</td>
<td>Indonesia</td>
</tr>
<tr>
<td>Italy</td>
<td>Belgium</td>
<td>Ireland*</td>
</tr>
<tr>
<td>Japan</td>
<td>Botswana*</td>
<td>Israel*</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>Brazil</td>
<td>Jordan*</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Bulgaria</td>
<td>Latvia*</td>
</tr>
<tr>
<td>Norway</td>
<td>Cambodia</td>
<td>Kenya</td>
</tr>
<tr>
<td>South Africa</td>
<td>Cameroon</td>
<td>Korea</td>
</tr>
<tr>
<td>Spain</td>
<td>Chile</td>
<td>Laos</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>China*</td>
<td>Lesotho</td>
</tr>
<tr>
<td>USA</td>
<td>Czech Republic</td>
<td>Malaysia*</td>
</tr>
<tr>
<td></td>
<td>Costa Rica*</td>
<td>Mali</td>
</tr>
<tr>
<td></td>
<td>Denmark</td>
<td>Mauritania</td>
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<tr>
<td></td>
<td>Ecuador*</td>
<td>Mexico</td>
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<td></td>
<td>Egypt*</td>
<td>Moldova</td>
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<td>Finland</td>
<td>Mozambique</td>
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<td></td>
<td>France</td>
<td>Namibia</td>
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<td></td>
<td>Germany</td>
<td>Nigeria</td>
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* new countries that have been identified through the survey as applying the concept

These results do not by any means represent a comprehensive assessment of where the concept is being applied around the world. The aim here is to highlight those areas where environmental flows has received little attention, yet an interest from people involved in water management has been shown and evidence of initiatives is emerging. It is envisaged that this information will help to identify specific areas and organisations where interest has been expressed and assistance is needed for establishing environmental flows work. This will in turn assist people and organisations involved in national or international flow initiatives to focus on areas where the concept is emerging.
When looking at the extent of application across regions, difficulties arose due to the limited number of respondents and countries representing entire regions. The ability to summarise the extent of application across a region based on responses from a small subset of individuals or countries is severely limited. For example, within the Oceania region, Australia and New Zealand are the only two countries represented and respondents from Australia account for 96% of total respondents from the region. The same can be said for the North American region (87% of responses from the USA) and the African region (53% from South Africa). These results demonstrate, among other things, that extensive work on the flows concept has occurred in these particular countries and that a number of individuals and organisations are actively involved in environmental flow work. Despite the lack of data for many areas, what can be said is that sufficient resources, knowledge and experience in environmental flows exists in these regions, which will most likely make it easier to expand the concept into new areas within the region. However, the amount of resources, knowledge and experience needed to accomplish this cannot be underestimated.

Keeping in mind the limitations of the data, the extent to which the concept is applied varies across the major regions (Figure 5.2). In the Oceania region, which is represented by Australia and New Zealand, respondents from areas where the concept was applied accounted for over 90% of all respondents in the region. For the African region as a whole, over 60% of areas represented by respondents have seen some degree of concept application. When South Africa, the country where most has been conducted, is excluded from the dataset for the African region, the extent of application falls below 40%. Regions where a majority of the areas represented by respondents have seen little or no application of the concept include Latin America and the Caribbean and Asia.

![Figure 5-2: Relative percentage of concept application across the six major regions.](image)
Careful consideration needs to be given when looking at the results shown in Figure 5.2, due to the fact that many countries within each of the regions were not represented in the survey. A more reliable illustration is shown in Figure 5.3, which compares developing and developed countries. A distinct gap can be seen between developing and developed countries in terms of concept application. South Africa is the exception for developing countries as far as application of environmental flows is concerned (indeed, the country is designated both as a developed and developing country depending on which source one refers to). For this reason, Figure 5.3 also includes the distribution in developing countries with data from South Africa excluded.

Close to 70% of respondents from developed countries stated that the concept is being applied in their areas, compared to fewer than 25% of respondents from developing countries. This follows a similar trend in environmental flow work found in previous studies. King, Tharme and Brown (1999) stipulate that environmental flows has received little attention in a vast majority of developing countries, and they point out that many of these countries are located in semi-arid and arid parts of the world where water resources are inextricably linked to socio-economic development. Furthermore, many developing countries, a number of which are represented in the survey, are “undergoing intensive water resource development” (King, Tharme & Brown 1999, p15).

Figure 5-3 Relative percentage of concept application and non-application across developed and developing countries.
To examine the extent of application in specific countries, the five countries that accounted for most responses to the survey were chosen (Figure 5.4). The high proportion of concept application within Australia, South Africa and the USA reflect the vast experience in research and application of environmental flows. Over 90% of respondents from Australia and South Africa stated that the concept is being applied in their areas, while the proportion was lower in the USA. For the two developing countries, India and Sri Lanka, the proportion of areas where application of the concept has occurred is below 35%. This shows that although the environmental flows concept has been introduced and evidence of application is apparent within these two countries, many river basins have received minimal attention and considerable work is required.

Figure 5.4 Relative percentage of concept application and non-application in five selected countries according to respondents

Figures 5.2, 5.3 and 5.4 reiterate the findings by Tharme (2003), who showed that a large gap exists between developed countries and developing countries in terms of environmental flow activities and initiatives. However, also consistent with Tharme’s findings, many encouraging signs are evident in countries where the concept has previously been non-existent. The fact that most survey respondents from developing countries were aware of or actively involved in implementation of the concept shows promising signs for the future.
5.2 Why is the concept not being applied?

To assess the problems and difficulties of concept application, a number of questions in the survey were specifically aimed at respondents who either viewed the concept as not useful or stated that the concept was not being applied within their area. These questions aimed to identify some of the underlying reasons for why the concept is not applied in particular areas around the world. It is hoped that this type of information will enable those involved in research and international projects on environmental flows to be able to determine the best approach for introducing the concept into new areas.

The breakdown of the major reasons for why the concept was not applied are shown in Figure 5.5. The two most common reasons were a lack of policy guidance and management capacity (33% of respondents) and a lack of awareness of the concept (27%). Generating awareness of the environmental flows concept is the first step towards successful application of the concept (Dyson et al. 2003). Once people are aware of the need to consider and implement environmental flows, providing sufficient policy guidance and management capacity follows. The emergence of the concept in many countries over the last decade has increased the awareness among people and organisations within the water sector and the public in general. However, as the results of the survey revealed, only a limited number of countries possess extensive experience and knowledge.

