

# Water ecosystem services and poverty under climate change

## Key issues and research priorities

James Mayers, Charles Batchelor, Ivan Bond, Rob Hope, Elaine Morrison and Breana Wheeler



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Report of a scoping exercise to help develop a research programme for the UK Department for International Development

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## Executive summary

Between October 2006 and July 2007 IIED steered a team that scoped a possible research programme for the UK Department for International Development (DFID) on freshwater ecosystem services and poverty reduction in the context of climate change and other drivers of change. The work identified key research areas and delivery mechanisms. It did this by: developing a drivers–state–impacts–response conceptual framework; seeking views from stakeholders internationally (334 web-survey respondents; 54 in-depth interviews); drawing key lessons from the literature; carrying out policy and practice analyses in key developing countries (Kenya, South Africa, India, Mexico and Bolivia); and capturing the results in this report to DFID.

The challenge addressed by this proposed research programme is a daunting one. Freshwater ecosystem services – the benefits obtained by people from freshwater ecosystems like rivers, swamps, floodplains and groundwater systems – are central to human well-being. But ecosystems are in trouble and the Millennium Ecosystem Assessment, the Comprehensive Assessment of Water Management in Agriculture, and the Intergovernmental Panel on Climate Change have each shown that freshwater ecosystem services are particularly vulnerable. Water problems for poor people are exacerbated by the abuse of ecosystem services and global climate change looks certain to increase the stresses and variability they face. The impacts will vary greatly by region, but the challenges to sustainable development in Africa are particularly acute.



Yet globally, we never destroy water – no matter how we use and abuse it: somewhere, sometime the rains will return. Water ecosystem services are the ultimate renewable resources and many promising solutions to the problems exist. The difficulty is in ensuring that water itself is where we need it, when we need it and of an acceptable quality. This requires efficient and equitable regimes for using the water that is available. In other words, it's all about how decisions are made about water ecosystem services – it's all about governance.

Water as a basic human right, and water left in stream to sustain environmental flows, are both necessary guiding principles yet characterise the tension at the heart of this subject. The adaptive capacity and resilience needed in the face of climate change and other further stressors to livelihoods, and the ever-increasing demand for water for food, fuel and forests, must be better understood and tackled. Key knowledge gaps can be filled by well-targeted research on how to secure regulatory and supporting services of ecosystems while doing most for poverty reduction.

Where river basins are 'closing' – with all water being used and residual flows reduced to a trickle – local conflicts and growing transboundary arguments demand more astute negotiating processes. Payments for water ecosystem

services are tools that need further sharpening to be useful here and in other contexts where buyers and sellers become clear. The scale and type of investment needed to secure water ecosystem services is not hopelessly unachievable, but greatly improved governance will be needed to make such investment work. Integrated water resource management incorporating the full range of water ecosystem services remains a fine ideal for governance, but an elusive reality. Yet efforts to achieve higher levels of integration are sensible and innovative forms of research and delivery have great scope to help.

## Recommendations on research content

Much existing research needs to be put into practice, and more research is needed to fill vital gaps. Indeed, perhaps perversely, one of the key functions for future research is to work out how to get past research into use. The following priority research issues are drawn from the evidence generated in this study and selected on the basis of the following criteria: researchable gap in knowledge; generic significance; innovation; integration potential; impact likelihood; and DFID comparative advantage. Research issues can be only roughly prioritised at this level because they are interconnected, and because the specific forms of the issues researched will have to be tailored and shaped by local circumstance. Some indication of relative priority of the issues in Africa, South Asia and Latin America is given in the report. Five research fields are proposed, all are important but they are in roughly descending order of priority. Within each field the issues are also of roughly descending order of priority:

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### 1 Governance of water ecosystem services

- Political economy of water ecosystem service management
- Integrated water resource management
- Managing/resolving competition, displacement and conflict
- Climate change as driver of decisions despite uncertainty
- Local institutional control of water ecosystem services

### 2 Variability, vulnerability, adaptation and resilience

- Resilience of water ecosystem services
- Responses to variability and risk
- Targeted and holistic adaptation
- Changes brought by disease burdens

### 3 Land use change impacts on water ecosystem services

- Urbanisation, migration and water ecosystem services under climate change
- Unrecognised consequences of climate change mitigation actions
- Land use impacts of market shifts
- Biofuel production – poverty and water ecosystem impacts
- Carbon storage and avoided deforestation – poverty and water ecosystem impacts

#### 4 Hydrology, technology and evaluation

- Tools for predicting hydrological and societal impacts of land use change
- Soil and water conservation decision-support tools
- Groundwater recharge and surface water–groundwater interactions
- Applying complementary knowledge systems
- Impact evaluation

#### 5 Market instruments, businesses and investment

- Informal markets and small businesses
- Prices, payment schemes and investment triggers in water ecosystem services
- Productivity–equity nexus
- From green accounting to green decision-making

### Recommendations on research delivery, and way forward for DFID

So how can research on these issues actually help? Too much research has focused on producing publications rather than actually helping policymakers and resource managers think through issues and make better decisions. Researchers often choose their topics without consulting the people they supposedly serve. These and other problems are well known, yet they persist. The analysis and recommendations in this report show that there is a better way.

DFID should consider structuring a research programme around the fields identified above, phasing in the issues identified over time according to the descending order in which they appear. Guidance for DFID in setting up this programme is provided in the report with the identification of the essential characteristics of effective research in these fields and on research programme management. These characteristics can be developed to guide potential programme applicants, who should be encouraged to design their research around some further desirable characteristics and key mechanisms also identified in the report.





Photo: Steve Anderson

The photo shows the very low, residual waters of Lake Chad in Niger territory at Malam Massari, a small fishermen's hamlet close to the border with Nigeria and Chad and the drowned trunks of the dead forest of *Prosopis africana*, a thorny tree that invaded the space between the islands when Lake Chad withdrew dramatically from the 1970s onwards. The low water levels mean that fishing is very poor at the moment. The withdrawal of Lake Chad is one of the most dramatic effects of climate change in Eastern Niger. The lake disappeared from Niger territory in 1975, and has reappeared irregularly since then. The effects of this on livelihoods are huge – some are positive (new spaces for pasture and agriculture) and some are negative (including loss of fishing and biodiversity).

## Introduction

The International Institute for Environment and Development (IIED) was asked by the UK government's Department for International Development (DFID) to develop ideas for a potential research programme on 'water ecosystem services and poverty reduction under climate change'. The study, carried out between October 2006 and July 2007, had two objectives:

- Identify the **key research areas and knowledge gaps** for improving the sustainability and equity of water provision and water ecosystem services management in the context of climate change in developing countries of Africa and Asia, and with reference to lessons from Latin America.
- Identify the **most effective means** by which research can contribute to achieving more sustainable and equitable water services and ecosystems management in these countries.

The remainder of this report presents the results. Section 2 summarises the approach taken, including identification of key issues, consultations, specialist inputs, country-specific studies and a workshop. Section 3 analyses the issues revealed during the study, using a drivers–state–impacts–response conceptual framework; examines the extent and use of existing knowledge, and gaps in knowledge, drawing on literature as well as activities conducted specifically for this study; and it looks at research organisation and delivery mechanisms. Sections 4 and 5 provide specific recommendations on research content, and on organisation and delivery. The report concludes with a proposed way forward for DFID.

In addition to this report, readers are encouraged to look at the annexes that are available online (see Appendix 1 for details) and examine the issues in much more detail than can be covered here.



## The approach

Terms of reference for the study formed the basis for a proposal from IIED, which was subsequently agreed with DFID, and which mapped out the approach. The approach had the following main elements:

- **Core team and specialist team** (specific shorter-term inputs) with experience in key subject areas: natural resource governance; analysis and support for improved livelihoods and reducing poverty; policy analysis; research-into-use approaches; surface and groundwater management and provision; water governance; integrated water resource management; payments and negotiation for watershed services; and climate change mitigation and adaptation.

### **Core team and expertise:**

- James Mayers – IIED. Project leader. Natural resources governance for livelihoods; coordinating lead author for Millennium Ecosystem Assessment; project management.
- Ivan Bond – IIED. Lead researcher. Payments for watershed services; environmental economics; community-based natural resource management.
- Elaine Morrison – IIED. Researcher. Asia water ecosystem services; research support; project administration.
- Breana Wheeler – IIED. Project assistant. Postgraduate research on markets for environmental services; database management and project administration.
- Rob Hope – Oxford University, School of Geography and the Environment, UK. Behavioural economics; human development; water policy.
- Charles Batchelor – Water Resources Management Ltd, UK. Water resources management; water governance; agricultural hydrology.

### **Specialist team and expertise:**

- Hannah Reid – IIED. Climate change impacts and adaptation; network and capacity building on climate change in developing countries; ecosystems research and policy analysis.
- Ashvin Gosain – Indian Institute of Technology, India. Policy, planning and practice in India; impact of climate change on water resources in India; modelling for integrated water resources management.
- Cynthia Awuor – African Centre for Technology Studies, Kenya. Policy, planning and practice in Kenya; climate change adaptation in Africa; socio-economic research.
- Gavin Quibell – Independent consultant, South Africa. Policy, planning and practice in South Africa, integrated water resources management; legal and social water issues.

- Nigel Asquith – Independent consultant, Bolivia. Water ecosystem services in Bolivia; environmental economics.
- Sofia Cortina – Ministry of Environment, Mexico. Environmental law; economic instruments in Mexico's environmental law; strategic planning, monitoring and evaluation of environmental management systems.
- Mike Mortimore – Drylands Research Ltd, UK. Management of water and other ecosystem services in drylands; climate change adaptation in drylands.
- Jeremy Evans – Greenfox consulting, UK. Social scientist with expertise in forest, water and natural resource management – carried out interviews.
- Tighe Geoghegan – Green Park Consultants, UK. Water ecosystem services in the Caribbean; water policy development.
- Aniol Esteban – New Economics Foundation, UK. Economics and development; climate change and carbon constraints; land use and agricultural change.

Inputs from the core team and the specialist team were supplemented by inputs from many other stakeholders, including policymakers and other end users, through the web survey and interview process described below. While resources did not allow for a second round of extensive consultation on the findings presented in this report, the authors continue to welcome reactions and responses such that the recommendations may be continually refined.

## 4

- **Learning from past DFID-supported work.** Key lessons from relevant past DFID-supported research initiatives were drawn on, notably those from: the Renewable Natural Resources Research Strategy and Engineering programme water theme, and their respective evaluations programmes; the OASIS resource centre's scoping study for possible DFID funding of research into water for development; the WELL resource centre for water, sanitation and environmental health; other research scoping processes such as on the Sustainable Agriculture Research Strategy, Climate Change Adaptation in Africa programme and current work on energy; and other Development Research Centre programmes.
- **Concerted exploration of the gaps and links.** The current level of integration of key research areas such as integrated water resource management, payments for watershed services and climate change was found to be weak. So particular efforts were made to unearth work that sheds light on these links, why there are gaps, and what opportunities/constraints exist for integration and improved policy.

### Seven main actions were undertaken:

#### A. Issues paper

The core team developed a short paper, describing the background and approach of the scoping study and setting out key issues and eight main questions about which views were sought. These eight main questions were:

1. **Water ecosystem services.** Which water ecosystem services need to be better understood in the context of poverty reduction and climate change?
2. **Poverty–water ecosystem direct links.** What are the research priorities in the direct links between poverty and water ecosystem services under climate change?
3. **Changes and transitions.** Which other changes affecting water ecosystem–poverty links will need to be better understood as the global climate continues to change?
4. **Technology.** What are the research priorities among the existing or promising technological solutions to water ecosystem service problems under climate change?
5. **Institutions and integration.** Which policy, legal, organisational and integrative approaches affecting water ecosystem services need to be better understood?
6. **Economic instruments.** What are the research priorities in enabling economic instruments to help tackle water ecosystem service problems under climate change?
7. **Research organisation.** Which are the key organisational characteristics of effective research and delivery on water ecosystem services and poverty reduction under climate change?
8. **Research and delivery mechanisms.** What research and delivery mechanisms will work best?

The issues paper also offered three annexes with methodologies for the consultations, country-level policy and practice analyses and literature review respectively. This issues paper was posted on the IIED website (Mayers 2007). The above eight main questions provided the framework for the web-based survey and interviews described below.

## B. Web-based survey

A web-survey instrument offered an efficient tool to collect data from a global sample of respondents. It was designed to collect responses in a closed question format for quantitative analysis. This approach permits a comparative understanding and measurement of research priorities. Under the above eight main headings, the study team agreed upon a list of 72 questions that reflected a range of issues under consideration. To elicit priorities, a Likert scale (here, 1 to 10) allowed respondents to determine their lowest priority (score = 1) to highest priority (score = 10). In addition, an open-ended text box was available for respondents to provide more detailed comments and observations. An introductory text laid out the scope and aims of the web survey, and provided links to the project website and issues paper. The survey was anonymous though respondents were obliged to complete a short set of profiling questions in order to allow disaggregation of the results. The survey was available in French and Spanish as well as English.

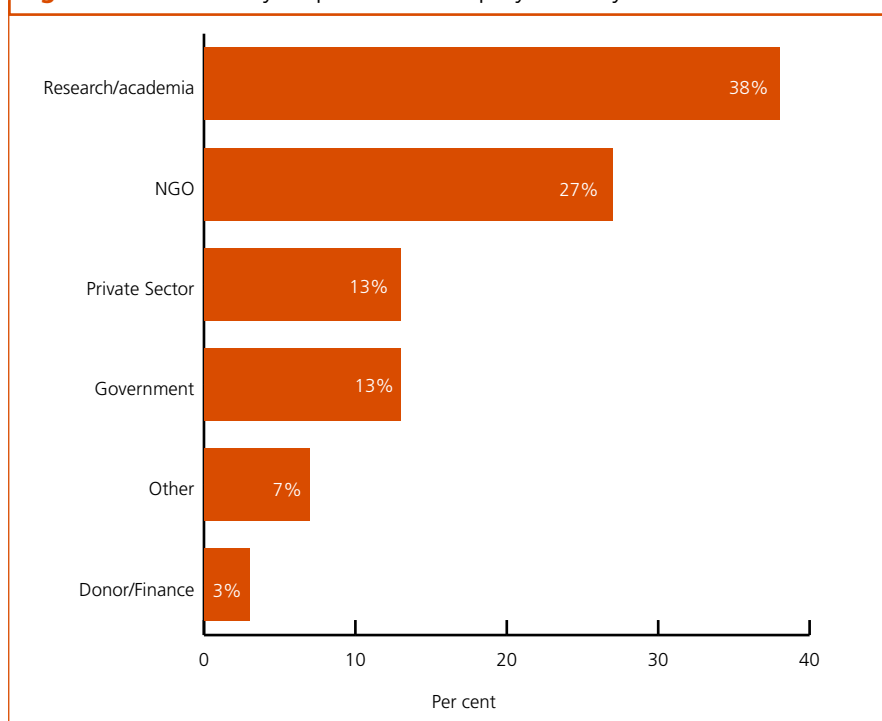
The project's website increased awareness of the study through a prominent banner on the front page of IIED's home page during the period that the web

survey was active. The study team also compiled a list of relevant contacts that were supplemented by institutional networks, e.g. IIED's database, Bradford University's Splash network. Stakeholders identified on the list were sent personal emails, where possible, or a generic message to a group. In some cases, stakeholders were introduced to the web survey in-person from opportunistic country visits. In addition, the web survey was promoted via requests made to web-based list-serves, for example:

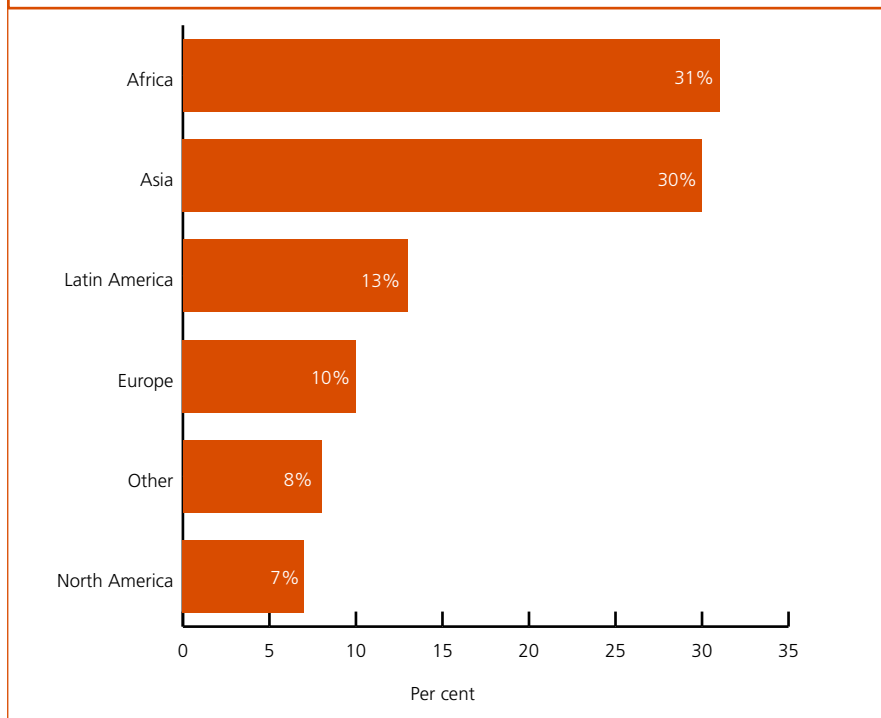
- International Institute for Sustainable Development (water and climate portals)
- UNESCO's water portal, the UN Water Newsletter and the FAO Land and Water newsletter
- WaterNet (Southern African water community)
- Water and Sanitation News Service (IRC-hosted);
- Decentralised Natural Resource Management discussion group (India-hosted)
- Flows – on payments for watershed services (IIED and World Bank)

Some 335 good analysable responses from 70 countries were received. Of these responses, the profile of the average respondent is of a man (63 per cent), over 40 years of age (50 per cent) with a post-graduate qualification (82 per cent), and over 10 years' relevant experience (42 per cent). Most respondents work as researchers while regional expertise is concentrated in Africa and Asia (Figures 1 and 2).

**Figure 1.** Web-survey respondents' employment by sector



**Figure 2.** Web-survey respondents' regional knowledge



Exploratory and multivariate data analysis was carried out on the web-survey results.<sup>1</sup>

### C. Interviews

The stakeholder list mentioned above was also used to identify a range of people with whom to conduct detailed interviews based on the main questions developed in the issues paper and listed above. The scope of this was international – key individuals and institutions in developing countries and in agencies in developed countries concerned with these issues. As with the web-based survey, particular effort was made to contact individuals who are well connected with issues at community level – ‘gatekeepers’ of local perspective. However, it should be recognised that this consultation was not conducted primarily with stakeholders at community level.

A particular emphasis was placed on African and Asian contexts, and on what can be learned and transferred from Latin American contexts. Brief initial messages and short exchanges were followed up where appropriate to press people for their views and as much focused information as possible. Some 54 interviews were carried out between February and April 2007 – 23 of these

1. A detailed report on the findings of the web survey is available on request from the authors.



by telephone and 31 in person (Table 1). Quotes used in text boxes in Section 3 of this report come from these interviews. (An analysis of the findings from interviews is available on request from the authors.)

<b>Table 1. Profile of interviewees</b>		
<b>Interviewees by region of expertise/interest</b>		
<b>Region</b>	<b>Percentage</b>	<b>Number</b>
Global	28%	15
Africa	11%	6
Latin America	26%	14
Asia	35%	19
<b>Total</b>	<b>100%</b>	<b>54</b>
<b>Interviewees by sector</b>		
<b>Sector</b>	<b>Percentage</b>	<b>Number</b>
Donor/Finance	22%	12
Government	26%	14
NGOs	17%	9
Private Sector	4%	2
Research/academia	31%	17
<b>Total</b>	<b>100%</b>	<b>54</b>

#### D. Literature assessment

An assessment of existing literature in relevant fields was conducted. These fields were divided into:

- **Water governance.** This focused on access to water, accountability, sector reform, economic and political change, participation and integrated water resource management.
- **Poverty implications of climate change impacts on water ecosystems.** This focused on water rights, strengthening adaptive capacity, water for food, managing water ecosystems, ecosystems as water infrastructure, investing in water, and water and growth.
- **Climate change, development and the water sector.** This briefly considered the results from a previous consultation on climate change adaptation (2005), and the major changes that have taken place since, in relation to water issues and water sector priorities.
- **Payments for watershed services.** This focused on the theory and current reality of payments for watershed services, on land use and hydrology, and on financing mechanisms.
- **Freshwater ecosystem services, climate change and poverty in the Sahel.** Concerted effort was made in this area because the new work by the

Intergovernmental Panel on Climate Change (IPCC) suggests it is one of the most vulnerable to climate variability and change due to multiple stresses and low adaptive capacity.

These assessments made particular efforts to access grey literature as well as web-based and published literature. Efforts were also made to uncover material that explores the links and integration among the above fields.

### **E. Policy and practice analysis: identifying influences on water delivery in key developing countries**

The aim of these analyses was to understand how, and to what extent, policy and planning related to water ecosystem services impact on practice, and to identify how research efforts might improve the situation in future. Analyses were carried out in India, South Africa, Kenya, Bolivia and Mexico.

Initial assessment suggested that much is already known about the immediate influences of policy and planning on water delivery. Much less is known or recognised about policy influences on the water and land use practices that ultimately affect the wider range of benefits to people from freshwater ecosystems. Thus the emphasis in these analyses was less on policy and planning influences on delivery of water, and more on their influence over on-the-ground practices that affect the quantity and quality of water available and poverty. The impact of climate change thinking and evidence on relevant policies and practices was also analysed. The analyses explored the relative impacts and relationships between different policies and planning priorities over time and place. Critically, they also explored the impact of research in these fields and concluded with assessment on where research is most needed and how its impact might be optimised.

The following six main steps were taken in each analysis:

1. 'Map' policies that affect the relationship between water ecosystem services and the poor
2. 'Overlay' the policy map with climate change
3. Assess the interests and effectiveness of the state in water ecosystem services
4. Assess the role and effectiveness of other parties in influencing policy that affects water ecosystem services
5. Forecast other changes
6. Highlight research priorities

'Policy' in this work was used as shorthand to mean the range of signals that stem from laws, regulations, policies, subsidies, incentives, institutional arrangements and major programmes and initiatives – primarily steered by government but not exclusively so (non-governmental and private sectors develop and use policies and institutions too). It was noted by these analyses that policy often sends very mixed and conflicting 'signals' yet their effectiveness, efficiency, equity and sustainability can, with some effort, be judged. It was also noted

that impacts of policy may be negative and positive, and act by compulsion, persuasion, incentive or the absence of all three – we are interested in policy in practice, not in theory.

The policy and practice analyses were each led by a key individual, who consulted available literature, his/her own knowledge and experience base and a modest number of key informants, before providing his/her own conclusions.

### **F. Workshop**

A workshop was held in London in April 2007 with a sub-set of those consulted, once preliminary findings had been generated. The objective was to share the results of the process to that point, to interrogate the preliminary findings and to identify issues that needed further examination or emphasis.

A good range of perspectives was brought together and a wealth of ideas and information was generated. Participants broadly endorsed the approach taken by the team and the validity of the major themes emerging from the work.<sup>2</sup>

### **G. Ways forward: identifying key research areas and approaches**

With the findings from the above tasks, the team debated and identified its recommendations for the key research areas and research-to-policy entry points for DFID-funded research on water ecosystem services and poverty reduction under climate change. These recommendations on key research priorities and delivery mechanisms are presented in Sections 4 and 5 below, following our analysis in Section 3 of the issues arising from consultation work, the literature review and the country policy and practice analyses.

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2. The workshop report is available online at [www.iied.org/pubs/display.php?o=G02513](http://www.iied.org/pubs/display.php?o=G02513)

## Analysis of issues

### 3.1 Conceptual framework

Fresh water is fundamental to life and contributes to all the major benefits provided to people, both directly and indirectly, from ecosystems. The Millennium Ecosystem Assessment, delivered in 2005, installs a wide definition of these 'ecosystem services':

- *Provisioning services* like food, fresh water and fibre
- *Regulating services* like climate and flood regulation
- *Supporting services* like soil formation and nutrient cycling
- *Cultural services* like spirituality, aesthetics, education and recreation

Fresh water is a provisioning service as it provides for human use of water for domestic use, irrigation, power generation and transportation. Fresh water and the hydrological cycle also sustain inland water ecosystems, including rivers, lakes and wetlands. These ecosystems provide cultural, regulating and supporting services that contribute directly and indirectly to human well-being through recreation, scenic values and maintenance of fisheries. Fresh water also plays a role in sustaining freshwater-dependent ecosystems such as mangroves, inter-tidal zones, and estuaries, which provide another set of services to local communities and tourists alike (see Table 2). The trade offs and balances between these different uses of fresh water – in the midst of increasing demand for all types of human benefit derived from fresh water – are, to say the least, major challenges.

Freshwater ecosystems include:

- Permanent and temporary rivers and streams
- Permanent lakes, reservoirs
- Seasonal lakes, marshes and swamps, including floodplains
- Forested, alpine and tundra wetlands
- Springs and oases
- Groundwater systems and geothermal wetlands

In addition to the climate regulating services provided by water bodies – sequestering and releasing a major proportion of fixed carbon in the biosphere – some water ecosystems, such as mangroves and floodplains, can play a key role in the physical buffering of climate change impacts.

**Poverty** is multi-dimensional state of deprivation, of which lack of access to adequate water of safe quality is a key characteristic. More water *per se* is unlikely to reduce poverty unless complementary improvements in, for example, health, education, infrastructure and employment are also made. Water poverty is not limited to access to water for basic needs alone. Improved access to productive uses of water is also a key determinant in lifting the poor out of poverty.

**Table 2.** Ecosystem services provided by fresh water and the hydrological cycle

Provisioning services	Regulatory services	Cultural services
<ul style="list-style-type: none"> <li>■ Water quantity and quality for consumptive use (for drinking, domestic use, and agriculture and industrial use)</li> <li>■ Water for non-consumptive use (for generating power and transport/navigation)</li> <li>■ Aquatic organisms for food and medicines</li> </ul>	<ul style="list-style-type: none"> <li>■ Maintenance of water quality (natural filtration and water treatment)</li> <li>■ Buffering of flood flows, erosion control through water–land interactions and flood control infrastructure</li> <li>■ Climate regulation (source and sink for greenhouse gases, and influence temperature and precipitation)</li> </ul>	<ul style="list-style-type: none"> <li>■ Recreation (river rafting, etc. and fishing as a sport)</li> <li>■ Tourism (river viewing)</li> <li>■ Existence values (personal satisfaction from free-flowing rivers)</li> </ul>
Supporting services		
<ul style="list-style-type: none"> <li>■ Nutrient cycling (role in maintenance of floodplain fertility)</li> <li>■ Ecosystem resilience</li> <li>■ Mitigation of climate change (mangroves and floodplains providing physical buffering)</li> </ul>		

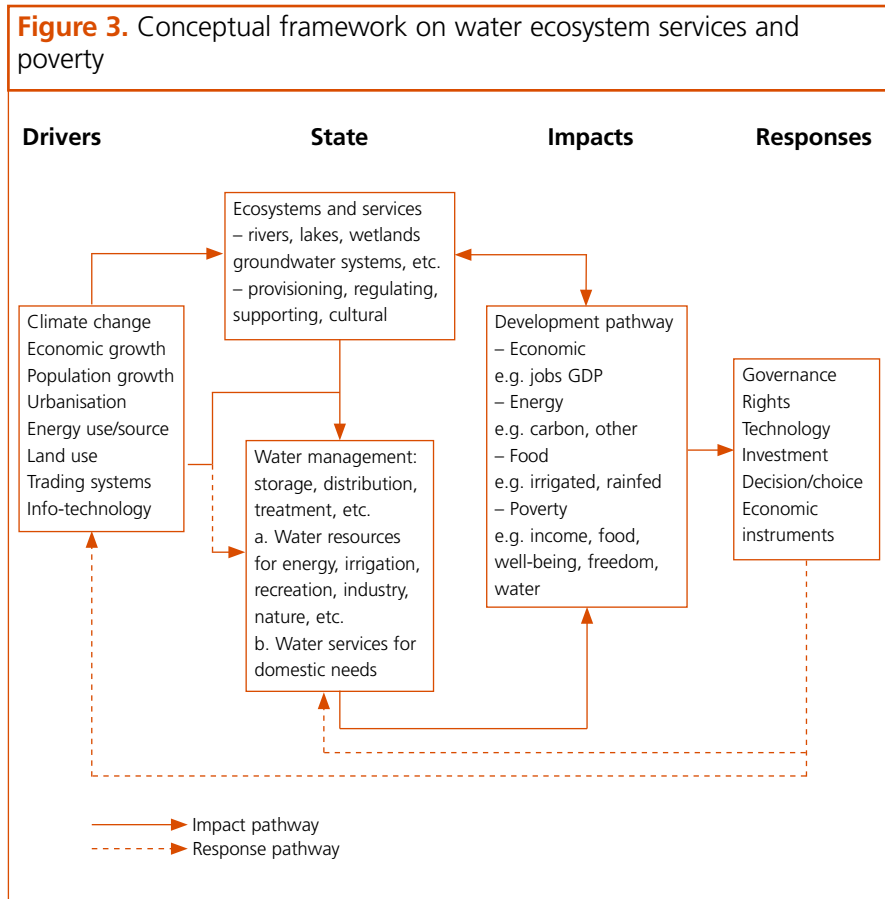
Source: adapted from Aylward *et al.* (2005)

Water availability introduces the temporal and spatial dimensions of water poverty. For example, a person can remain permanently below a stylised poverty line and be ‘chronically poor’. Alternatively, a person can be ‘transitorily poor’ and step out of poverty following a good harvest or reduced disease burden but fall back into poverty the following year. The transitorily poor may cause additional development policy concern to the enduring problems of ‘chronic poverty’ as this group may have increased exposure to **climate change**. With few livelihood options, the poor may adopt a range of low-risk, low-return activities or informal insurance networks that may reduce their risk from minor perturbations but that leave them exposed to the next major climate event.

Given the complexity in water and poverty relationships, a **Drivers–State–Impacts–Response** framework provides a conceptual understanding of some of the linkages between drivers of change, water ecosystems and poverty (Figure 3). The framework illustrates the role of change in water ecosystems and how this has direct impacts on development pathways, including water poverty, and a range of responses available to society. Drivers of change affecting water ecosystems include climate change, economic growth, population growth, urbanisation, energy use, land use change or trading systems. Drivers can work independently or in combination to alter the state of water ecosystems. Combined drivers might occur when economic growth leads to higher incomes, increased energy demands, urbanisation and changes in dietary requirements, such as from low water use (e.g. cereals) to high water use (e.g. meat).