![Figure 5-5](image.png)

**Figure 5-5** Relative percentages of the different reasons for why the concept is not being applied according to respondents in the survey

The respondents who ascribed a lack of awareness as the primary reason for non-application of the concept represented a number of countries (Table 5.2). In addition, all six organisational types were represented within this subgroup of respondents, including government agencies, scientific organisations and NGOs. As the concept continues to emerge and more research and projects are undertaken, awareness will undoubtedly increase. However, the lack of awareness that persists in many countries and organisations will need to be addressed if the environmental needs of rivers and other water systems are to be recognised and taken into account in water management.
Awareness is not limited to recognition of the concept, but extends to various aspects including awareness of the costs and benefits of implementation, the consequences if the concept is not considered, and the trade-offs that would come into play between social, economic and environmental objectives within a river basin. Once these aspects have been identified within an area, the process of training and capacity building forms a crucial step in raising awareness among policy-makers, politicians and other stakeholders. The IUCN guide on environmental flows (Dyson et al. 2003) outlines a number of ways in which to generate awareness and convince the larger community of the importance in establishing the concept.

Table 5-2 Countries in which respondents attributed lack of awareness as the primary reason for non-application

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Once awareness of the concept has been established among the relevant parties, policy guidance and management capacity are essential for the successful implementation of the concept. The importance of effective guidance and capacity building in environmental flows cannot be underestimated, particularly within a field that is continually evolving and emerging. The injection of international expertise and support plays an important role in building the capacity of local stakeholders to recognise the environmental needs of the ecosystems and begin to undertake assessments and work towards policy integration.

The third most common reason for non-application, that the concept was very new, was provided by respondents as an alternative to the four specified options in this question. This reason is closely related to awareness of the concept and the need for policy guidance and management capacity. If environmental flows work has only recently been introduced to an area, many actors within the water sector will not be fully aware of the concept and will require technical guidance and training. Further effort is obviously needed in these areas to progress the recognition and understanding of the concept within water management.

Inability to apply the concept due to water shortages was highlighted by 10% of respondents. The issue of water scarcity and environmental flows is a complex one, with two distinct opinions emerging. Firstly, some people see that water scarcity makes it very difficult to be able to consider the needs of the environment, particularly when there is a shortage of water for basic human needs. This viewpoint is highlighted in Box 3 using the example of the Walawe Catchment in Sri Lanka, an area where the concept has not yet been applied. The second viewpoint was that the environmental flows concept is especially important in water scarce areas due to the increased vulnerability of the environment and the close link between river ecosystems and livelihoods of poorer communities. The issues of water scarcity and flows will be discussed in further detail in Section 6.

Reasons that fell into the ‘Other’ category for why the concept is not applied included an over-allocation of water rights, increased competition for human needs for water resources within the area, existing regulations for water management that fail to consider the concept, the lack of socio-economic value placed on environmental flows, political choice, and lack of funding. All these factors must be acknowledged and taken into consideration by those attempting to introduce and implement the concept in new areas.
Box 3: Walawe Catchment, Sri Lanka and impediments for concept application

The Walawe catchment in the southern part of Sri Lanka provides a good example of the challenges facing many developing countries in applying the environmental flows concept in water management practice.

The Walawe River Basin covers an area of 2,442 km² and is the largest in southern Sri Lanka. The Walawe River flows from the central highlands, which are relatively wet with limited water resource development. The downstream areas are drier and flat with developed water resources and three main water storage sites, Uda Walawe reservoir, and Ridiyagama and Chandrika water tanks. Two monsoonal periods dominate the climate pattern, yet during the inter-monsoon periods, rainfall is extremely limited and severe water shortages can occur. The rainfall pattern defines the two main cultivation periods: Maha Season from September to March and the Yala Season from April to September. Land use in the catchment is dominated by shifting cultivation and irrigation agriculture, with the major crops being paddy rice and what is collectively termed Other Field Crops (OTC). The basin plays an important role nationally by making significant contributions to food production from the irrigation schemes (Molle, Jayakody and de Silva 2003). Through the assistance and funds provided by other countries, extensive water resource development is occurring in the region, despite recent periods of severe water shortages and drought.

Discussions with representatives of the irrigation departments in the basin shed some light on the challenges faced by those dealing with water resources in the region. The individuals interviewed held the responsibility for water allocations in the basin and were aware of the concept of environmental flows and Integrated Water Resource Management. Despite this awareness, they stated that during times of water shortages, considering the water needs of the river ecosystems was simply not possible. The first priority was providing for the basic needs of the population, ie. water for drinking and bathing. The second priority was meeting the demands of irrigation agriculture in the efforts to achieve food self-sufficiency for the region and the country as a whole. The representatives believed that opportunities to account for the environmental needs were more available in developed countries that had sufficient resources and were food secure. Particularly during times of water scarcity, environmental flows was not a “luxury” that they could afford to incorporate in the Walawe Catchment.

Although the irrigation sector representatives were aware of the concept, the recognition of the potential benefits associated with implementing environmental flows was not apparent during the interviews. In addition, the consequences of not considering the environmental needs of ecosystems when releases were made from the dams and reservoirs were not realised. The irrigation department, according to the interviewees, was under considerable pressure to allocate water in the right quantities and at the right time to farmers in the irrigated paddy fields. During times of acute water shortage, the ability to allocate water to meet even the basic needs of the basin population was severely restricted. The interviews highlighted the intense pressure faced by water managers in a water scarce area of a developing country.

Furthermore, the problems and consequences of water shortages within the region appear to be worsening in recent years. An extended drought period in 2001-2002 led to extreme water scarcity and according to the interviewees, often resulted in violent disputes between farmers and the irrigation department and among the farmers themselves over water allocations. Farmers located in the downstream areas were worst affected. Surveys conducted in the region indicated that inhabitants have claimed that rainfall and water discharges have declined over the last 10 years. This apparent decline in water resources has led to induced changes in crop choice and collective action (Molle et al. 2003).

Initial work is being undertaken in the region, as well as other river basins in Sri Lanka, on environmental flows. A limited number of studies have commenced on the aquatic ecosystems and the hydrological characteristics of the rivers, wetlands and estuaries. The researchers involved in the studies have indicated that the time is ripe for more detailed assessments of environmental flows and the initiation of capacity building exercises for the water managers and other stakeholders in the basin. However, in order for the concept of environmental flows to be established, a crucial requirement is that researchers, government officials, irrigation managers and farming groups understand and appreciate the alternative views and pressures that exist within the basin.
5.3 How was the concept established?

Related to the application of the concept is how this field of research was established in the different river basins and countries. It provides an opportunity to compare how the concept originally emerged with how it continues to evolve and expand into new areas. Understanding the factors behind how the concept was introduced in different countries and regions may also help to establish the concept in areas where the concept is emerging or where little awareness currently exists. Respondents were asked to choose from seven options for how the concept was established, plus an option for recording alternative reasons. Many respondents selected more than one option, indicating that a number of factors contributed to the emergence of the concept. Figure 5.8 presents the distribution of the options according to how the respondents replied.

![Figure 5-6](image)

**Figure 5-6** Distribution of responses to how the concept of environmental flows was established

King, Tharme and Brown (1999, p6) stated in a contributing paper to the World Commission on Dams, that the introduction of environmental flow assessments to many countries reflected, and was partly responsible for, “a fundamental shift in attitudes concerning the exploitation of water resources.” The concern about degradation of water resources occurred as part of and contributed to the overall environmental movement, which began in the 1960s (McNeill 2000). Rising public concern was influenced by, and at the same time guided research on ecology and the environmental impacts caused by human activities. New national environmental legislation in many countries reflected the overall public concern with how human activities were impacting the natural environment. The role of the community as a driving force in initiating change and creating awareness of environmental flows will continue, as Dyson, Bergkamp and Scanlon (2003) stipulated in IUCN’s publication on flows.

As discussed in the introduction, the emergence of the environmental flows concept was largely in response to a growing recognition of the impacts caused by human development and management of water resources. As Figure 5.8 shows, the results of the survey are consistent with this finding. The growing public awareness of environmental issues was the most common reason for the establishment of the environmental flows concept within the areas represented by the respondents. No significant differences were detected across regions or according to development status, indicating that, according to the survey, the influence of public awareness was relatively similar across all areas.
Another important factor in the establishment of the concept has been the introduction of Environmental Flow Assessment (EFA) projects either by government agencies or outside sources. The proportion of respondents who nominated EFA projects approached 50%. An Environmental Flow Assessment is defined by Tharme (2003, p400) as “an assessment of how much of the original flow regime of a river should continue to flow down it and onto its floodplains in order to maintain specific, valued features of the ecosystem.” EFA projects were an important factor in the emergence of environmental flows as a new field of research and branch of science. Three countries where the concept has been well-established, Australia, South Africa and the USA, have conducted extensive EFA projects, primarily in response to national and state government initiatives. Undertaken for different reasons, EFA projects in these countries paved the way for the establishment of the environmental concept as a whole. It is most likely for these reasons, that a high proportion of respondents from these countries attributed EFA projects as a major reason for the rise of the concept within water management (see Figure 5.9). EFAs and the extent to which they have been undertaken will be discussed in further detail in the next section.

Other countries, particularly developing countries, have had comparatively little experience in EFA projects. However, due to government initiatives, resources and expertise provided from outside sources and collaborative research efforts, projects in many river basins are underway. In many cases, the introduction of the concept into new regions and countries has been the result of input from external agencies and experts as well as collaborative research projects (King, Tharme & Brown 1999). The introduction of EFA projects in developing countries is evidenced by the results shown for India and Sri Lanka in Figure 5.9. As the views of the respondents indicate, Environmental Flow Assessment projects have played a crucial role in the establishment and expansion of the concept worldwide. As the science of environmental flow assessment continues to develop, the availability of adequate resources and expertise to undertake assessments is a limiting factor, particularly in areas where people are unaware or unconvinced of the concept.
The recognition of the importance of environmental flows to local livelihoods was accredited with the establishment of the concept in many areas. This finding illustrates the growing recognition of the link between sustaining and restoring ecological systems and livelihood security. The link appears to be strongest in the poorest communities in developing countries, who often rely on the goods and services provided by river ecosystems for subsistence farming and fishing. The importance of environmental flows to livelihood security is increasingly being emphasised as part of the promotion of the concept within water management and development. Highlighting the benefits of environmental flows to local communities and the consequences if environmental flows are not considered comprise a powerful message when establishing the concept in new areas.

Forty-two respondents attributed a “triggering event” as the catalyst for the establishment of the concept in their region (Figure 5.8). Further information as to the nature of the triggering event was not required in the survey; however, many respondents included details of the events. Examples of triggering events included:

- successive drought years and acute water shortages,
- aquatic species, including economically valuable species, being threatened with extinction,
- water pollution events and salinity problems, and
- river dessication from the over-allocation of water resources.

The Murray-Darling Basin in Australia was the setting for a triggering event that led to an increase in awareness in environmental flows and extensive water policy reform. Identified by several respondents in the survey, the 1991 occurrence of the world’s longest continuous blue-green algae bloom along the Darling River flagged to many in the community the degraded state of the freshwater systems within Australia (Blanch 2002). The plight of the Murray-Darling has seen a large public awareness campaign undertaken in the region. This culminated in a 2000, when a marathon swimmer, Tammy van Wisse set out to swim the entire 2,440 kilometers of the Murray River to bring attention to the degradation of the most important river system in Australia (Fullerton 2001). Indeed, this may also be an example of an individual that helped to plant the concept of environmental flows firmly on the public agenda.

Even though strong lobbyist groups and individuals, triggering events and the need for long-term water supply and recreation were chosen by a smaller proportion of the respondents in Question 8, these factors remain important factors in the establishment of the concept around the world. This also applies to the list of alternative reasons provided by respondents for how the concept was established in their region. These alternatives included:

- The introduction of national water resource legislation and strategies that incorporate the concept of environmental flows at some level (eg. South Africa, USA, Spain, Australia, Italy, Brazil);
- The injection of international knowledge and resources, and global discussions and forums on the concept (related to EFA projects and expertise option); and
- The recognition from the scientific community and the general public of the need to protect water resources and riverine and wetland ecosystems.
5.4 Environmental Flow Assessments

Following establishment of the environmental flows concept within an area the translation of the concept into practice forms the second step. The extent to which the concept of environmental flows has been translated into practice comprised a major part of the questionnaire. Environmental Flow Assessments (EFAs) represent the environmental flows concept being put into practice. It is often applied in connection with a proposed water development, and is used to assess how much water can be abstracted from a river before unacceptable degradation occurs. EFAs are also used in river rehabilitation projects for assessing how much of the original flows should be reinstated to rehabilitate the ecosystem to some required condition (King, Tharme & Brown 1999).

As seen in the previous section, the initiation of EFAs represented a common reason for why the concept was established, highlighting the importance of these projects and initiatives in the emergence and growth of the concept. Question 10 of the survey asked the respondents whether an EFA had been undertaken within their region, and Question 11 focussed on the completed actions following the recommendations put forward in the EFA. The results from Question 10 of the survey indicated that just under half of the respondents replied that an EFA had been conducted within their respective areas, which is consistent with the results from the first question related to the extent of concept application. Of this subgroup, approximately 55% indicated that initial EFAs had been undertaken and the remaining 45% indicated that extensive EFAs had been undertaken. A total of 42 countries were represented and over half were developing countries.

The percentage of respondents who were not sure whether EFAs had been undertaken in their area exceeded 25%, which may indicate the limited exposure of these types of projects within particular regions. Whether this means that more effort is needed to raise the awareness among people in the water resource sector of environmental flow related projects is a potential area for more focus.