The state of water ecosystems will have water management implications in terms of availability of water for allocation to domestic, industrial, agricultural or energy uses. The timing, allocation and access to water have implications for development pathways across economic, energy, food systems and poverty sectors. In turn, these sectors may have direct impacts on water ecosystems in terms of abstraction, pollution or system modification (e.g. draining wetlands). Society has an array of responses at its disposal to alter drivers of change, subject to its political, economic, institutional and environmental situation. Responses available to global, national or local actors and institutions to mitigate, adapt or cope with climate-related changes to water ecosystems include improvements in governance, rights-based approaches, technological innovations, investment allocations, individual or collective decision-making, policy shifts or economic instruments, such as water pricing.

**Figure 3.** Conceptual framework on water ecosystem services and poverty



## 3.2 Analysis of existing knowledge, its use and key researchable gaps

### Productivity of land and water are increasing...

Some promising trends were identified by the Comprehensive Assessment of Water Management in Agriculture (CAWMA) – pulling together five years of work by more than 700 scientists and practitioners from around the world (Molden 2007):

- Land and water productivity are rising steadily – with average grain yields rising from 1.4 metric tons per hectare to 2.7 metric tons over the past four decades.
- Average global per capita daily food supply increased from 2400 kilocalories (kcal) in 1970 to 2800 kcal in 2000 (slower rises to 2400 kcal in South Asia and 2200 kcal in sub-Saharan Africa by 2000).
- Potential increases in yields are greatest in rainfed areas, where many of the world's poorest people live and where managing water is the key to such increases.
- While some expansion of irrigated land will be needed to feed the world population of 8–9 billion expected by 2050, with determined change there is real scope to increase production on many existing irrigated lands, while there is potential in many areas for highly productive pro-poor groundwater use, e.g. in the lower Gangetic plains and parts of sub-Saharan Africa.

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The CAWMA concluded that there is enough fresh water to produce food for all the world's people over the next half century, but also that failure to drastically improve water use in this period will mean that environmental crises will be experienced in many locations.

#### Box 1. Freshwater ecosystem services are central to human well-being

- Each person needs over 4000 litres of water each day to produce enough food for a healthy diet. A calorie of food takes a litre of water to produce. A kilo of grain takes 500–4000 litres, a kilo of industrially produced meat 10,000 litres.
- Of the water available for withdrawal from rivers, lakes and groundwater, humans take some 3800 cubic kilometres. Some 70 per cent of this is used for irrigated agriculture, industry takes another 20 per cent and municipalities take the remaining 10% for domestic use.
- Some 55 per cent of the global gross value of crop production is grown under rainfed agriculture on 72 per cent of harvested land. There are large regional differences in the percentage of rainfed cultivated land, from almost 95 per cent in sub-Saharan Africa and almost 90 per cent in Latin America, to less than 70 per cent in the Near East and North Africa and less than 60 per cent in South Asia. In Southeast Asia the picture is more mixed.
- It is estimated that global wetlands generate values to humans worth in the region of US\$70 billion per year.
- Fresh water is crucial to climate stability. For example, although covering only an estimated 3–4 per cent of the world's land area, wet peatlands are estimated to hold 540 gigatons of carbon, representing 25–30 per cent of global carbon contained in terrestrial vegetation and soils.

Sources: Falkenmark and Rockstrom (2005), Finlayson *et al.* (2005), Molden (2007), WWF (2006)

## ...But freshwater ecosystem services are in trouble – hitting the poor hardest

The Millennium Ecosystem Assessment (MA) showed that the gains made for human well-being over the last 50 years have come at the expense of ecosystem degradation, which is now being compounded in particular by climate change and nutrient pollution. Already some 2 billion people living in dry regions are intensely vulnerable to the loss of ecosystem services, including water supply.

The MA and CAWMA demonstrated that freshwater ecosystem services are in trouble particularly. It found that the degradation of lakes, rivers, marshes and groundwater systems is more rapid than that of other ecosystems. Similarly it found that the status of freshwater species is deteriorating faster than those of other ecosystems. This loss of species and genetic diversity decreases the resilience of ecosystems – their ability to maintain ecosystem services as conditions change. However there is a severe lack of information on freshwater biodiversity, its links to livelihoods and the impacts of current changes.

*‘The water ecosystem services approach is a good way of breaking down “water” into its essential components and making the links with other parts of the landscape; it’s a good political tool. In Tanzania, the environment ministry gained support from other ministries on the issue of climate change by using this approach’*  
Gordon Conway, survey respondent

Primary direct drivers of degradation of freshwater ecosystem services include infrastructure development, land conversion, water withdrawal, eutrophication and pollution, overexploitation, and the introduction of invasive alien species.

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### Box 2. Problems for freshwater ecosystem services

- Lake Chad shrank over 35 years from about 2.5 million hectares in surface area to only one-twentieth of that size at the end of the 20th century as a consequence of, at first, low rainfall, then a poor understanding of the climate and badly planned irrigation projects – with the subsequent loss of many species and ecosystem services.
- The surface area of the Mesopotamian marshes (located between the Tigris and Euphrates Rivers in southern Iraq) decreased from an area of 15,000–20,000 square kilometres in the 1950s to less than 400 square kilometres today due to excessive water withdrawals, dams and industrial development (these marshes have since been large rehabilitated since the removal of the Saddam regime).
- The volume of water in the Aral Sea basin has been reduced by 75 per cent since 1960 due mainly to large-scale upstream diversions of the Amu Darya and Syr Darya river flow for irrigation of close to 7 million hectares.
- Of the 1138 waterbird biogeographic populations whose trends are known, 41 per cent are in decline. Of the 964 bird species that are predominantly wetland-dependent, 203 (21 per cent of total) are extinct or globally threatened.
- Approximately 20 per cent of the world’s 10,000 described freshwater fish species have been listed as threatened, endangered, or extinct in the last few decades.
- According to the World Water Council, more than half of the major rivers of the world are seriously polluted (WWC 1999 cited in Aylward *et al.* 2005).

Sources: Vorosmarty *et al.* (2005), Finlayson and D’Cruz (2005), Finlayson *et al.* (2005), Aylward *et al.* (2005), UNDP (2006)



Many indirect drivers of change work through the impacts of land use arising from agriculture-related activities. Both the extensive use of water for irrigation and excessive nutrient loading from the use of nitrogen and phosphorous in fertilisers have, despite their major contributions to global food production and employment, resulted in a decline in the delivery of services such as fresh water and fish species.

Degradation of ecosystem services hits the poor disproportionately. It is also sometimes the principal factor causing poverty, often contributes to the growing inequities and disparities across groups, and increasingly fuels social conflict. With limited other resources, poor people are more vulnerable to ecosystem change. The absence of clean water is a major cause of poverty and malnutrition.

Of the estimated 850 million people who are undernourished globally (FAO 2004), several types of dependency on water ecosystem services can be characterised:

- Smallholder farmers (50 per cent of those undernourished) – depend on access to secure water supplies for food production, nutrition, income and employment.
- Urban poor (20 per cent) – also depend on access to water supplies, have benefited from the lower food prices made possible through productivity gains in agriculture, and show an increasing pattern of urban–rural family linkages.
- Rural landless (20 per cent) – depend on water access and may gain employment in rainfed or irrigated agriculture.
- Pastoralists, fishers and forest-dependents (10 per cent) – vulnerable respectively to drought and climate change, water pollution and river water depletion, and clearing of land for agriculture and eventually deforestation.

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Poor people's dependency on water ecosystem services is greatly affected by policy decisions and the actions of the more wealthy. Mounting pressure to reallocate water from agriculture to industry threatens to increase rural poverty. Richer people's greater access to many ecosystem services, their over-consumption and waste, and prevailing resource-intensive development patterns are the flip-side of the same coin of 'water poverty' and require equal efforts to redress.

### Box 3. Poor people are hit hardest by degraded freshwater ecosystem services

- 1.6 million children under five years of age die each year because of unclean water and poor sanitation.
- One in five people in the developing world – 1.1 billion in all – lacks access to an improved water source. The Millennium Development Goal (MDG) of halving by 2015 the proportion of people without sustainable access to safe drinking water will be missed on current trends by 235 million people. To meet the MDG, 300,000 people need to gain access each day, every day from now until 2015.
- Most of these 1.1 billion people use about 5 litres of water a day – one quarter of the 20 litres now considered a minimum threshold and, increasingly, a basic human right, and one-tenth of the average daily amount used in rich countries to flush toilets
- Diseases and productivity losses linked to water and sanitation in developing countries amount to 2 per cent of GDP, rising to 5 per cent in sub-Saharan Africa—more than the region gets in aid.
- In many of the poorest countries the poorest households pay as much as 10 times more for water as wealthy households.
- Africa and Asia account for 80 per cent of people currently unserved by an improved water source, of whom rural people are five times less likely to be served than urban dwellers.
- Within the household the gender division of labour means that women and girls shoulder a greater burden of disadvantage than do men because they are responsible for collecting water, cooking and caring for young, elderly and sick family members.
- Water is a vital productive input for the smallholder farmers who account for more than half of the world's population living on less than \$1 a day.
- The number of people living in water-stressed countries will increase from about 700 million today to more than 3 billion by 2025.
- Over 1.4 billion people currently live in river basins where the use of water exceeds minimum recharge levels, leading to the desiccation of rivers and depletion of groundwater.
- In water-stressed parts of India irrigation pumps extract water from aquifers 24 hours a day for wealthy farmers, while neighbouring smallholders depend on the vagaries of rain. In parts of India, groundwater tables are falling by more than 1 metre a year.
- Groundwater depletion poses a grave threat to agricultural systems, food security and livelihoods across Asia and the Middle East.
- In Ethiopia the military budget is 10 times the water and sanitation budget – in Pakistan, 47 times.
- The United States stores about 6000 cubic metres of water per person compared to 43 cubic metres in Ethiopia.

Sources: Vorosmarty *et al.* (2005), UNDP (2006), WHO and UNICEF (2006)

### Water problems are increased by ecosystem degradation

Huge gains have been made in meeting human needs through water resources development – the construction of dams and irrigation channels, the construction of river embankments to improve navigation, drainage of wetlands for flood control, and the establishment of inter-basin connections and water transfers. Between 1990 and 2000, 1.2 billion people have been supplied with both improved water and improved sanitation (WHO and UNICEF 2006). This is a massive achievement, although population growth has diminished its impact, but reaching the 'second billion' is proving a harder and slower task (as noted in the box above).

At the same time, these approaches have themselves become direct drivers of ecosystem degradation. The impacts of water resource development are twofold: less water remains in the ecosystem and the distribution and availability of the remaining water often has a different pattern from that present under natural conditions. It is estimated that the amount of water withdrawn from inland water systems has increased by at least 15 times over the past two centuries. The impact of withdrawals, though, is not evenly spread and it is estimated that about 80 per cent of the global population is living downstream of only 50 per cent of Earth's renewable water supplies (Vorosmarty *et al.* 2005).

Inland water ecosystems have also been polluted by excessive nutrients, which drive eutrophication; heavy metals; nitrogen and sulphur based compounds, which cause acidification of freshwater ecosystems; organic compounds; suspended particles, both organic and inorganic; contaminants such as bacteria, protists, or amoebae; and salinity. Changes in the condition of freshwater and associated inland water ecosystems have also occurred at the hands of other direct drivers such as species introductions and land use change (Table 3).

**Table 3.** Impacts of human activity on freshwater ecosystems

Human Activity	Impact on Ecosystems
Dam construction	Alters timing and quantity of river flows. Water temperature, nutrient and sediment transport, delta replenishment, blocks fish migrations
Dyke and levee construction	Destroys hydrologic connection between river and floodplain habitat
Diversions	Depletes stream flow
Draining of wetlands	Eliminates key component of aquatic ecosystem
Deforestation/land use change	Alters runoff patterns, inhibits groundwater recharge, fills water bodies with silt
Release of polluted water effluents	Diminishes water quality
Overharvesting	Depletes species populations
Introduction of exotic species	Eliminates native species, alters production and nutrient cycling
Emission of pollutants into the atmosphere	Alters chemistry of rivers and lakes, and changes in runoff patterns from increase in temperature rainfall changes

Source: Aylward *et al.* (2005)

## Climate change will exacerbate water problems

One of the greatest impacts of climate change will be on water cycles. A changing climate can modify all elements of the water cycle, including precipitation, evaporation, soil moisture, groundwater recharge, and runoff. It can also change both the timing and intensity of precipitation, snowmelt and runoff. Modelling exercises point to complex and still uncertain outcomes. But the weight of evidence suggests that many of the world's most water-stressed areas will get less water, and water flows will become less predictable and more subject to extreme events.

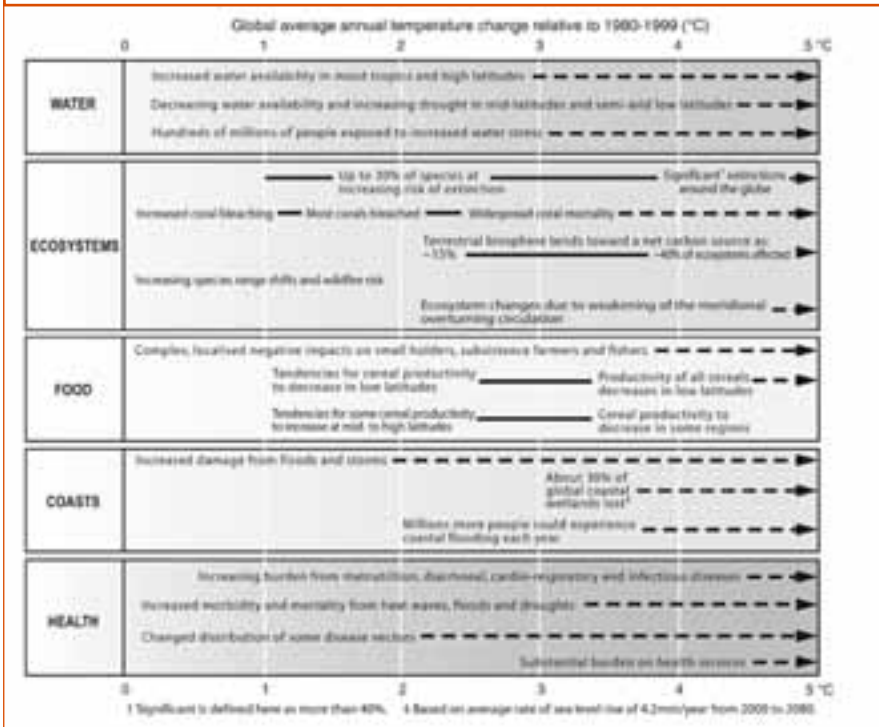
### Box 4. Climate change will intensify water problems for the poor

- Water insecurity linked to climate change threatens to increase malnutrition by 75–125 million people by 2080, with staple food production in many sub-Saharan African countries falling by more than 25 per cent.
- Marked reductions in water availability in East Africa, the Sahel and Southern Africa are predicted as rainfall declines and temperature rises, with large productivity losses in basic food staples. Projections for rainfed areas in East Africa point to potential productivity losses of up to 33 per cent in maize and more than 20 per cent for sorghum and 18 per cent for millet.
- Disruption of food production systems has been predicted, exposing an additional 75–125 million people to the threat of hunger.
- The UN estimates that 50 million 'environmentally displaced' people around the world could join the exodus of migrants crossing borders in search of new livelihoods.
- Rising sea levels are likely, resulting in freshwater losses in river delta systems in countries such as Bangladesh, Egypt and Thailand.
- Some 150,000 people a year are now dying as a result of climate change, as diseases spread faster at higher temperatures. WHO warns that globally some 80 million more people could become infected with malaria.
- The 'Stern Review' carried out by the UK government on the economics of climate change calculated that the dangers of unabated climate change would be equivalent to at least 5 per cent of global GDP each year for a narrow range of direct effects, and about 20 per cent of global GDP if a wider range of impacts on the environment and poor people are taken into account.

Sources: DWC (2003), IPCC (2007a), Scholze et al. (2006), SDI (2007), Stern (2006), UNDP (2006), WHO (2003)

The fourth assessment reports of the IPCC in 2007 synthesise current scientific understanding of impacts of climate change on ecosystems, and the vulnerability and capacity of social systems to adapt. The overall message is that the ability of many ecosystems to adjust to change and bounce back from shocks will be exceeded this century (Figure 4).

**Figure 4.** Potential climate change impacts on water, ecosystems, food and health



**Notes to figure.** The figure shows examples of global impacts projected for climate changes associated with different amounts of increase in global average surface temperature in the 21st century. Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left hand side of text indicates approximate onset of a given impact. Source: Reproduced from IPCC (2007b)

Annual average river runoff and water availability are projected to increase by 10–40 per cent at high latitudes but decrease by 10–30 per cent over some dry regions at mid-latitudes and in the dry tropics (Figure 5). Drought-affected areas will likely increase in extent. Heavy precipitation events are likely to increase in frequency, augmenting flood risks. Poor communities are considered to be particularly vulnerable in high-risk regions, such as the tropics and coastal zones – having limited adaptive capacities and being vulnerable to changes in climate-sensitive resources, such as local water and food supplies.

IPCC (2007a) predictions by major region can be summarised as follows:

**Africa.** New studies confirm that Africa is a particularly vulnerable continent because of multiple stresses and low adaptive capacity. Agricultural production is likely to be severely compromised in many regions by climate variability and change. The projections suggest increasing challenges in terms of increased water stress and adverse effects on food production as areas suitable for agriculture along the margins of semi-arid and arid areas are expected to decrease. An estimated 600,000 km<sup>2</sup> of arable land could be lost with between 75 and 250 million of sub-Saharan Africa's 800 million people facing physical water scarcity. Rising sea levels pose threats to Gambia around to the Gulf of Guinea and a predicted band of desiccation will wrap around the Congo Basin from the Gambia to Angola (Figure 6). Although some adaptation to current climate variability is taking place, it may be insufficient for future climate changes.

**Asia.** An expanded set of challenges is predicted for Asia linked to glacial melt in the Himalayas, affecting water resources first by increasing flooding, and later followed by decreased dry-season river flows as the glaciers recede over the next 20–30 years. The glaciers of the Himalayas and Tibet alone feed seven of the world's greatest rivers – Brahmaputra, the Ganges, Indus, Irrawady, Mekong, Salween and Yangtze – which provide water supplies for more than 2 billion people. Some modelling exercises for India predict an increased proportion of rain falling during intensive monsoon episodes in parts of the country that are already well endowed with rainfall. Meanwhile, two-thirds of the country will have fewer rainy days. This will translate into a net loss for water security, placing a premium on water harvesting and storage (Figure 7). The dense populations in the mega-delta regions in South, East and Southeast Asia will also be at great risk from sea-level rise. Many of these regions are under intensive rice cultivation, and sea-level rise is likely to keep hunger risks very high in several countries in Asia.

**Latin America.** In Latin America, decreases in green water (soil moisture) are projected to lead to gradual replacement of tropical forests by savannah in eastern Amazonia, where significant biodiversity loss is also foreseen. In drier areas of the continent, salinisation and degradation of agricultural land may be expected. Glaciers on this continent may disappear, while areas of critical water stress will increase (Figure 8).

In addition to the direct impacts on species and ecosystems noted by the MA and IPCC, indirect impacts of climate change on the physical, chemical and biological characteristics of wet ecosystems include (DWC 2003): shifts in vegetative season; species invasions; range extensions and contractions; shifts in nutrient cycles related to fluctuations in water levels, and shifts in intensity and frequency of structuring processes (fire, flood, pests).

### Box 5. The Sahel – A crucible of the issues for water ecosystem services, climate change and poverty

In the past quarter century the Sahel has experienced the most substantial and sustained decline in rainfall recorded anywhere and river discharge has fallen by more than 40 per cent. Yet the Sahel, like other drylands, is in continuous transition as its ecosystems and human systems adapt to many drivers of change, including climate change, demographic and economic change, and changes in natural resource management (de Oliveira, Duraiappah and Shepherd 2003; Dobie and Goumandakoye 2005). Climate change scenarios for the region do not all agree (Haarsma *et al.* 2005; Held *et al.* 2005; Hulme *et al.* 2005), and according to the IPCC, 'it is uncertain how rainfall in the Sahel... will evolve this century' (IPCC 2007b: 866).

In the Sahel, seasonal streams with associated flooding in topographical depressions are the basis of support for grazing and temporary settlements, while for drinking, watering animals and domestic use in permanent settlements, Sahelians depend on groundwater. Early research found that in the arid Sahel, annual rainfall is a strong correlate of plant biomass productivity, because nutrients are not limiting, whereas in the semi-arid Sahel (where rainfed farming is undertaken), nutrient deficiencies may set a ceiling to productivity (Bremner and de Wit 1983; Penning de Vries and Djiteye 1991). Recent research emphasises the importance of soil biology, and especially where organic manure is used rather than agro-chemicals alone (Harris 2002; Mortimore and Harris 2005; Uphoff *et al.* 2006). It is noted that water (rather than soil moisture) is necessary for making compost, which can double yields on poor soils.

Research tends to confirm that the mobility of nomadic and transhumant pastoralists is rational, efficient and non-destructive of the natural resource, and mobile grazing systems derive fresh relevance under conditions of increasing rainfall variability predicted in climate change scenarios. But conflict over closed borders and zones of exclusion is increasing, and wetlands and access routes are increasingly alienated from the pastoralists. There has been a significant increase in violent incidents, e.g. along the Hadejia River in northern Nigeria.

Throughout the region market demand for food commodities is rising very rapidly with urbanisation predicted to increase from 40 per cent in 1990 to 63 per cent in 2020. There is rising demand for meat, which requires more water per kg to produce than cereals. The mismatch between urbanisation and the availability of blue water in the Sahel becomes ever more stark.

In urban areas water delivery to poor households is often by carriers and a situation where poor people pay while the rich get it free is common. Piped water systems in urban areas are prone to local failures in the treatment of sewage, which finds its way into streamflow. In the dry season, it is common for urban waste water to be used for irrigating vegetables and fruit trees in the peri-urban zone. A growing market for safe water is suggested by the sales of bottled water, which have spread from a few francophone cities in the 1960s to most West African markets today. This trend among a growing salaried class, however, should not deceive: poor people in urban areas are still at risk.

Problems for water ecosystem services in the Sahel are likely to intensify regardless of the direction of climate change. Catchment planning is an urgent priority. This suggests that governments need to move beyond simple strategies of drilling boreholes to capture water from rural areas, and suggests a transition from a perception of water as a free and unlimited good to one of scarcity in which management is driven by considerations of value. It also means that development and disaster relief agencies need to look harder at the root causes of vulnerability – which is crucially influenced by gender, ethnic group and generation issues, and by contemporary and historical processes often not analysed.

Source: Mortimore (2007)

## Governance is the key

Decisions about water ecosystem services, who makes them and how they are made, are at both the core of most of the main problems and the target of most attempts to improve matters. Better governance of water ecosystem services thus stands out from the research scoping exercise as both the necessary solution to many challenges and the appropriate target for research itself.

The above analysis of the links between poverty, water ecosystem services and climate change illustrate some of the governance imperatives. Further shifts in governance, much called for in the literature and consultations, would for example enable decisions that (e.g. Falkenmark and Rockstrom 2005, Molden 2007):

- Establish and implement systems of water use rights and entitlements.
- Recognise green water issues and land use issues in water resources management much more – to reduce the loss of green water through non-productive evaporation and make it accessible to plants as productive transpiration in forestry products, grain farming and market food needs.
- Enable water to be re-allocated from lower- to higher-‘value’ uses particularly in closing river basins. How ‘value’ is assessed across social and economic considerations is of course critical.
- Provide incentives for water conservation including rewards for saving water.
- Set and enforce water quality standards.

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### Box 6. Research issues highlighted in the in-depth interviews

Among the interviewees discussing Asian contexts there is a growing sense of ‘water crisis’ exacerbated by rapid economic growth and urbanisation. ‘Basin closure’ and the severe depletion of groundwater are realities that are already being experienced in many parts of the region and are likely to spread. In contrast, the challenges to freshwater systems in Africa are generally felt less acutely, but the likely impacts of climate change in the semi-arid and arid regions of the continent will have severe and long-term impacts on freshwater ecosystems, economic development and poverty.

**Provisioning services** of freshwater ecosystems are seen as the most important category of ecosystem services in terms of poverty and the likely impacts of climate change. **Regulating services** are seen as less well understood and an appropriate focus for the proposed research programme – often best approached through initial consideration of provisioning services.

**Governance**, and the range of imperatives in improving how decisions are made and by whom, is seen as the core challenge by many in sustaining ecosystem services and the needs of the poor in all regions. There is a range of research themes on governance around which the proposed research programme might best be built.

**Urbanisation, migration and economic development** are powerful drivers of change. In the short term they are likely to have as much influence over freshwater ecosystems and poverty as climate change. Increasing frequency and severity of extreme climatic events and absolute shortages of water may increase urbanisation trends and lead to large-scale local, regional or international migrations.



**Hydrological** research needs are strongly perceived by a body of interviewees who see critical gaps in understanding which, if filled appropriate to context, would unlock action generally for better management of water ecosystem services. Others perceive sufficient existing understanding on most hydrological issues.

**Economic instruments** for better sustaining water ecosystem services were also identified as an area of research priority by some and not others. Payments for watershed services were recognised as a tool for integrating upstream and downstream stakeholders in some contexts and these contexts need more research. The role of economic instruments in achieving greater efficiency with equity in water use is another area where research is seen as high priority.

Important challenges that will need to be considered in the design of the proposed research programme were raised in the interviews. Foremost is doing more than has been done in the past to ensure that research and research outcomes feed into policy process. Second is making better use of the enormous body of research work on freshwater ecosystems and their links with poverty that already exists. Third is taking care to overcome the potential barrier that the language of 'water ecosystem services' may represent among water sector practitioners and potential end users in developing countries.

Ultimately, any development of water resources will involve a trade-off between provisioning, and the cultural, regulating and supporting services. Current trends to continue favouring provisioning services should reduce poverty. But due to the linkage between ecosystems and their cultural, regulatory and supporting services, poverty can only be reduced so far before feedback loops from ecosystem degradation cascade back through these services, thereby reducing well-being, particularly for the poorest members of society (Aylward *et al.* 2005). While optimisation is unlikely in the real world, balance across ecosystem services remains a key imperative for their governance. For this to make progress, key direct drivers of governance change need to be addressed, such as internalising environmental externalities, ensuring stakeholder participation, and increasing transparency and accountability of government and private sector decision-making.

A trend in water governance thinking towards 'distributed' governance systems – which aim to supplement formal authority by an increasing reliance on informal authority, for example through genuine public-private cooperation – is having some influence (Green 2007). This might be usefully extended to governance of water ecosystem services.

Governance is political – it will tend to be defined to suit those who hold a particular vision of the future. Good governance is therefore only meaningful if developed to suit local conditions. Incremental improvement and flexibility are key and support is best targeted at capacity for governance (i.e. information systems, stakeholder platforms, legal and regulatory mechanisms, executive capabilities and conflict resolution systems) to enable society to respond to and adapt to uncertainty, variability and change that could be local or regional, short or long term, political, economic or environmental.

Current writing on governance tends to be gender blind while physical presence and the exercise of public voice continue to be major elements of the formal institutions of water resource management. Clearly governance of water ecosystem services needs to take better account of the roles of women in managing water service delivery and in water-related decision-making (Clever 2007).

**Box 7.** Bolivia's need for research on what policy interventions actually work, and on capacity

Water ecosystem services in Bolivia are split along a series of fault lines, the most important of which are geographical and biophysical. The altiplano highlands are a low precipitation desert with most available water coming from summer glacier- and snow-melt, which is only minimally affected by land use. At the other extreme, lowland Bolivia is humid with high year-round rainfall and relatively little human impact on water ecosystem services. Thus it is only the area between the high Andes and the Amazon – the transitional inter-Andean valleys and slopes – where human activities can define the scope of water ecosystem services.

Climate change will likely increase extreme flows in the altiplano in the short term, while long-term increased temperatures may serve to reduce summer base flow. In the mid-altitude valleys, under a scenario of 'permanent' El Niño-like conditions, rainfall and flooding extremes will likely increase. Data for the Amazon suggest that warmer temperatures and decreased precipitation during already dry months could result in more severe droughts. Coupled with land use changes, these changes could lead to increased ecological degradation and spread of infectious diseases. Effects on agricultural yields will vary by region and by crop – with the positive physiological effects of CO<sub>2</sub> enrichment being countered by temperature increases in some conditions, leading to shortening of the growing season, rainfall changes and consequent reductions in crop yields.

Policymakers have tried and failed 32 times to update and modify Bolivia's antiquated 1906 water law. Faced with this legal gridlock, various new sectoral laws and policies have been developed instead. Many of these laws affect water service provision, but contradict, strengthen, oppose or ignore the articles of the water law itself. Added to this confused and unmanageable system is the general inability of the Bolivian state to reach into its more remote areas, which leaves a jurisdictional vacuum that at least in the short term will most likely be filled by locally developed activities and policies. Even if central government laws and policies were actually implemented, biophysical realities mean that such policies would affect water ecosystem services only in the mid-altitude valleys.

There is a clear need for research that can help Bolivian policymakers to develop appropriate institutions, policies and laws that ensure the provision of water ecosystem services. But the above-mentioned abortive attempts to create new water legislation act as a warning. Greater understanding is needed of how, and under what circumstances, policies and interventions protect water ecosystem services. One of the greatest bottlenecks is the lack of human capacity, so cost-effective donor research investments are likely to build local capacity to carry out such policy research.

Source: Asquith and Vargas (2007b)

There is no shortage of guidelines or toolboxes that can be helpful in improving different aspects of governance for water ecosystem services. For example:

- Guidelines for improved local water governance: [www.empowers.info/page/2850](http://www.empowers.info/page/2850)
- Sustainable livelihoods toolbox: [www.livelihoods.org/info/info\\_toolbox.html#1](http://www.livelihoods.org/info/info_toolbox.html#1)
- Global Water Partnership toolbox: [www.gwpforum.org/](http://www.gwpforum.org/)
- Tools to support transparency in local governance: <http://www1.transparency.org/toolkits>
- 'Power tools' series from IIED: [www.policy-powertools.org](http://www.policy-powertools.org)

The challenge, however, is to adapt, pilot and mainstream these tools such that they are brought into everyday use.

Governance has received increasing attention from DFID in both its development and research programme in recent years (DFID 2006a; Moore and Unsworth 2006) so the organisation is well placed to support effective research initiatives on governance of water ecosystem services.

### Water rights and sustainability – a particular governance challenge

Insecurity of water rights, mismatches between formal legislation and informal customary water rights, and an unequal distribution of water rights are frequent sources of conflict (UNDP 2007a; Hodgson 2004). In contrast, the establishment of well-defined and coherent roles and responsibilities through legislation of formal and informal water rights may lead to a number of social, economic and environmental benefits including: equitable water use; improved efficiency and productivity of existing water supply allocations; an increased willingness of users to take economic risks by investing in improved water management and practices in both rural and urban contexts; and reduced pressure on water resources because those with water rights have incentives for managing resources sustainably.