In terms of follow-up actions to meet the recommendations put forward in an Environmental Flow Assessment, Figure 5.8 shows that over half of respondents indicated that some of the follow-up actions had been completed and almost 30% indicated that all actions had been completed. The issue of implementation of EFAs is one that has attracted considerable attention from people involved in water management and is a cause for concern according to many of the respondents to the questionnaire (see Section 6). Implementation of EFAs can be costly and requires considerable expertise, adequate institutional and legal arrangements, and effective stakeholder participation. In addition, the complex nature of flows and the inherent uncertainties of this field of science require resource intensive monitoring programs and a long period of fine-tuning the flows to ensure that the objectives are met.
5.5 Methodologies used

Considerable research has been undertaken regarding methodologies that have been adopted for environmental flow assessments around the world (Tharme 2003; King, Tharme & Brown 1999; King & Brown 2003; Dyson, Bergkamp & Scanlon 2003; Hirji & Panella 2003). The purpose of this survey was to add to the databases already established for summarising the types and extent of methodologies. Therefore, the results shown here will be limited to the types and extent of the methodologies referred to by the respondents. For further information regarding methodologies it is recommended to refer to the above studies. Hirji and Panella (2003) stated that the science of environmental flow assessment (EFA) is still a young discipline without uniform agreement on approach, methods or criteria. The results in Figure 5.9 tend to support Hirji and Panella’s statement, by illustrating the extent to which the different methodologies are being used in the areas represented in the survey.

Many respondents indicated that multiple methodologies were in use in their respective areas, reflecting the evolving and experimental nature of EFA methodologies. The extent to which the different methodologies were adopted depends on many issues, including how the concept was established, from where expertise and technical support originated, the amount of resources available and the type of water resource project involved.

The most common methodology used in the respondents’ areas was hydrological methods using desk-top analysis. Hydrological methods, using both look-up tables and desk-top analysis, represent the simplest methodologies and rely primarily on hydrological data for making flow recommendations (Tharme 2003). Hydrological methodologies are considered to be the most appropriate at the initial planning stages of water resource development and in low controversy situations due to the ability to make flow estimates rapidly and using limited resources. Hydraulic rating methodologies were the least common methodology used according to the respondents. This type of methodology was based on the relationship between hydraulic variables, such as wetted perimeter or maximum depth of a river, and...
habitat factors related to specific target species. Hydrological and hydraulic rating methodologies are considered the precursors to the more sophisticated habitat simulation methods, which incorporated modelling programs based on hydrological, hydraulic and biological variables (Tharme 2003). As Figure 5.9 shows, approximately 70 respondents indicated that habitat simulation methods were in use in their area.

The final type of methodology, holistic methods, accounted for the second most responses in the survey. This type of methodology is based on an ecosystem approach to river management and in recent years has received considerable attention, particularly in South Africa and Australia. The high number of survey responses from these two countries (refer to Figure 3.4) most likely accounts for the high proportion of responses highlighting holistic methods. However, this should not discount the result, particularly as the 76 respondents represented 23 countries where this type of methodology was being applied (Table 5.3). As Tharme (2003, p402) indicated, the holistic approach to river management “has been heralded as one of the chief directions of evolution of the [EFA] science.”

Table 5-3 Countries represented in the survey as using holistic methodologies for environmental flow assessment.

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Figure 5-9 Relative distribution of the methodologies used by the respondents
6 Challenges and opportunities for environmental flows

This section attempts to look at the future of environmental flows through the eyes of the survey respondents. Focus will be given to several key issues that emerged from the responses to the survey: the perceived level of importance of the concept in water management; the major difficulties and obstacles for further understanding and implementation; common fears and concerns related to the concept; 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. Each section below begins with a relevant quote from the respondents to the survey.

6.1 How necessary is the environmental flows concept in water management and policy?

The environmental flow concept is at the core of all water management strategies.\(^2\)

The literature related to environmental flows often emphasises the fundamental need to consider and integrate the principle of environmental flows into water management. For example, in the IUCN publication “Flow: The essentials of environmental flows,” Dyson, Bergkamp and Scanlon (2003, p3) declare that “the absence of environmental flows puts at risk the very existence of ecosystems, people and economies” and “the question is…not whether environmental flows can be afforded, but whether and for how long a society can afford not to provide environmental flows.” Does this standpoint coincide with the opinions of people representing a diversity of water-related fields?

Question 25 in the survey looked at whether the respondents thought that environmental flows were a necessary part of the efforts to solve problems related to water scarcity. As Figure 6.1 shows, a large majority (88%) of the respondents agreed that the concept was necessary. Despite the range of interpretations and terminologies used and the different degrees of application, there was widespread recognition that the concept formed an essential part of water management. Although those in support of the concept were more likely to respond to a survey of this kind, it cannot take away from the fact that a considerable majority of respondents felt that the concept plays a crucial role.

Further demonstrating this view of the concept, many respondents included additional comments at the end of the survey in which they underlined the vital role of environmental flows within the broader picture of water, food and livelihood security. Several comments drew attention to the link between environmental flows, Integrated Water Resource Management and the goals of sustainable development. For example, one respondent identified the critical role of environmental flows in fostering the transition to “systems thinking” on the public and political agendas. This “systems thinking” was mentioned as key to the success of Integrated Water Resource Management and the ultimate efforts to achieve the United Nations Millennium Development Goals and an environmental sustainable society.

\(^2\) Quote from respondent number 44
"Estimation and implementation of environmental flows is a necessary part of the efforts to solve problems related to water scarcity."

The connections between environmental flows, water resource policy and the larger issue of Integrated Water Resource Management (IWRM) formed a key focus of the questionnaire. Several questions dealt with how the concept of environmental flows was being translated into water policy and legislation. In addition, many respondents flagged the issue of policy integration as a crucial step in the advancement of the concept and expressed the need for clear guidelines for how environmental flows were to be combined with sustainable development and Integrated Water Resource Management (IWRM).

The extent to which the provision of environmental water requirements was being incorporated into IWRM was covered in Questions 17 and 18. Firstly, Question 17 measured the extent to which IWRM and Water Efficiency Plans were being developed in line with the recommendations put forward at the World Summit on Sustainable Development in Johannesburg in 2002. Just under 60% of respondents were aware that IWRM and Water Efficiency Plans were being progress at some rate in their country. Within this subset of respondents, 10% of respondents indicated that there was no mention of environmental flows within IWRM plans or policies. Around 35% of respondents stated that environmental flows was referred to sparingly and almost 40% said that the concept was explicitly stated and taken into account in IWRM. Although many respondents were unaware of the progress of IWRM in their country, the finding that environmental flows was being integrated at some level as part of IWRM should indicate that it is possible and advancing in some areas. Effort should be given to sharing the experiences and knowledge behind the integration of the concept into water policy and management.

Although integration was occurring between the flows concept and IWRM, the results of the survey also revealed a level of uncertainty on behalf of the respondents regarding IWRM. Some individuals specified the need for hands-on practical guides for implementing IWRM and also for incorporating environmental flows. Others stated that existing practices of IWRM did not acknowledge the importance of the flow regime within the decision-making framework. The issue of IWRM and its application was clearly demonstrated through the questionnaire as an issue that needs considerable attention in many areas around the world.
6.2 Major obstacles for further understanding and implementation of the concept

Environmental degradation of water resources continues due to limited awareness and capacity, population growth, and lack of funds.3

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 to…

Related to the question that dealt with why the concept was not applied in certain regions, a second 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. In addition to the set questions within the survey, a significant number of respondents 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 6.4 presents the results of the question aimed at identifying the major difficulties and obstacles for the concept. Despite the request to limit the choice to the three most critical difficulties, many respondents provided more than three answers, with several ticking all available options. While this affects the results to a certain degree, it does highlight the fact that a number of respondents considered a range of issues as critically important in their area in terms of environmental flows. 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.