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In 2002, the United Nations recognised water as a human right in a legally non-binding normative framework, which has been supported by DFID and other bilateral donors (UNDP 2006; DFID 2006b). The moral case is complemented by economic and political arguments to foster national prosperity and stability. What is less clear is how such desirable outcomes can be achieved effectively and sustainably given past water policy failures (Thompson, Porras *et al.* 2001; Biswas 2003). For example, will making water a 'right' tip the balance in favour of the poor or paralyse embattled governments and service providers? Anand's (2006) analysis of changes in water (and sanitation) access between 1990 and 2004 suggests that the context-specific historical roots of the issues matter along with an uncertain combination of growth and social sector spending.

Research may need to more effectively combine back-casting to data points in the past with forward-casting through narrative scenarios that recognise risk and uncertainty to better evaluate societal demands and preferences, ecosystem integrity and the financial sustainability of delivering water as a human right. DFID could make significant gains for water rights and sustainability by supporting this kind of research.

### **Box 8.** Research issues highlighted by the web survey

The top 10 (of 52) research issues by mean ranking of the 335 full responses to the web-based survey were:

1. Water quantity and quality for domestic water
2. Soil and water conservation technologies
3. Build capacity of water managers
4. Equity in access to water for basic needs
5. Institutions/norms/rules/rights for productive water use
6. Effective participation in water decision-making
7. Land use change, including forest cover and wetlands
8. Sustainable groundwater use
9. Regulating water investment decisions
10. Social change/coping/adaptation/resilience

**Domestic water and equity of access** for basic needs rank as high priority issues in the survey results. This supports DFID's renewed engagement with the water sector and focus on improved water access to reduce poverty. Equity, in a broad sense, may be promoted by improved understanding of the risks poor people face over time; and better knowledge of how risks are distributed and how people respond to risk is likely to be increased with better longitudinal data that can evaluate climate-related impacts to ecosystems and livelihoods.

**Water resource management**, including areas such as soil and water conservation, land use change, groundwater use and wetland use, is a research area that records high scores from the analysis. These issues are particularly important for African experts – the region does stand apart from Asia in terms of its limited water storage infrastructure and associated exposure and vulnerability to climate change. The descriptive rankings also reinforce the argument that groundwater management is one of the most pressing challenges for Asia. Africa may be considered to face first-order physical water constraints, while Asia may be facing second-order socio-political constraints to sustainable water resource management.

**Institutional environment**, including aspects of water legislation, regulation and enforcement from the local level to the catchment scale, and on to transboundary issues is also emphasised in the results. While global evidence illustrates the difficulties in effectively implementing IWRM, it appears to be the best, or often the only, game in town. The analysis here may be understood as endorsement for more and better research that improves and strengthens integrated approaches across management, legal and regulatory domains.

**Adaptation**, including rainfall variability, farming adaptive capacity, water-related disease and social coping mechanisms, is another strong theme in the survey findings. Building on knowledge from both advances in theory and technology and existing indigenous knowledge emerges as an important area for continuing research investment.

## Adaptive capacity and resilience need to be understood, and built

The array of potential options to adapt to changes in water ecosystem services wrought by climate change is large, ranging from purely technological measures such as sea defences, through behavioural adaptation such as altered food choices, to managerial adaptation such as altered farm practices, to policy such as planning regulations. For developing countries, availability of resources and adaptive capacity building are particularly important. The MA proposes that removing the existing pressures on freshwater ecosystem services and improving their resilience is the most effective method of coping with the adverse effects of climate change and a key element in its mitigation. A key question then is whether practical strategies for supporting and developing such resilience can be found and implemented (Mortimore and Anvell 2006).

*'Climate change is creating a conceptual framework to better understand implications of impacts on water resources. Suddenly, intergenerational equity is a key issue. From a planning point of view, sustainable development has been very nebulous, but with climate change it becomes a very pragmatic issue'*  
Sarah McIntosh,  
survey respondent

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Research needs to evaluate how effective current adaptive strategies are in reducing food and water security risk for vulnerable groups in developing regions at higher temperatures (IPCC 2007a) and higher agricultural commodity prices related to cropland conversion to biofuel production. Technological innovations for natural resource use under climate variability can also play a role in poverty reduction (Mortimore and Manvell 2006), particularly when strengthening existing adaptive capacity among poor people. Wider concerns exist in terms of how the political economy of climate change influences development policy priorities between meeting immediate needs in favour of laying down effective plans for the future. Climate change may perversely offer a political window where public support drives institutional change in exploiting synergies between Poverty Reduction Strategy Papers, National Adaptation Programmes of Action and water policy.

*'Political and media interest in climate change has meant that scarce resources are being diverted away from other development priorities to fund climate change activities of as yet uncertain return on investment'*  
John Hudson,  
survey respondent

From its experience with the Renewable Natural Resources Research Strategy in particular, DFID is well placed to capitalise on the opportunity that climate change agendas bring to support research on land use change, adaptation and resilience.

## Box 9. Mexico's need for research on investment, adaptation and resilience

Currently, Mexico is characterised by considerable diversity in water resources between the largely arid northern areas of the country and the much better and well-watered southern states. Some 75 per cent of water is used for agriculture. Because water is considered a national good, farmers are only required to pay for the costs of abstraction. Large quantities of water are wasted because there are few, if any, incentives to use it efficiently. Mexico's water resources have suffered from the discharge of industrial waste, urban effluent and non-point pollution from agro-chemicals to the extent that only 10 per cent of water supplies are considered to be 'good quality' or unpolluted.

Even without the impact of climate change, water resources in Mexico will come under enormous stress from economic growth, population growth and the increased use of water for agriculture. Climate change will exacerbate these projections as surface and ground water diminishes and farmers try to compensate with higher levels of irrigation. Indirect effects of land use change such as deforestation will impact on water quality, water quantity and seasonal flows. Climate change projections also indicate that Mexico will bear a heavy burden with an increasing frequency and severity of extreme events – particularly hurricanes.

National Water Law presents a definition of water 'environmental' services as those benefits of 'social interest generated by watersheds and its components', such as climate regulation, conservation of hydrologic cycles, mitigation of erosion, mitigation of floods, recharge of aquifers, management of natural filtration for water quality and quantity, soil creation, sinks for greenhouse gases and conservation and protection for biodiversity. Meanwhile, national forestry law has created a trust fund for interventions with environmental services and to support an increasingly impressive community forest enterprise programme.

To date then, water and forest policy have been dominated by government expenditure on supply-side investments. Recently, through the Payment of Hydrological Environmental Services (PSAH), the government has sought to build bridges between the water and forestry sectors. Under the PSAH programme, government is a buyer of watershed services from land managers in areas that are known to be critical for aquifer recharge, and increasingly in areas with high poverty incidence. These experiments with payments for hydrological services have so far fostered substantial engagement of stakeholders. They do show promise, but have also met with substantial criticism, largely due to their basis in subsidy, and face numerous challenges.

Research priorities may include: sustainability of payments for watershed services in the context of market instruments and investment; governance of water ecosystem services; and many aspects of variability, vulnerability, adaptation and resilience of water ecosystem services under climate change.

Source: Cortina (2007)

## Water for food, fuel and forests

As populations and incomes grow, demand for agricultural water will rise. For example, by 2050 food demand is expected to double. Rockstrom (2007) argues that 'investments in rainfed agriculture have large payoffs in yield improvements and poverty alleviation through income generation and environmental sustainability'. The challenge is to tackle rainfall variability rather than an absolute lack of water. Yet rainfed innovations also require complementary investments in infrastructure, market access, credit, farm diversification and building adaptive capacity for productivity gains to be sustainable in reducing poverty. Key questions

include: who will bear the costs, what will be the role of prices on agricultural productivity and land use, and how will local improvements in rainwater harvesting impact on interdependent water users?

While advances are being made to improve weather forecasting in order to communicate early warnings/opportunities to rainfed farmers in Africa (Brew and Washington 2004), how significant and usable this information will be is difficult to predict. Equally, the actual benefits of innovative financial mechanisms such as monsoon-indexing and climate reinsurance in semi-arid Africa and South Asia are uncertain, though they may provide farmers with more choices and reduce risk in the face of increasing climate variability (Hess 2003). Equally, wider initiatives are being called for in social marketing to change dietary attitudes and preferences to reduce agricultural water demand and fuller understanding of 'virtual water' trading approaches (Molden 2007).

*'A particular challenge for the UK government is the frequent and increasing contradiction between domestic policy pronouncements – like buy local – and the aid agenda which is supporting agriculture as a driver of growth'*  
Anna Nileshwar,  
survey respondent

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The case of biofuel production is illustrative of how market forces are driving ecosystem change as prices for oil have risen and global demand for alternative energy has soared. Increasing farmer returns, higher foreign exchange earnings, reduced fossil fuel imports and investment in rural areas are some of the positive outcomes. The flip-side is that impacts on ecosystems are poorly understood – although rapid processes of agricultural intensification or expansion certainly have negative impacts. For example, it is estimated that under a scenario of heavy reliance on biofuels, by 2050 total water demand for biofuel production will be equivalent to today's total agricultural water demand (Molden 2007).

Land use decisions effectively act as water resource decisions by partitioning rainfall between vapour flow (green water) and liquid flow (blue water). This understanding has been recognised in South Africa where Stream Flow Reduction Activity (SFRA) policy taxes land uses that have an incremental impact on water resources above a baseline natural condition. For example, commercial forestry is taxed by area on non-native forest species based on reductions in runoff. With increased physical water scarcity under climate change, improved understanding of forest-water interactions is needed (Bruijnzeel 2004, Calder 2005, Calder *et al.* 2004, FRP 2005). It requires a fine balance to understand in different contexts the type and extent of forests which meet societal needs and environmental requirements. Simplified statements that 'forests are bad/good' are unhelpful given the complexity of system interactions and the limited extent of adequate biophysical data, environmental evaluation or societal assessment (ETFRN 2005).

*'Answering the main hydrological questions is the key to unlocking many other water ecosystem services issues'*  
Stefano Pagiola,  
survey respondent

Filling key knowledge gaps in determining under what conditions agricultural, fuel and fibre systems enhance water ecosystem services for poverty reduction is a particularly important niche for DFID-supported research.

### **Box 10.** India's need for research on practical governance of water ecosystem services and on the drivers of land use change

Projections of water demand in India indicate, according to the Ministry of Water Resources, that the nation's water requirements can be met until the year 2050 if integrated water management plans are properly implemented. Beyond 2050, demand will exceed supply even with such implemented plans. But two crucial factors have been absent in painting this relatively rosy picture: the impact of new interventions such as watershed management programmes, and the impact of climate change.

Policy provisions are reasonably solid – those in the National Water Policy provide a basis for addressing many of the problems in the water sector while those in the 2006 Environment Policy are the first to address climate change – but implementation to date is feeble.

Watershed development guidelines, most recently the 'Hariyalli' guidelines of 2004, are useful (apart from the objective to harvest 'every drop of water' without accompanying guidance on the potential lack of supply to downstream areas). However, implementation so far reveals weak application of hydrological principles, and excessive focus on expenditure rather than a balance of implementation means. Integrated watershed management would greatly benefit from being based on a framework that effectively incorporates both administrative and hydrological systems, and the generation and use of the right information to evaluate the cause and effect of all proposed actions.

India developed its first 'National Communication' (NATCOM) on climate change impact assessment for the UNFCCC in 2004. This and subsequent NATCOM area-specific reports remain the only significant national-level assessment of the impacts of climate change on water resources. The Fourth IPCC Assessment report in 2007 predicts severe stress on the already stressed ecosystems of India – ranging from increased drought and river system closure to reduced flows in Himalayan river systems, extreme precipitation events, changes in crop yields and reduced ecosystem resilience. India has experienced a series of extreme events that fall outside 'usual' natural variability and are associated with climate change.

Recent developments in collaborative research with UK institutions and others indicate increasing concern about freshwater ecosystem services among policymakers and researchers in India, but wider awareness is limited. Religious and value-based beliefs prevail, yet some of these are highly questionable in hydrological terms. Other drivers of change in water ecosystem services – such as afforestation targets, biofuel development and free extraction of groundwater – are not addressed coherently, and not in the context of climate change.

Suggested research priorities are those that aim to improve the policy implementation environment with a particular focus on links between policies, consideration of ecosystem effects, participation and negotiation, and evaluation. Focused research should also aim to address the mismatch between hydrological and administrative boundaries, and to improve understanding and management of the drivers of land use change. Research networks may be best placed to take the initiative on these issues and to communicate findings to policymakers.

Source: Gosain (2007)



### Payments for water ecosystem services – a tool worth further developing

Of various possibilities for 'payments for environmental services', initiatives to establish payments for watershed services have received particular attention recently. The assumption is that a payment or compensation by downstream beneficiaries of changes in quantity or quality of water will provide an incentive for upstream land users to adopt conservation and sustainable land management practices that guarantee these changes. Payments for watershed services schemes range from a pilot project in Nicaragua that rewards just five families on 13 hectares of land to a massive state-run Chinese project that aims to reach 15 million farmers and 27,000 villages over 32 million hectares of land by 2010. Many emerging schemes and programmes are characterised by considerable ingenuity and creativity (Landell-Mills and Porras 2002) as stakeholders struggle to find new ways of addressing long-standing and often intractable problems. A new global review identifies nine active national programmes and 39 local schemes (as well as another 45 proposals). Latin America leads the field with Asia catching up and Africa lagging behind (Porras *et al.* 2007).

*'Even with our current climate, variability is poorly understood, which generally leads to land use practices in the uplands being blamed for everything'*  
Meine van Noordwijk,  
survey respondent

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Emerging evidence identifies transaction costs, behavioural change, compliance, institutional development, economic valuation, and resource evaluation and monitoring as some of the key obstacles (Porras *et al.* 2007; IUCN 2006). Schemes acknowledge the implicit inequality in expecting poor people to sustainably manage ecosystems, whose goods and services benefit remote, unpaying or future generations. To date, there is ambiguous evidence whether these schemes, like traditional integrated conservation and development programmes, can successfully combine environmental improvements and poverty reduction (McCauley 2006; Porras *et al.* 2007; Gutman 2003). Limited quantified evidence for positive impacts of payments for watershed services on livelihoods and poverty comes from Latin America (Echavarria *et al.* 2004, Porras *et al.* 2007, Miranda *et al.* 2003, Munoz 2004; Ortiz Malavasi 2003), while there is a developing consensus that these schemes are unlikely to benefit those trapped in extreme poverty because the barriers to their participation are too great (Wunder 2005).

Imposing strict poverty reduction criteria may, in some cases, be counter-productive as a broader definition of rural development may mean the approach can be more widely applied to explore innovative interventions while not making the poor worse off. For example, research in Latin America and India suggests that transitional payments to assist farmers move from degrading land management practices to more benign practices can be self-funding over time, can reverse ecological decline, and are socially acceptable, if there is adequate compensation and support during the costly transition process (Bassi 2002; Pagiola *et al.* 2004; Hope *et al.* 2006). Payments for watershed services may thus be worthy of concerted further exploration in broader contexts of governance,

primarily as a new way to construct relationships between key stakeholders around water and land use issues (IIED 2007; van Noordwijk *et al.* 2004). Having backed pioneering work in these areas, DFID is well placed to follow this up.