Tables 6.1 and 6.2 identify the three most critical difficulties according to region and organisational type. The need for an understanding of the socio-economic costs and benefits associated with environmental flows was identified across all regions and in four out of the five organisational types. In addition, political will was identified in five out of the six regions and four out of five organisational types as a critical problem in the advancement of the concept. Other obstacles that were commonly identified by the respondents included legal, institutional and monitoring arrangement, effective stakeholder involvement and expertise and technical support. For the remainder of this section, focus will be given to the most pressing difficulties as identified in the figure and tables below.

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. There are examples of improved ecosystem health following the implementation of an environmental flow program (King, Tharme and Brown 1999). The holistic approach to environmental flow assessment has started to integrate the social and economic implications of different environmental flow scenarios and 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

3 Quote from respondent 134
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.

Figure 6-2 The distribution of responses for the major difficulties and obstacles in understanding and implementation of the environmental flows concept within the respondents’ areas.

Table 6-1 Three most critical difficulties according to the six major world regions.

<table>
<thead>
<tr>
<th>Oceania</th>
<th>North America</th>
<th>Latin America and Caribbean</th>
<th>Asia</th>
<th>Africa</th>
<th>Europe and the Middle East</th>
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</thead>
<tbody>
<tr>
<td><strong>Understanding of costs and benefits</strong></td>
<td>Political will</td>
<td>Understanding of costs and benefits</td>
<td>Political will</td>
<td>Understanding of costs and benefits</td>
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<td><strong>Effective stakeholder involvement</strong></td>
<td>Legal, institutional and monitoring</td>
<td>Political will</td>
<td>Understanding of costs and benefits</td>
<td>Legal, Institutional and monitoring</td>
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<tr>
<td><strong>Political will</strong></td>
<td>Understanding of costs and benefits</td>
<td>Effective stakeholder involvement</td>
<td>Legal, Institutional and monitoring</td>
<td>Expertise and technical support</td>
<td>Financial resources</td>
</tr>
</tbody>
</table>

Table 6-2 Three most critical difficulties according to organisational type.

<table>
<thead>
<tr>
<th>Government agency</th>
<th>Private Sector</th>
<th>Intergovernmental agency</th>
<th>NGO/Civil Society/Professional</th>
<th>Scientific/Research/Academic</th>
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</thead>
<tbody>
<tr>
<td>Understanding of costs and benefits</td>
<td>Political will</td>
<td>Legal, Institutional and monitoring</td>
<td>Political will</td>
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<td>Political will</td>
<td>Financial resources</td>
<td>Effective stakeholder involvement</td>
<td>Understanding of costs and benefits</td>
<td>Political will</td>
</tr>
<tr>
<td>Legal, Institutional and monitoring</td>
<td>Understanding of costs and benefits</td>
<td>Expertise and technical support</td>
<td>Expertise and technical support</td>
<td>Expertise and technical support</td>
</tr>
</tbody>
</table>
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 environmental flows was one of the most common obstacles highlighted in the survey. As the results in Table 6.1 showed, the problem of political will was not restricted to particular areas, but was equally identified 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.

A lack of political and legislative pressure has been cited in other studies as a major reason why environmental flows fail to be implemented throughout the world (Brown and King 2003; Arthington et al. 2004). To remedy this problem, Brown and King (2003, p26) list a number of desirable features related to political will and legislation that are likely to lead to successful implementation of flows. These features include:

- Recognition of the tangible and intangible costs of degraded rivers;
- Supporting legislation to empower water managers to manage river flows according to recommendations;
- Necessary tools to implement and enforce legislation;
- Ethical, moral and other intangible considerations form important inputs into the final decision making process; and
- Commitment of politicians, developers and water resource managers to adhere to agreed-upon environmental flow objectives.

Appendix C lists additional challenges, obstacles and difficulties identified by respondents to the survey. Many of these are related to the ones listed in Figure 6.2 above; however, many are also unique to the areas represented by the respondents.
6.3 Common concerns regarding environmental flows

Policy making is easy, but personal sacrifice in the face of water scarcity is difficult.¹

The above quote was included within one of the submitted responses and it captures a common concern regarding the environmental flows concept. The concern was that water allocated to meet environmental needs implies that the amount of water available for human needs is less, thereby increasing competition as well as the propensity for conflict. The threat of conflict and disputes over water was a cause of great concern to many respondents of the survey. 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 livelihood? These types of questions are at the heart of the water for food and water for nature dilemma discussed in the opening section of this study. They are also related to what many respondents saw as one of the biggest roadblocks for further 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 is particularly the case for water scarce regions and those respondents representing river basins where water stress is already high (see Table 3.1). 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 6.3 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 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.

¹ Quote from respondent 23
Estimation and implementation of environmental flows will be a cause of further problems and conflicts in dealing with water scarcity.

Two diverging views emerged in the survey in regards to the applicability of the concept in water scarce countries in developing regions. Initially, the diverging views were highlighted when the respondents were asked how closely they agreed with the statement: estimation and implementation of environmental flows are only applicable in basins or regions where there is a surplus of water. Figure 6.4 indicates that while a majority disagreed, the proportion of people agreeing with the statement was noticeable. Furthermore, it was found that 75% of people agreeing represented developing countries.

The diverging views were also highlighted in additional comments provided by many of the respondents. Several respondents stated that the application of environmental flows was simply not possible within their area due to water scarcity. The increasing demands for water to firstly meet basic human needs then to meet the consumptive water needs of irrigation and other sectors meant that little or no water could be reserved for the environment. This relates to the example in Walawe Catchment in Sri Lanka (Box 3) and the basic dilemma of water for food and water for nature described in the opening section. Although the concept was considered important, it was simply not possible to implement according to these respondents, due to the priorities of meeting basic human needs and achieving food self-sufficiency.

A number of respondents opposed this view by stating that the flow concept was especially crucial in water scarce environments, particularly in developing countries. The rationale was that water scarce areas were often subject to the highest variability in rainfall and river flows, and that the terrestrial and aquatic environments in these areas were especially vulnerable to any changes in the natural hydrological patterns. Environmental flows often have close links to the livelihoods of the poorest communities in developing countries, who often depend directly and indirectly on the ecological goods and services provided by rivers. Examples of services crucial to the livelihoods and well-being of these communities include flood recession agriculture, small-scale irrigation and subsistence level fishing. The poorest communities in many countries often inhabit the vulnerable fringe areas, such as floodplains and degraded watersheds, and the needs of these communities are often excluded from water management and development decisions. As Hirji and Panella (2003, p668) state,
“understanding the biophysical, social and economic linkages is critical to addressing the environment, water, and poverty nexus.”

In relation to Figure 6.4 below and the corresponding question in the survey, it should be noted that several respondents called attention to the issue of “surplus water.” They mentioned that surplus water only applies when discussing the human uses of water. Surplus water for the environment is not applicable. If there is more water available when human uses have been taken into account, this only means that there may be a high flow period that occurs as a natural part of the flow regime or that the region has a high average rainfall. These high flows serve important ecological functions for river and floodplain ecosystems, with many plants and animals dependent on high flows and flood events as part of their lifecycles.

![Figure 6-4 Distribution of responses indicating level of agreement with the given statement: Environmental flows are only applicable in areas with surplus water.](image)

A final concern that should be noted was raised by several respondents. The concern was that environmental flows form only one part of overall water management and allocation and that solely concentrating on environmental flows would not ensure the health of river ecosystems. Taking into account the natural variability of flows and allocating sufficient quantities of water to the environment needs to be jointly considered with other mitigation measures, such as water quality, to ensure the health of rivers is maintained or restored (Brown and King 2003). To be most effective, Dyson, Bergkamp and Scanlon (2003) stress that environmental flows must be seen within the context of IWRM and the broader package of mitigation measures, such as soil protection, pollution prevention, and protection and restoration of habitats. They continue by saying “the provision of environmental flows should be supported by a comprehensive package of basin-wide management practices and regulations, for example related to land-use, water rights and in-stream uses” (Dyson et al. 2003, p7).
6.4 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.\(^5\)

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 respondents to the survey was a promising sign. In line with the recognition highlighted in Section 6.1 of the concept playing an important role in water management, almost all respondents indicated that they would support the establishment or continued expansion of the concept within their areas. The respondents who indicated that they fully support the concept approached 80%, while 17% suggested that they would support the concept on a limited basis. This support also extended to the general public and media according to almost 70% the respondents, even though public acceptance of the concept was identified as a major obstacle (Figure 6.2).

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 who will be affected by water management decisions, including upstream and downstream users and countries, was identified as essential for effective dialogues 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 (Figure 6.2). Many of the people who answered the survey represented scientific organisations and were actively involved in research projects associated with environmental flows. Many other respondents expressed interest in developing the concept, but were unable to 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.

Work undertaken in Australia and South Africa provides two examples of water scarce regions where extensive assessment of environmental flows has occurred. Important lessons learned in these two countries can be transferred to those regions where environmental flows are yet to be established or are emerging. Although assessment has been extensive in these countries, the actual implementation and follow-up to the assessment has been limited. Furthermore, as identified by one respondent, there is a need for robust scientific methods and tools to be developed for water managers, so that in the event that conflict arises, water managers and the methods they use are able to withstand potential rigorous cross-examination. “Exchange of information and experience is key” according to one respondent.

\(^5\) 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 and 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, each country’s situation is different and the development of a single simple technique for rapidly 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.

A final opportunity that was identified in the survey concerned the efforts to improve water productivity in all water-related sectors. Although this opportunity was identified by a very small number of respondents, it has great potential in improving the ability to make tradeoffs between the human consumptive uses of water and the environmental needs of riverine ecosystems. It also has the potential to alleviate the possibility of conflict over water resources. Molden et al. (2001) state that increasing the productivity of water, particularly within the irrigation agricultural sector, is essential for food and environmental security. The rationale behind water productivity is that by producing more food with less water, the water that is saved will be available to meet environmental needs.
7 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.6

This study looked primarily at how people perceived the concept of environmental flows. The results of the survey clearly demonstrated 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 alone.

It is hoped that by identifying the people interested in environmental flows, the process for bringing these people together in a constructive dialogue will be set in motion. Almost 95% of the respondents to the survey indicated that they would like to receive the results of the study and more information related to the concept. The 272 respondents included in this study now comprise a database for which relevant and up-to-date information can be distributed and further contacts established, if needed. A common request expressed by people in the survey was identifying who and how to contact for further information on the concept. The establishment of a global network on environmental flows may allow open sharing of information, knowledge, experience and references between countries and organisations.

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 then be legitimately recognised and addressed within water management (Baron et al. 2002). Environmental flows allow the ecological requirements of rivers 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 river 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.

Even though the survey indicated a high level of interest and the concept is considered a necessary component of water resource management, the allocation of water for environmental purposes remains a low priority in most countries and degradation of freshwater ecosystems continues to occur (Smakhtin et al. 2004). It seems that there is an imbalance between the flows deemed most valuable economically, the flows most socially acceptable and the flows needed to maintain the environment. Clear recognition and understanding of the tradeoffs between “economic flows”, “social flows” and “environmental flows” are essential for the movement towards “sustainable flows.”

6 Modified quote from respondent 268
8 References

Appendices
## Appendix A: Countries and regions represented in the survey

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Freq.</th>
<th>Region</th>
<th>Country</th>
<th>Freq.</th>
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<td><strong>Europe and the Middle East</strong></td>
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Appendix B: Environmental Flows Questionnaire

Instructions:
1. Save the questionnaire file to your computer and fill out.
2. Send the completed questionnaire as an attachment to environmentalflows@siwi.org

First, please provide the following information on your background:

Title (i.e. Dr., Prof., etc.): ________________

First name: ____________________________

Last name: ____________________________

Gender: [ ] Female [ ] Male

Company/Organisation: ____________________________

  Government Agency [ ]
  Private Sector [ ]
  Intergovernmental Agency [ ]
  NGO/Civil Society/Professional [ ]
  Scientific/Research/Academic [ ]
  Media [ ]

Your title at Company/Organisation: ____________________________

River Basin: ____________________________

Mailing Address: ____________________________

Age: ____________________________

Email: ____________________________

General Field(s) of interest: ____________________________

To select your option(s) in the multiple-choice questions, please write an “x” in the box to the left of your choice(s), as follows: [ x ]

Start here

1. Do you consider the concept of environmental flows useful in your country or basin?

   [ ] No, I do not consider the concept of environmental flows useful
   [ ] Yes, I do consider it useful, but it is not applied in my country or basin
   [ ] Yes, I do consider it useful and it is currently applied in my country or basin – skip to Question 6 on page 3
Section 1: Environmental flows concept not applied in your region or basin

2. Why is the concept of environmental flows not used in your region? (please choose one of the following options)
   - [ ] Not aware of the concept
   - [ ] Concept is considered too abstract or theoretical
   - [ ] Concept is not able to be applied due to water shortages
   - [ ] Concept is not able to be applied due to a lack of policy guidance or management capacity
   - [ ] Other reasons, please explain in the space below:

3. Protection of the environment is an increasingly common concern in areas such as water resource management. What is your interpretation of the notion of “the environment”?
   - [ ] The natural ecosystem comprised of living organisms and the physical landscape
   - [ ] Human health
   - [ ] The productive capacity of the land to provide food and other resources for human use
   - [ ] Other, please explain:

4. Given that the environmental flows concept is not recognised or used in your region, do you still consider environmental considerations are addressed in your region in relation to water management?
   - [ ] No environmental considerations are made
   - [ ] Environmental considerations are made only a limited basis
   - [ ] Environmental considerations share the same priority as other issues
   - [ ] Environmental considerations are of the highest priority

5. Which of the following issues are currently considered as part of water management decisions in your region? (you may select more than one option)
   - [ ] Sewage treatment
   - [ ] Industrial wastewater treatment
   - [ ] Efficient water use practices and technologies
   - [ ] Optimal fertiliser and pesticide use in agriculture
   - [ ] Wetland construction for nutrient runoff
   - [ ] Preservation of natural vegetation
   - [ ] Soil conservation measures
   - [ ] Other, please specify:

Continue to the next sections (Sections 2 and 3) and answer those questions that you think are relevant and/or applicable to your region or basin. Please be sure to answer all questions in the final Section 4.
Appendix B

Section 2: Concept definition and interpretation

6. What is the terminology most commonly used to define the concept within your region? (you may select more than one option)
   
   [ ] Environmental flow
   [ ] Ecological reserve
   [ ] Environmental water allocation
   [ ] Environmental demand
   [ ] In-stream flow requirements
   [ ] Natural flow regime
   [ ] Compensation flow
   [ ] Minimum flow
   [ ] Surplus water
   [ ] Other, please specify in space below:

7. Which of the following aspects does your interpretation of environmental flows include? (you may select more than one option)
   
   [ ] Quantity of water flows, i.e. flow magnitude
   [ ] Flow frequency
   [ ] Flow duration
   [ ] Timing of flows, e.g. annual and seasonal patterns
   [ ] Rate of change of flows
   [ ] Water quality
   [ ] Floodplain interactions
   [ ] Estuarine and coastal zone aspects
   [ ] Groundwater interactions
   [ ] River geomorphology
   [ ] Environmental flow objectives
   [ ] Social aspects
   [ ] Other, please specify:

8. How was the concept of environmental flows established in your region? (you may select more than one option)
   
   [ ] From a “triggering” event, such as an environmental incident
   [ ] From gradually increasing public awareness of environmental concerns
   [ ] From strong lobbyist groups or individuals
   [ ] From Environmental Flow Assessment projects and expertise funded by government or outside sources
   [ ] From the recognition of the importance of environmental flows to local livelihoods (e.g. fisheries, floodplain agriculture)
   [ ] From the increased needs of recreation
   [ ] From the need for long-term water supply
   [ ] Other, please explain:
Appendix B

Section 3: Translation into policy and practice

9. For the development and implementation of environmental flows in your region, which of the following views do / would you take?

[ ] The environment has first priority over all other uses
[ ] The environmental needs must be balanced with other societal and economic uses and therefore allowing trade-offs among economic, social and environmental objectives
[ ] The environmental needs are the lowest priority and should receive the left-over water following allocations for human use
[ ] Other, please explain:

10. Has an Environmental Flow Assessment (EFA) been undertaken in your region?

[ ] No – skip to Question 12
[ ] Unsure – skip to Question 12
[ ] Yes, initial EFAs have been undertaken
[ ] Yes, EFAs have been undertaken extensively

11. If an Environmental Flow Assessment has been conducted, what follow-up actions have been taken?

[ ] None to date
[ ] Addressed some EFA recommendations
[ ] Addressed all EFA recommendations
[ ] Addressed all EFA recommendations and established monitoring programs
[ ] Addressed all EFA recommendations and expanded the use of EFAs to other regions
[ ] Other, please explain:

12. To what level are environmental flows incorporated into local, regional or national policies and plans?

[ ] Unsure
[ ] Only discussed at a general level and not practiced
[ ] No mention in policies or plans, but being applied in specific river basins
[ ] Implemented in water management on a project level, e.g. dam operations
[ ] Currently being drafted into policies and plans
[ ] Explicitly stated in policies and plans as a requirement in water management decisions
[ ] Other, please explain:

13. Does a gap currently exist between policy and practice in terms of implementation of the concept?

[ ] No
[ ] Yes
[ ] Unsure
14. How does the current system of water rights/allocations affect the identification, assessment and application of environmental flows?

- [ ] No impact
- [ ] Water rights/allocations will stand as they are
- [ ] Water rights/allocations will need to be re-negotiated
- [ ] Other, please explain:

15. The following categories are used to group the different methodologies for assessing environmental flow requirements. Which of the following categories contains the method(s) used in your region? (you may select more than one option)

- [ ] Unsure of the methodologies used
- [ ] Hydrological methods using look up tables
- [ ] Hydrological methods using desk top analysis
- [ ] Hydraulic rating methods
- [ ] Habitat simulation methods
- [ ] Holistic methods
- [ ] Other, please specify:

16. Are specific methodologies for environmental flows embedded in the law in your country?

- [ ] Unsure
- [ ] No
- [ ] Yes, please specify country and methodology:

17. In August 2002, the World Summit on Sustainable Development was held in Johannesburg, South Africa, where Heads of State, researchers and non-government organisations met. At this meeting it was decided that all countries develop Integrated Water Resource Management (IWRM) and Water Efficiency Plans by 2005. To what extent are these Plans being developed in your region? (For more information on IWRM or the Plans see the Report of the World Summit on Sustainable Development A/CONF.199/20 Paragraph 26, or visit [http://www.johannesburgsummit.org/](http://www.johannesburgsummit.org/))

- [ ] No knowledge of the IWRM and Water Efficiency Plans – skip to Question 19
- [ ] Very early stages of development
- [ ] Plans underway and progressing
- [ ] Latter stages and finalisation of development

18. To what extent does the IWRM and Water Efficiency Plans include environmental flows?

- [ ] No mention of environmental flows
- [ ] Environmental flows referred to sparingly
- [ ] Environmental flows explicitly stated and taken into account throughout plans
- [ ] Other, please explain:
Appendix B

19. Do you think that assigning an economic value to natural ecosystem goods and services (for example, a river’s natural flow regime providing fish habitat and breeding areas) would make the environmental flows concept easier to implement?

[ ] Yes
[ ] No
[ ] Unsure

20. Has an attempt been made to assign economic values to natural ecosystem goods and services within your region?

[ ] Yes
[ ] No
[ ] Unsure

Section 4: Conclusion – the future of environmental flows

21. What do you see as the major difficulties or obstacles in understanding and implementing the concept of environmental flows in your region? (you may select more than one option, but please limit to three most critical)

[ ] Understanding of socio-economic costs and benefits
[ ] Hydrological data
[ ] Capacity for modelling and scenario development
[ ] Effective stakeholder involvement
[ ] Legal, institutional and monitoring arrangements
[ ] Public acceptance
[ ] Expertise / technical support in understanding and implementing the concept
[ ] Political will
[ ] Financial resources
[ ] Other, please explain:

22. To what extent do / would you support the introduction and implementation of the environmental flows concept in your region?