### Environmental flows and valuing ecosystems – still to break through in policy

Environmental flows maintain freshwater ecosystems, whose services provide critical contributions to surface and groundwater availability and quality, economic development and poverty reduction (IUCN 2003). As might be anticipated, the South Africans have legislated for such an Environmental Reserve in the National Water Act (RSA 1998) and Europe has attempted to follow suit with the Water Framework Directive requirement for 'good ecological status'. The devil, as always, is in the detail and difficulties arise in defining, measuring and valuing environmental flows against societal preferences and governance capacity. Gutman (2003) provide global lessons from 10 river basins, which suggest that key ingredients for success are an adaptive mix of governance across spatial levels with long-term and participatory visioning, in association with effective partnerships and knowledge, plus predictable and sufficient investment.

Valuing ecosystems as water infrastructure is one approach that acknowledges the considerable economic benefits the world's ecosystems generate (IUCN 2004; Gutman 2003). However, high but unredeemable environmental values in the context of climate shocks are meaningless as the poor have no choice but to liquidate all available assets, including natural resources, to buffer losses from other assets (Dercon 2002; Pearce 2005). Policy responses here need to recognise that vulnerable groups have no effective insurance mechanisms against large negative climate shocks and more accessible and effective savings schemes need to be developed to insulate them against these. (Hess 2003, Dercon 2004; IPCC 2007b).

A common perception is that valuation of ecosystem services and quantification of environmental flows are too complex and too uncertain to be included in decision-making. In some contexts, this is changing. Techniques are improving; the critical factor now is recognition of their results in governance such that the market and non-market values of services sustained by ecosystems are internalised in water resources management.

### Investing in water ecosystem services

The Camdessus Report (2003) estimates that more than US\$13 billion per year is needed to meet drinking water provision targets in developing countries. Toubkiss (2006) compares more recent studies of water investment estimates and concludes: 'if the results are analysed on comparable bases, they appear quite similar: approximately US\$10 billion per year is needed to supply low-cost water and sanitation services to people who are not currently supplied, a further US\$15 to 20 billion a year to provide them with a higher level of service and to maintain

current levels of service to people who are already supplied. A much larger figure, up to US\$80 billion is projected solely for collecting and treating household wastewater and for preserving the environment through integrated water resources management and ecological methods”.

*‘In SE Asia governments think that planting trees is the answer whatever the problem – and this can be a terrible misdirection of public funds. Why is it that planting trees satisfies the public? We need to work more in the interface of science, public knowledge and what people do’*  
Meine van Noordwijk, survey respondent

While the UNDP (2006) estimates that there is currently a significant investment funding gap that cannot be met by government or (poor) users alone, it should also be noted that investments of the above magnitude are only likely to be effective, and avoid the mistakes of the past, with greatly improved governance of water ecosystem services. Where infrastructure investments are emphasised well ahead of institutions, or vice versa, the returns on investment are likely to be low, ecosystems may be damaged and the poor may not benefit (Grey and Sadoff 2006).

### **Box 11.** Kenya’s need for research on tradable rights, adaptation and resilience, and effective tools for integration and up-scaling

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Population growth, uneven distribution of water over space and time, climate variability, pollution and ecosystem degradation all continue to exacerbate water shortages in Kenya.

Climate change is already thought to have increased the frequency of droughts and floods – with impacts on economic activities such as agriculture, tourism, industrial and hydroelectric power production. One estimate puts the costs to Kenya of La Nina drought in 1998–2000 at \$28 billion. Increased prevalence of climate sensitive diseases such as malaria, Rift Valley fever and meningitis is also anticipated.

Various policies and laws affecting water ecosystem services have been overhauled in recent years. Water, forest and environmental policy now generally promotes decentralised natural resource management and provide for the establishment of institutions such as the National Environment Management Authority and the Water Resources Management Authority. Policy also now institutes the licensing and privatisation of service provision, fiscal incentives and disincentives, and water quality standards.

While the state’s capacity to handle water ecosystem issues is constrained by weak technological and financial capabilities, and by poor data, the level of political awareness about water issues is high. Participation by civil society, research institutions and the private sector in water management is increasing.

Areas for further research include the development of markets in tradable water rights that secure ecosystem services and equitable livelihoods; water ecosystem services, climate change, poverty and economic development; effective tools and methods for the integration of water ecosystem services and climate change in national policy processes; and up-scaling best practices in watershed management. The strengthening of stakeholder engagement and partnerships in research is also recommended.

Source: Awuor (2007)

## Sector reform that can grapple with institutional mayhem

Many countries are currently moving away from conventional forms of water governance, which usually have been dominated by a top-down supply-driven approaches, towards bottom-up demand-driven approaches, which combine the experience, knowledge and understanding of various local groups and people (UNDP 2007a). Perhaps reflective of the bureaucratic approaches that have prevailed in the water sector – there are 23 UN agencies dealing with water and sanitation. This flowering of institutions is mirrored at other levels: the state of Andhra Pradesh in India has over 30 government departments that have an interest in water management. Such institutional proliferation can prove a huge challenge for coordination and this is increasingly subject to review. Many governments are also moving towards better policy alignment in recognition of the fact that many policies outside the water sector can have a major bearing on levels and patterns of water demand and use (Figure 9).

**Figure 9.** Inter-relationships between different policies affecting water ecosystem services in Bolivia



**Notes to figure.** Four 'circles of influence' of policies on water ecosystem services can be discerned. The closer the circles to the centre the more direct impact they have on the provision of water ecosystem services.

Until recently, governments, and bilateral and multilateral organisations involved in sector reform, have tacitly accepted corruption in the way water is governed. Corruption has been seen as something that could 'grease the wheels' of development efforts. However, thinking is shifting and anti-corruption measures are now perceived as central to equitable and sustainable development water service delivery. A positive step on behalf of the European Union Water Initiative (EC 2007) has been to link water and sanitation expenditure to initiatives aimed at improving water governance.

## Conflicts increase as basins close

In most cases, water governance challenges intensify and become more complex as river basins approach 'closure' – the condition in which water demand outstrips supply to the extent that water resources are fully allocated (see Table 4). Molden and colleagues (2005) contend that river basins pass through three phases as available resources are developed and demand outstrips available supply. What is clear in many countries is that systems of water governance have been slow to recognise and adapt to challenges related to basin closure.

**Table 4.** Characteristics and concerns during different phases of river basin development

Characteristics/ Concerns	Development	Utilisation	Reallocation
<b>Approximate fraction of already flow allocated</b>	Low (0–40%)	Medium (40–70%)	High (70–100%)
<b>Dominant activity</b>	Construction	Managing supply	Managing demand
<b>Value of water</b>	Low	Increasing	High
<b>Groundwater</b>	Development	Conjunctive use	Regulation
<b>Pollution</b>	Limited pollution. Pollutants are diluted	Increasing pollution. Increasing regulations	Emphasis on control and clean-up
<b>Poverty</b>	Some improvements in access to safe water supply, irrigation and employment opportunities	Similar to 'development phase' but with O&M and rehabilitation employment opportunities	High risk of deteriorating safe water supply, irrigation access and employment opportunities
<b>Conflicts</b>	Few	Within sector	Cross-sectoral
<b>Typical institutional tasks</b>	Planning & implementing construction	O&M. Rehabilitation	Inter-sectoral planning. Often large complex infrastructural projects

Source: Batchelor (2007) after Molden *et al.* (2005)

## 'Integration' remains alluring yet elusive

Integrated water resources management (IWRM) is the current paradigm for sustainable water use and conservation. It was adopted by the World Summit on Sustainable Development in Johannesburg in 2002 as part of the wider international strategy for the MDGs. The starting point for IWRM is that all water should be treated as a single environmental resource and allocated within a coherent public policy framework among the main groups of water users: agriculture, industry and households. A definition of IWRM that is in common usage is as follows: *IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order*

*to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP 2000).*

By factoring in sustainability, the model also recognises that there are ecological limits to water use and that the environment has to be treated as a user in its own right (UNDP 2006). Another key concept installed is that of process. IWRM is a process of getting from some existing state to some envisaged and preferred future state through the involvement of all relevant stakeholders. IWRM is being promoted by many organisations, implemented in some areas and piloted in others.

However, in much of the world it is business as usual (Moriarty *et al.* 2004). The political naivety of IWRM has been denounced by Biswas (2004) because of the discrepancy between the concepts of integrated management and actual political institutions and property rights. These approaches can only succeed if the authority and resources of the management mechanisms are consistent with their responsibilities. IWRM requires institutions that take several years to develop, even with strong political commitment, and attention to the equity and social justice issues that are central to long-term sustainability and poverty reduction (UNDP 2006). Adopting an incremental approach – focusing on a few issues initially then gradually addressing additional ones as capacity increases – is often more feasible and effective.

*'We have pushed the mantra of IWRM long enough and deep enough – we need to DO it now, prove how useful it can be'*  
Simon Thuo,  
survey respondent

Yet the vagueness of the means by which holistic management might be achieved does not remove all utility from the IWRM concept nor should it be used as an excuse to regress into out-dated technocratic governance. IWRM continues to inspire many adherents among international agencies and it has inspirational value for the direction of improvement in governance for water ecosystem services.

## Box 12. South Africa's need for research that supports actual decisions and capacity rather than striving for unachievable levels of integration

South African water resources policy is considered by many to be among the world leaders in provision for protection of water ecosystem services. But despite various innovative policy developments over the last 10 years, much is yet to be translated into action.

A high-level framework for environmental protection and social redress is provided by the Constitution, while policy for water resource protection is focused on the maintenance of vital ecological functions and the 'silent services' these functions provide. The National Water Policy and National Water Act also provide for the re-allocation of water, through a process of compulsory licensing, and a Classification System that explicitly recognises the need to balance the protection of water ecosystem services with the use of the water for productive purposes (irrigation, industrial and mining uses).

Slow progress in introducing these mechanisms stems in part from a paralysis by analysis syndrome, where water resources managers attempt to fully understand the integrated nature of water resources, and the possible response of water ecosystem services, before making decisions.

While many water ecosystems in South Africa are adapted to extreme variability in water, many water ecosystem services are still likely to be vulnerable to climate change (Figure 10). South Africa's National Climate Change Response Strategy recognises that mitigation of these impacts requires coordinated action across a number of government departments, and pressures are building to shift water use away from agriculture towards industrial and mining uses that produce more jobs and income per drop. But this would increase South Africa's carbon footprint and fly in the face of international climate change agreements.

A lack of knowledge on threshold responses for some water ecosystem services makes it difficult to predict how they will respond to changes in climate – it is possible that increased temperatures, and a widening of the winter and summer shoulder seasons, may shift biological triggers affecting the functioning of ecosystems earlier or later. There are as yet no policy provisions on how these shifts could be accommodated in the Classification System.

Past economic policies in South Africa have unfortunately led to a widening gap between rich and poor, although they have made major progress towards addressing the injustices of apartheid. The new Government and President elected in 2009 may well make sweeping changes to economic policies in order to promote a more inclusive and equitable society. At this point, the impacts of these broader policy shifts on water policy and water ecosystem services are speculative.

Potential priority research questions identified through analysis in South Africa include:

- How to value water ecosystem services and how can pricing shift water use?
- How much integration is needed for practical approaches to IWRM?
- What are the threshold and amplification effects of climate change on water ecosystems?
- How can variability and vulnerability be managed by small businesses/producers?
- How do we move water ecosystem services up the political agenda?

Source: Quibell (2007)

**Figure 10.** Possible climate change effects on policy and practice in water ecosystem services in South Africa

THE IMPACTS OF CLIMATE CHANGE ON WATER ECOSYSTEM SERVICES						
	Water quality	Water quantity	Water for productive use	Ecosystem services*	Resilience	
<p>THE NATIONAL CLIMATE CHANGE RESPONSE STRATEGY</p> <p>→</p> <p>IMPACTS OF CLIMATE CHANGE</p> <p>→</p> <p>MITIGATION RESPONSES</p>	<p>Sets out a national response to both mitigate the impacts of climate change, as well as the country's response to its international obligations. It recognises that international action on climate change can be a vehicle to redress the historic, inequitable and unsustainable north/south divide of the world's economy and prosperity. The Strategy highlights a number of particularly vulnerable sectors, including the health sector, maize production, plant and animal biodiversity, water resources and rangelands. It also recognises that the South African economy is vulnerable to the responses of developed nations.</p>	<p><b>Increase in water borne diseases,</b> particularly an increase in the areas prone to cholera. Increased eutrophication and sediment loads. Shifts towards mining and industrial pollution use due to increasing water stress.</p>	<p><b>Reduced rainfall, amplified in reduced runoff and reduced water yields.</b> Reduced and more variable water yields increase unit costs of water. Reduced groundwater variability.</p>	<p><b>Increased demands for irrigation water.</b> High vulnerability of small scale water users compromises the effects of water reallocations. Loss of drylands farming areas forces more people into irrigation use.</p>	<p><b>Potential loss of ecosystem services due to changing runoff and flow patterns.</b> Increased temperatures and widening of rainfall runoff seasons impact on biological triggers. Possible threshold levels reached.</p>	<p><b>Increased frequency of droughts and floods</b> affects ability of systems to recover.</p>
	<p>Greater effort to realise MDGs for WSS in cholera affected areas. Tighter controls on industrial discharges as water use patterns shift. Land care and land rehabilitation projects.</p>	<p>Promoting shifts in water use that provide more crop and income per crop by pricing and other mechanisms.</p>	<p>Increased assurance of supply to smaller users. Promoting on-farm storage to capture short term high runoff events.</p>	<p>Maintain reserve, class and resource quality objectives by releases from upstream storage, or adapt these recognising the natural impacts of climate change.</p>		

\*Ecosystem services are used in the broadest sense as including natural filtration in wetlands, provision of housing materials, cultural uses, recreation, provision of food and medicines, and mitigation of floods and flows.

Source: Quibell (2007)



### 3.3 Analysis of research organisation and delivery mechanisms

If it is recognised that the knowledge needed for learning accumulates slowly, largely through practice, and that the time and resources invested in learning determine how quickly development occurs, the question arises: do we need more research on freshwater ecosystem services and poverty, or do we just need to put more existing research into practice? The answer is almost certainly that we need both – and we need them together. And it is likely that some of the most important understanding needed is on exactly how more research can be converted into practice.

*'People can't distinguish between good information and infomercials. The biggest function of research is to produce critical minds that can distinguish between trash and real findings'*  
Jesse Ribot,  
survey respondent

DFID is well placed to support those tackling the problems of governance that constrain the potential for wise use of ecosystem services. In its 2006 White Paper, DFID brings a major new focus on this potential. More specifically, the White Paper commits DFID to help partner countries develop sustainable and equitable ways of managing their fresh water resources. DFID recognises a key role for research in this effort and now seeks to set the scope of an appropriate research programme to be run by its Central Research Department. This programme will only work if it is shaped by the demands and views of those it seeks to help, if it finds a niche that complements the work of others, if it builds effectively on the strengths of DFID-supported past and current research and existing experience, and if it is focused both on spreading understanding of the problems and getting solutions into use.

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Multi-functional freshwater ecosystem services – and their problems, prospects and trade-offs – exemplify the need for a type of research that can meet the challenges of sustainability. This means research that can bridge the divide between disciplines and analyse the dynamics of ecosystems, economics and social interactions. The type of cutting edge research that is needed will be set in local contexts and applied in ways that recognise the special circumstances of the poor – particularly as regards risk, dependency, and long-term productive potential and environmental externalities.

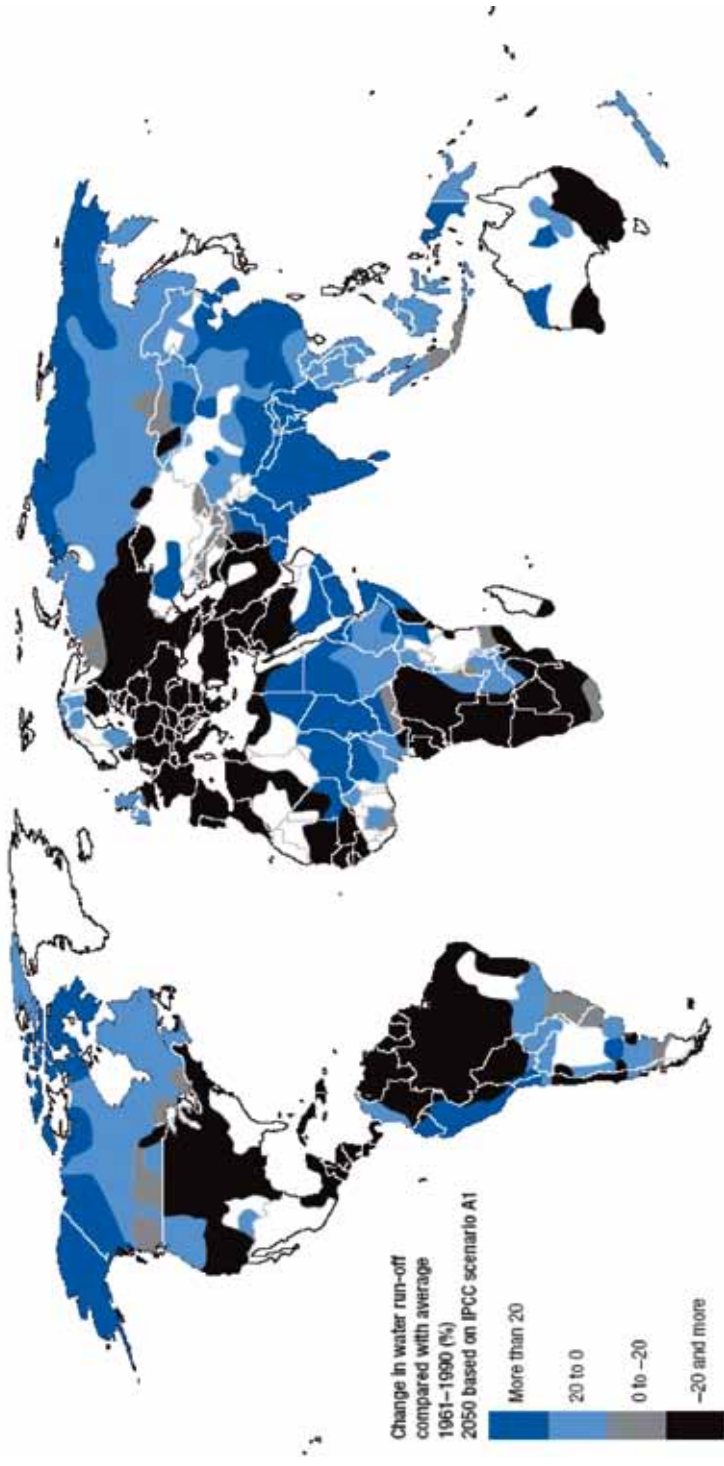
Many have argued that the idea of integration is conceptually appealing but impossible to achieve in practice as many attempts to integrate complex sets of knowledge and the interests of diverse actors into a common framework have yielded disappointing results. The desire to achieve integration persists but our inability to achieve practical results on the ground has bred disillusion.

Yet in other spheres it seems to be possible: large groups of diverse scientists collaborate to produce complex computer systems and unravel the complexities of human diseases. In contrast to these endeavours the markets for the products of integrated research and action on ecosystem services, at least in the developing world, are often embryonic. The costs of failure are not borne by scientists and researchers or by their supporters and users in governments and donor agencies. These costs are manifest in the suffering of resource-poor farmers and urban dwellers, and by society at large. Ultimate integration may indeed be impossible but efforts to achieve higher levels of integration are sensible. Integration is more costly in the short term but is likely to bring greater benefits in the longer term.

Sayer and Campbell (2004) identify seven conditions needed for this type of research:

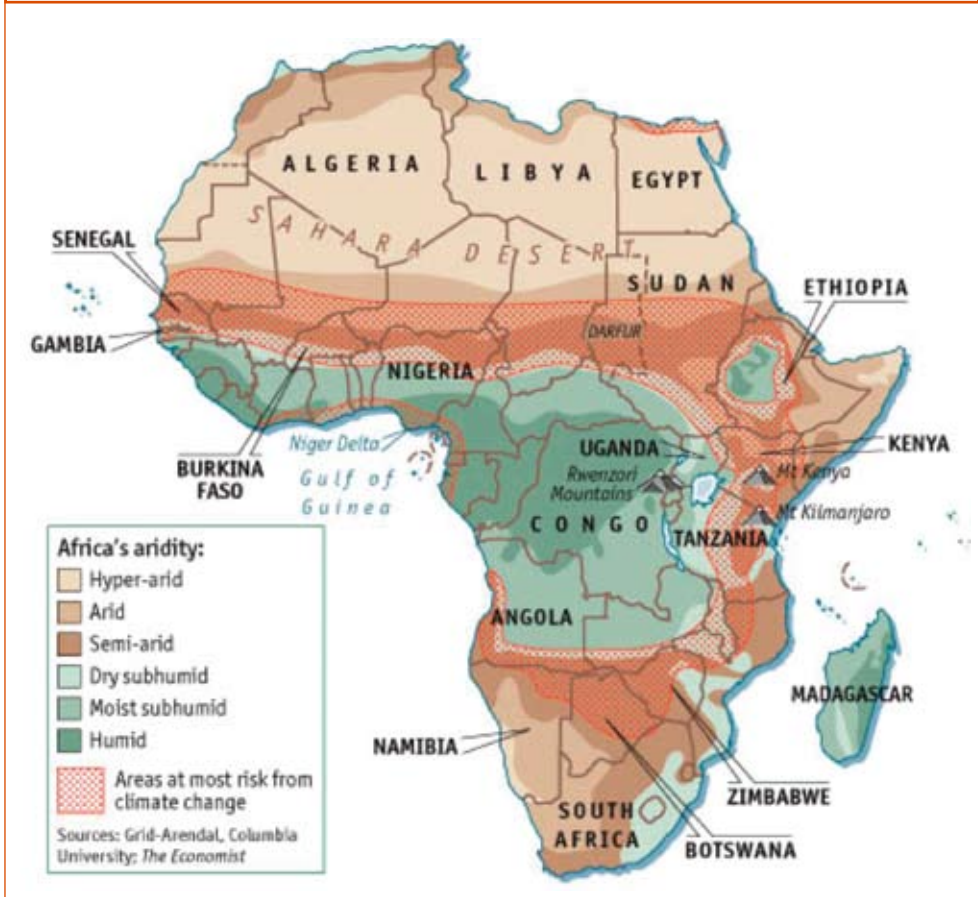
- Acknowledge and analyse the complexity of natural resource systems
- Use action research – become actors in the system
- Consider effects at higher and lower scales

**Figure 5.** Climate change will cause decline in water runoff in many regions



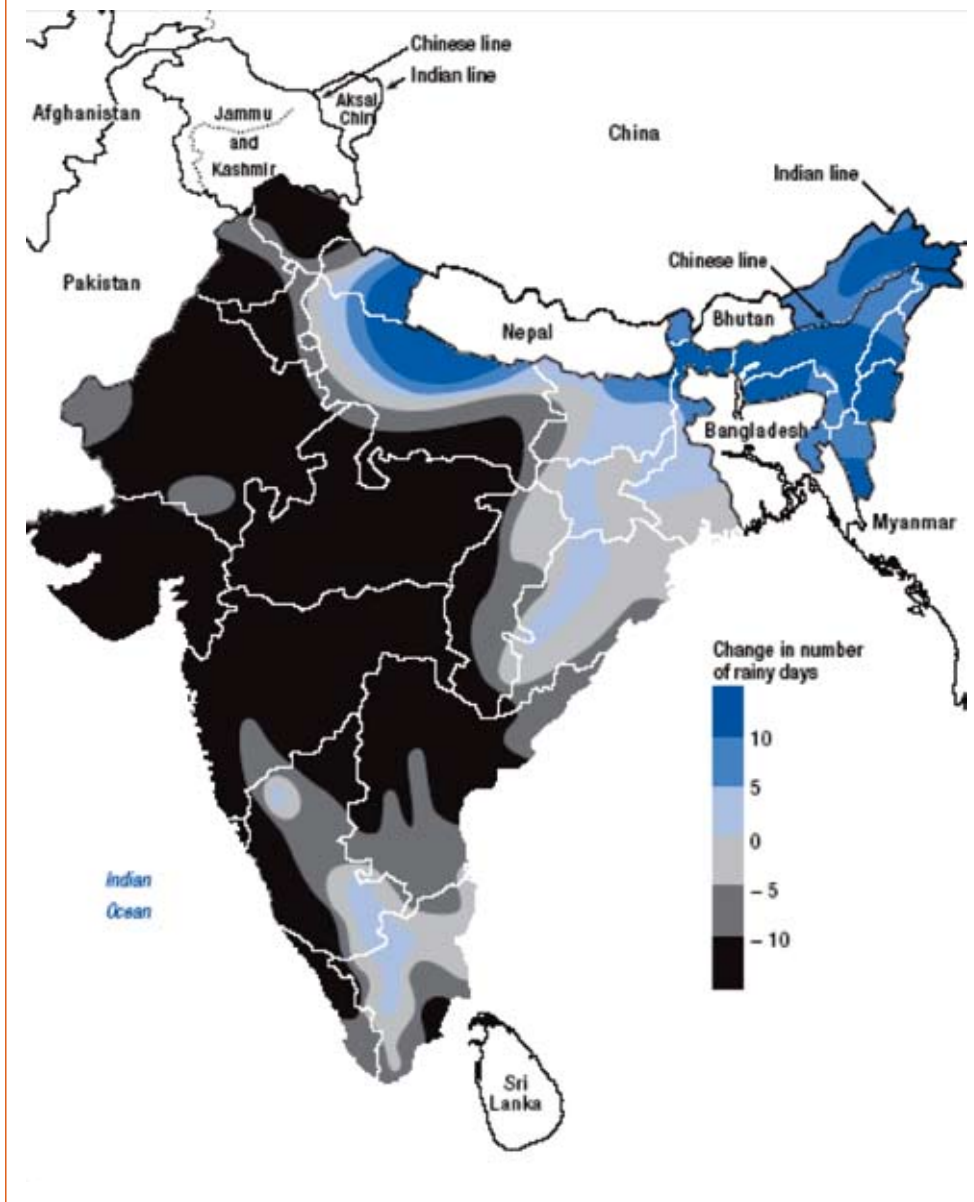
Source: Arnell (2004) cited in UNDP (2006), 162. Reproduced with permission by Palgrave Macmillan

**Figure 6.** Climate change risk in Africa



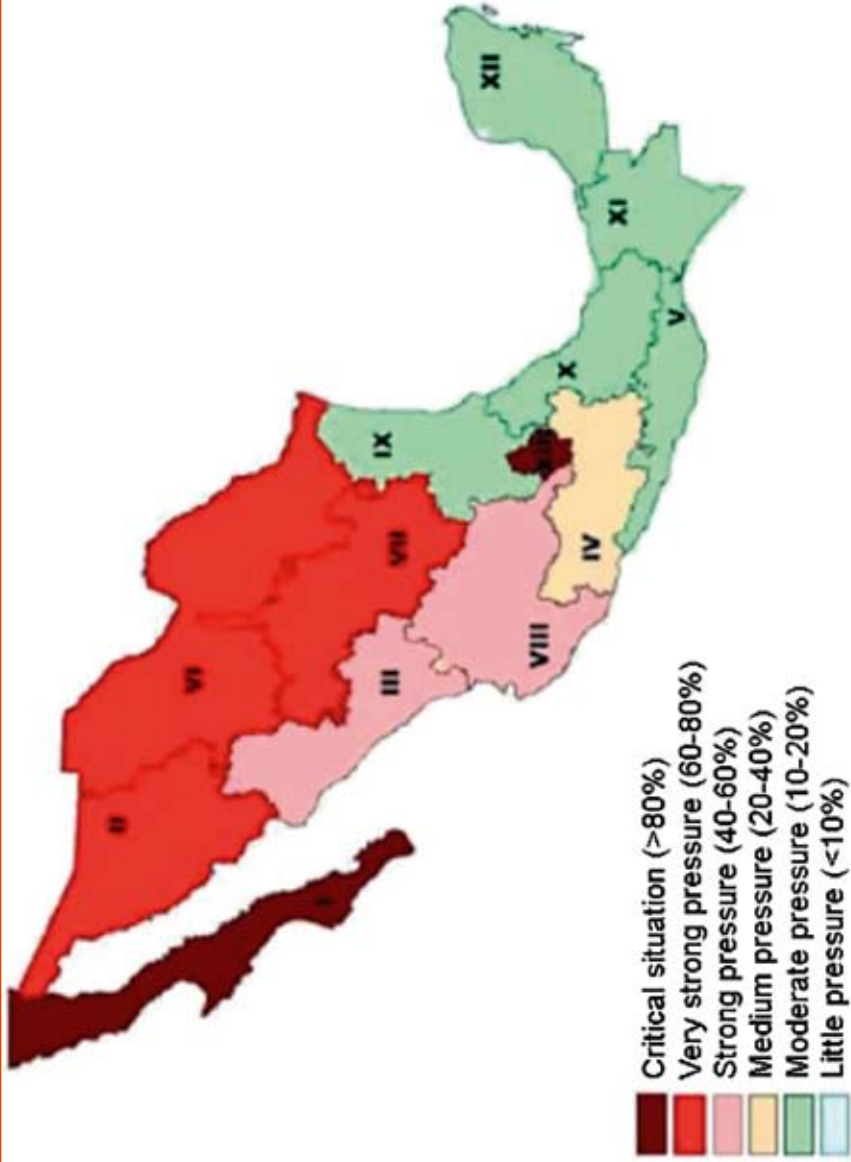
Source: *The Economist* (2007). Reproduced with permission by *The Economist*

**Figure 7.** Climate change will leave India with fewer rainy days



Source: Sharma and McCornick (2006) cited in UNDP (2006): 167. Reproduced with permission by Palgrave Macmillan

**Figure 8.** Water availability with climate change in Mexico – scenario for year 2030



Source: FGRA-FBS (2004) reproduced in Cortina (2007)

### Box 13. Research organisation and delivery priorities highlighted by the web-based survey and in-depth interviews

The top 10 (of 21) research organisation issues and delivery mechanisms by mean ranking of the 335 full responses to the web-based survey were:

1. In-built communication/policy uptake/impact strategies in research strategies
2. Involvement of local institutions in research cycle
3. Time/resources to tailor/disseminate research
4. Policy and practice analysis
5. Action research
6. Explore different stocks of knowledge and ecosystem–social system interactions
7. Longer time frames for adaptive research
8. Between project funding
9. Shape research by user demand
10. Learning groups/networks

Descriptive analysis and multivariate analysis of the responses to the web-based survey broadly coincide in identifying ‘process mechanisms’ and ‘research principles’ as key priorities. The following emphases on research organisation and delivery are drawn from the 54 interviews carried out:

**Research organisation.** There are many reasons why research outputs often do not translate directly into technologies and policies to support the lives of poor people. They include inappropriate research methodologies and poor communication strategies. Many interviewees felt that the subject matter of the proposed research programme lends itself to a stronger, but not exclusive, emphasis on ‘action-research’ and ‘action-learning’ methodologies. More effective communication of research results can generally be achieved through the establishment of ‘learning groups’ – organisations that are closely aligned and associated with action-based research methodologies.