[ ] Fully support
[ ] Support on a limited basis
[ ] No support
[ ] Unsure

23. What would you estimate the reaction of the general public and media to the idea of environmental flows?

[ ] Supportive
[ ] Critical
[ ] No reaction or interest

24. Do you think the government (local, regional or national) should pay more attention to environmental issues?

[ ] No
[ ] Yes
[ ] Unsure
25. To what extent do you agree with this statement: “Estimation and implementation of environmental flows is a necessary part of the efforts to solve problems related to water scarcity.”

[ ] Strongly agree
[ ] Somewhat agree
[ ] Neither agree or disagree
[ ] Somewhat disagree
[ ] Strongly disagree

26. To what extent do you agree with this statement: “Estimation and implementation of environmental flows is only applicable in basins or regions where there is a surplus of water.”

[ ] Strongly agree
[ ] Somewhat agree
[ ] Neither agree or disagree
[ ] Somewhat disagree
[ ] Strongly disagree

27. To what extent do you agree with this statement: “Estimation and implementation of environmental flows will be a cause of further problems and conflicts in dealing with water scarcity.”

[ ] Strongly agree
[ ] Somewhat agree
[ ] Neither agree or disagree
[ ] Somewhat disagree
[ ] Strongly disagree

28. Would you be interested in receiving the results of this study and further information about the environmental flows concept?

[ ] Yes
[ ] No

29. Additional comments regarding the environmental flows concept or environmental issues related to water management.

Thank you very much for your time and effort in completing this questionnaire – it is greatly appreciated! We hope to provide you with helpful information regarding environmental flows following the completion of the study.
Appendix C: Difficulties, obstacles and needs related to environmental flows

The following table lists the difficulties, obstacles and needs as identified by some of the respondents to the survey.

<table>
<thead>
<tr>
<th>Difficulty/Need</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing and implementing environmental flow regimes</td>
<td>Requires community and stakeholder involvement, community education and negotiations with the irrigation industry.</td>
</tr>
<tr>
<td>The combination of knowledge on environmental flows</td>
<td>Needed to connect these concepts to decision making and management.</td>
</tr>
<tr>
<td>I believe the issue is not about water scarcity</td>
<td>Not about how water is shared. Determining and allocating water for the environment is about changing the sharing of water from consumptive uses towards the environment.</td>
</tr>
<tr>
<td>To me, a key to implementation of environmental flows in developing countries</td>
<td>Lies in the assessment and management of actual trade-offs with other pressing priorities (food security, poverty alleviation, etc.).</td>
</tr>
<tr>
<td>Environmental flows is a very important concept for water management</td>
<td>Needs to be extended to all stakeholders of water management, include politicians, researchers and others.</td>
</tr>
<tr>
<td>Environmental flows are assessed in many countries</td>
<td>As part of the water allocation policy, but almost nowhere are the assessments implemented. Worldwide, there is a huge gap between the number of water resources for which env flows have been assessed, and those for which the flows are being provided. In South Africa, with some of the most advanced and comprehensive environmental water legislation in the world, there is an estimate of env flow requirements for every river in the country, but partial implementation has actually happened in only two or three rivers.</td>
</tr>
<tr>
<td>Open sharing of information, and trust among different agencies and institutions</td>
<td>Is a problem (especially in areas where large industries are located). And funding to sustain projects over time is an issue.</td>
</tr>
<tr>
<td>The obstacle is a cultural one of placing</td>
<td>Real value (not just an economic value, but a priority value that is rooted in ethics and spirituality/religion) on maintaining or restoring a healthy aquatic ecosystem. Without such a cultural value, the only argument can be based on economics, which may not be convincing enough to safeguard the river's health.</td>
</tr>
<tr>
<td>Without ongoing research into how flows drive ecological processes</td>
<td>The EFs concept and the EF methods will continue to depend on best guesses and advocacy.</td>
</tr>
<tr>
<td>The ability to determine flows is going to be problematical due to</td>
<td>Lack of finance is also a negative factor. There is just insufficient knowledge and expertise to drive the implementation of the concept.</td>
</tr>
<tr>
<td>Working as an environmental consultant I often need real &quot;hands-on&quot;</td>
<td>Description and tools.</td>
</tr>
<tr>
<td>We need help regarding the concept and methodologies for estimation of</td>
<td>Environmental flow. Armed with this information, I will then do an audit on that river and then march up to the Department Director with the results and say “Sir, here is the flow you asked for. As the river now is flowing below this level, please tell your guys to stop abstraction immediately!”</td>
</tr>
<tr>
<td>Scientists and engineers responsible for implementing environmental flows and</td>
<td>Environmental issues related to water management need to engage in public forums discussing these issues.</td>
</tr>
</tbody>
</table>
Appendix C

It is a complex concept that requires huge quantities of highly specific types of data and analyses, which are often lacking due to resource constraints or capacity constraints in many countries.

Three biggest challenges on environmental flow concept
1. Understanding of the concept and public acceptance
2. Development of tools for assessment of environmental flows. This include the analysis of benefits (quantification) from sustained environmental flows
3. Institutional and Legal frameworks support for applying appropriate the concept in water scarce river basins

Since ours is a very vast country having a wide biodiversity, the environment flow concept in this country cannot be explained and implemented in a single manner. In some places there is surplus of water and floods occurring in regular intervals, some states face drought almost every year, some states have precipitation over 3000mm etc etc. In such cases to have a national policy on environment flows needs deep consideration to evolve the general understanding of the concept and its requirements and benefits with respect to the geographical and climatic condition of the area.

For implementation of the environmental flow concept it would be very useful to have a model which would enable the determination of environmental flow on the basis of monitoring data and extrapolation for the sections between two monitoring stations

Assessment of Environmental flow is essential to deal with the co-riparians in the negotiation of transboundary river flows.

Appears to be difficult and expensive to implement and to effectively monitor environmental flows without substantial acceptance and voluntary compliance from all stakeholders. Will require long-term monitoring to ascertain whether allocated environmental flows are in fact, correct and to then to fine-tune these flows over time.

Political will and more public awareness will become a critical issue in the near future in order to implement environmental regulations to the full scale in this country

I think in developing countries now the urgent problem is the acquisition of the water related data and techniques in order to assess water problem at the national scale or regional scale

A lack of technical knowledge, political willpower and government capacity will ensure that through time the issue grows and becomes a regional problem with little hope of resolution

I am always surprised at the lack of mention of the field of environmental ethics in the context of discussing environmental flows. Yes, econvironmental economics offers an important and useful way of looking at environmental flows, but this is not the only perspective. Nor is it the most convincing perspective, because it is open to all the weaknesses of the assumptions that it is forced to make. Ethics, like economics, is a universal feature of human societies. It is even more fuzzy than economics, but it is equally pervasive as a motivator of human behavior. Bring in ethics and you will make a lot more progress with the concept of environmental flows. Leave it out, and you will be reinventing the old environment vs. development debates of the 1980s and 1990s.

Environmental flows are monopolized by environmental consultants for whatever purpose and this situation results in distrust from both political and technical people wanting development and infrastructure respectively.