There was broad consensus that favoured more user- and farmer-led research and that greater co-leadership within developing countries of research programmes was necessary and a potential DFID niche. But there was also widespread recognition of the paucity, and ongoing decline, of research skills in many developing countries that limits the formation of effective partnerships. There were some suggestions that DFID should focus its work through regional research organisations.

A number of respondents challenged DFID to achieve higher levels of coordination between the research activities of its central and bi-lateral development programmes, specifically with PSA (public service agreement) countries.

**Research delivery mechanisms.** There was a sense that too little research supported by DFID translates into technologies or policies that alleviate the constraints on poor peoples livelihoods. Again, investment in ‘action-research’ that allows a fuller understanding of challenges faced by poor people was emphasised, accompanied by learning platforms where stakeholders can share and reflect upon the results.

High levels of concern were expressed by interviewees that, while key messages about the future impacts of climate change are being effectively communicated to the public in Europe and North America, in Asia and Africa the level of engagement and debate is low. One of the challenges for a new research programme will be to consider how research process and outputs can support effective messages to policymakers and the public.

- Use models to build shared understandings and as negotiating tools
- Be realistic about the potential for dissemination and uptake
- Use performance indicators for learning and adaptation
- Break down the barriers between science and resource users

A range of tried-and-tested approaches and more experimental and innovative mechanisms for research and delivery may need to be considered. More developing country input in defining areas of need is likely to be central, as is more involvement of local institutions, federations of the poor and new social movements in the governance of the whole research cycle. In some of this work, methodologies that recognise and build on the value of plural stocks of knowledge (e.g. western science and indigenous knowledge) may prove important.

Longer time frames than have been the norm are likely to be needed – to allow for more in-depth analysis, adaptation to changing circumstances and greater use of action-research approaches. Significant flexibility and responsiveness may need to be built into management so that small and micro-grants, key meetings, publications and other communication products can be covered. Funding that remains available ‘between’ projects to maintain networks and avoid the feast/famine effect for priority research needs might be an important innovation.

A greater focus on research methods that engage with enabling environments may need to be considered, with capacity and uptake elevated from assumption level to objective level – e.g. work on governance, policies, institutions, property rights and market access. The timescales for research and the delivery of in-country development programmes are seldom synchronised. Research has a longer time horizon while the demands for development programmes are generally immediate. Better assessment methods may be needed especially for policy and poverty impact work. Efforts to ensure that robust evaluations of research and delivery programmes become routine would also be useful.

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Too much research is done only on the basis of a credential-check at the proposal stage rather than also involving follow-up and impact tracking. And too much research is too ‘safe’ – with short time horizons and a focus on familiar territory. More risk taking is needed – with funding for longer-term work with impact tracking.

Finally, a key set of mechanisms, in which experience is fast developing with promising results, is learning groups, communities of practice and networks that explicitly set out to develop and effect practical systems and capacity for re-orienting institutions and professional practice. They are recommended in particular where the field is not dominated by a single actor and there is a basic willingness to communicate. There is likely to need to be an external facilitating agent who convenes and motivates the grouping.



## Recommendations on research content

The following recommendations for priority research fields and issues draw on the preceding analysis of the evidence-base provided by the combined elements of this scoping study. The recommendations reflect the study team's judgement. Each of the fields and issues identified meets the following **criteria used for selection**:

- **Researchable gap in knowledge.** The issue is a key gap in knowledge that could benefit substantially from research.
- **Generic significance.** The issue cuts across development contexts (issues of concern in particular circumstances are of vital importance but are not included here).
- **Innovation.** The issue breaks new ground, offers a new angle or will require new thinking and perspectives to pursue.
- **Integration potential.** The issue is likely to open doors and be catalytic or encouraging of integration of bodies of separated work.
- **Impact likelihood.** The issue if well researched, with good organisation and delivery mechanisms (the subject of Section 5), is likely to have policy impact.
- **DFID comparative advantage.** The issue can be particularly well tackled through DFID, and wider UK government, support.

There are several principles about the *content* of research that cut across the fields and issues outlined below (principles of research *process* are dealt with in Section 5). All research content should reflect the following **principles**:

- **Scale.** All research efforts must identify and be clear about the scale(s) and geography they are dealing with. Concerted application of the concept of subsidiarity in managing water ecosystem services is also important – revealing, for example, many issues to be best dealt with at catchment level that were previously assumed to require basin-level approaches.
- **Change.** Change should be assumed and the flexibility to deal with it planned for. This applies equally as much to shifts in institutions and social systems as it does to shocks and stresses in the physical world. For water ecosystem services these issues come together dramatically in closing river basins – which demand a major research focus.
- **Trade-offs.** Trade-offs between competing objectives for water ecosystem services are the norm, integration is the exception. All research should bear this reality in mind and have clear politically astute targets based on a theory of change that recognises its drivers. It should also make every effort to explore potential unintended consequences.
- **Rights and sustainability.** Water should be treated as a basic human right, and water is needed for sustaining environmental flows (water left in stream). These are both guiding principles and sources of underlying tension (the trade-off at the heart of this subject).



- **Regulating and supporting services.** It is the regulating and supporting services of freshwater ecosystems that generally cry out most for greater recognition and understanding. There has been much more research on provisioning and cultural services. However, the main route to this recognition and understanding is often through better decision-making about provisioning services (hence the considerable attention to these in the recommendations below).

There are **five fields** of research that DFID should consider supporting, **each with priority research issues**. Research issues can be only roughly prioritised at this level because they are interconnected, and because the specific forms of the issues researched will have to be tailored and shaped by local circumstance. Some indication of relative priority of the issues in Africa, South Asia and Latin America is provided in a table below. All five research fields are important but they are in roughly descending order of priority. Within each field the issues are also of roughly descending order of priority:

#### A. Governance of water ecosystem services

- **Political economy of water ecosystem service management.** Empirical and theoretical understanding of the socio-political process of water decision-making from competing interest groups, sources of knowledge and power domains across community, catchment and transboundary levels. Tensions, trade-offs and degree of democratisation in decision-making on rights, access, allocation and sustainability. Awareness of training needs for those involved in, for example, international transboundary management negotiations.
- **Integrated water resource management.** Where institutional capacity enables planning to yield returns: evidence-based investments in public water services delivery that match sustainable supply and demand on a catchment or urban area basis; taking account of climate change when planning and developing water infrastructure; and raising the profile of water ecosystem service management in partnerships and working practices of agencies, for example, land, water, industry, education and health.
- **Managing/resolving competition, displacement and conflict.** Focused particularly on contexts of basin closure and movement of people from dryland areas into areas of higher potential, development of methods and tools for improved dialogue and conflict resolution, and approaches to move from assumptions of reallocation of water to higher economic value uses to more democratic development and management of water.
- **Climate change as driver of decisions despite uncertainty.** Adaptation and uptake of methods and tools that improve integration and accountability of water ecosystem service decision-making under conditions of limited data and uncertainty. Seizing the political opportunity of integration that climate change and other drivers of change can bring. Frameworks and tactics that realise multidisciplinary components and inter-sectoral negotiation. Sharpened decision

support systems including water scarcity mapping (i.e. balance between supply and demand) and use of remotely-sensed data on green-water management.

**Local institutional control of water ecosystem services.** Institutions that can govern access, regulate distribution and markets, negotiate for investments and give voice to the most marginalised users. ‘Policy subtlety’, subsidiarity and ‘distributed governance’ in the recognition of local and traditional water governance systems. Locally based conservation and use strategies informed by catchment-level data and policies. Institutional frameworks to handle transition from water understood as a free good to water seen as increasingly scarce. Mechanisms to ensure poor communities are guaranteed access to water, particularly where water privatisation is occurring.

## B. Variability, vulnerability, adaptation and resilience

■ **Resilience and reliability of water ecosystem services.** When variability and uncertainty are the norm – focus on resilience and reliability of regulatory and support services of ecosystems, e.g. over-design of water services infrastructure, early risk detection, negotiation to maintain water flows, conservation and restoration tactics for wetlands under variability. Increase knowledge of freshwater biodiversity and its links to livelihoods, and impacts of biodiversity loss on resilience.

■ **Responses to variability and risk.** Better understanding of variability of rainfall and water ecosystem service supply and their impacts on subsistence production and water services (with attendant risks of increased burden on women and children, divestment, indebtedness, loss of resource access and increased health risks) – and better practical insurance mechanisms. Informal or formal risk-reducing, insurance and knowledge-sharing institutions and approaches for poor people to reduce livelihood vulnerability from climate change.

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**Targeted and holistic adaptation.** Targeted adaptation, including social coping strategies, appropriate technological solutions, improved crop varieties, pollution control measures, indigenous soil and water conservation and farming adaptive capacity. Holistic adaptation mechanisms that avoid negative externalities.

■ **Changes brought by disease burdens.** Changes in vector and water-borne disease burdens, and impacts of the HIV/AIDS pandemic, on use of water ecosystem services.

## C. Land use change impacts on water ecosystem services

■ **Urbanisation, migration and water ecosystem services under climate change.** Links between critical water scarcity, migration and increasing urbanisation under conditions where climate change also causes sea level rise and more frequent extreme events (e.g. flooding, cyclones, etc.), with potentially severe impacts on the urban poor in coastal and low-lying areas.

- **Unrecognised consequences of climate change mitigation actions.** Impacts of changing energy and transport use on, for example, the terms of agricultural water use and costs of production for poor people, and on increased groundwater extraction.
- **Land use impacts of market shifts.** Impacts of production shifts, for example of food and horticulture with declining costs of airfreight, on water ecosystem services such as downstream water and groundwater quantity and quality as a result of agricultural intensification, waste disposal, etc. Water impacts of production systems and market supply chains fuelling rapidly emerging economies such as China, Brazil and India.
- **Biofuel production – poverty and water ecosystem impacts.** Potential types and scales of impacts and feasibility of their modification and mitigation – e.g. increased water use, reduced food production, reduced access of poorer groups to land, economic growth changes, impacts on water ecosystems including wetlands, river flows and groundwater systems.
- **Carbon storage and avoided deforestation – poverty and water ecosystem impacts.** Water ecosystem service impacts of evolving arrangements for carbon sequestration, including bundled and stacked water and carbon services, and incentives for protection of water ecosystem services in carbon markets.

#### D. Hydrology, technology and evaluation

- **Tools for predicting hydrological impacts of land use change.** Methods and particularly models that enable more precise prediction and monitoring of effects of land use change in arbitrary environments – reflecting non-linear cause and effect relationships in water ecosystem services and land use.
- **Soil and water conservation decision-support tools.** Effective approaches for ensuring that solid water conservation measures are planned and implemented to meet specific needs while taking full account of potential negative downstream impacts.
- **Groundwater recharge and surface water-groundwater interactions.** Causes and implications of rates of recharge, hydrological and hydro-geological processes relating to the contamination of groundwater with both pollutants and naturally occurring contaminants (e.g. arsenic, fluoride).
- **Applying complementary knowledge systems.** In seeking a stronger convergence between indigenous and scientific knowledge systems, focus on the decision-maker (at farm, community, or policy levels), whose capacity to critique and implement promising indigenous and scientific technologies is central.
- **Impact evaluation.** To maximise returns on investment for poverty reduction and ecosystem service sustainability – longitudinal data and stronger analysis

of pilot initiatives and other development interventions. Governance reforms demand particular scrutiny (e.g. decentralised decision making, establishment of stakeholder platforms, increased transparency, etc.), in particular the extent to which they are leading to more democratic water management and more sustainable water service delivery (as opposed to token participation and improved opportunities for expropriation of resources by elites).

## E. Market instruments, businesses and investment

- **Informal markets and small businesses.** Economic incentives and small business water issues recognising that most poor people operate entirely in the informal sector.
- **Prices, payment schemes and investment triggers in water ecosystem services.** Inter-disciplinary market chain and impact assessment work identifying better contracts, trade-offs, prices and taxation levels related to water ecosystem services. Environmental valuation as a necessary precursor to payment schemes and markets. Further exploration of payments for water ecosystem services, e.g. avoided abstraction and ecosystem modification, and work to expand their legitimacy. Understanding the conditions under which commercial actors invest in water scarcity solutions and sustaining water ecosystem services.
- **Productivity–equity nexus.** Water allocation to agriculture and ecosystems under conditions of scarcity against competing criteria of productivity (food, income) and of equity (nature, generational) across formal and customary legal systems. Potential for re-allocation of water to small entrepreneurs; possible re-allocation from the agricultural sector. Balancing markets that solve scarcities (water sellers; municipal water charges; bottled water, etc.) with access to safe water as a human right.
- **From green accounting to green decision-making.** Mechanisms that sharpen and install much solid work on valuing water ecosystem services in the key planning frameworks and macro-economic decision-making – from valuing services to getting them paid for.

**Regional prioritisation.** As stated above, the research fields and issues are pitched at a relatively broad level. This is because the team considers research organisation is best carried out at this level – with the specifics to be tailored to local circumstance in research proposals developed for particular contexts in South Asia, Africa or Latin America. Table 5 offers the team’s indication, on the basis of the criteria described above, of the differing priority of the issues across the three regions. This is the team’s opinion based on experience and review work carried out as part of this study and is a subjective assessment; further research and regional consultation would be needed to provide a truly comparative quantitative assessment. Latin America tends to receive comparatively lower priority for some of the issues, given that it hosts the majority of functioning schemes based on markets for environmental services (Porrás *et al.* 2007).

**Table 5.** Proposed regional priority of identified research issues, for this particular research programme

Research issue	Africa	South Asia	Latin America
<b>(a) Governance of water ecosystem services</b>			
Political economy of water ecosystem service management	XXX	XXX	XXX
Integrated water resource management	XXX	XXX	XX
Managing/resolving competition, displacement and conflict	XXX	XX	XX
Climate change as driver of decisions despite uncertainty	XX	XX	XX
Local institutional control of water ecosystem services	X	X	X
<b>(b) Variability, vulnerability, adaptation and resilience</b>			
Resilience and reliability of water ecosystem services	XXX	XX	X
Responses to variability and risk	XXX	XX	X
Targeted and holistic adaptation	XX	XX	X
Changes brought by disease burdens	XX	XX	X
<b>(c) Land use change impacts on water ecosystem services</b>			
Urbanisation, migration and water ecosystem services under climate change	XXX	XXX	XXX
Unrecognised consequences of climate change mitigation actions	XXX	XXX	XXX
Land use impacts of market shifts	XX	XX	XX
Biofuel production – poverty and water ecosystem impacts	XX	XX	XX
Carbon storage and avoided deforestation – poverty and water ecosystem impacts	XX	XX	XX
<b>(d) Market instruments, businesses and investment</b>			
Informal markets and small businesses	XXX	X	X
Prices, payment schemes and investment triggers in water ecosystem services	XX	XX	X
Productivity–equity nexus	X	X	X
From green accounting to green decision-making	X	X	X
<b>(e) Hydrology, technology and evaluation</b>			
Tools for predicting hydrological impacts of land use change	XXX	XXX	X
Soil and water conservation decision-support tools	XX	XX	XX
Groundwater recharge and surface water–groundwater interactions	XX	XXX	X
Applying complementary knowledge systems	XX	XX	XX
Impact evaluation	XX	XX	XX

Very high priority = XXX, High priority = XX, Priority = X

## Recommendations on research organisation and delivery

This section is divided into four parts. First, it suggests the essential characteristics of the kind of research needed to be effective in spreading learning and achieving policy impact in the above thematic areas, irrespective of institutional level and context. Second, it suggests some less essential but still generically desirable characteristics. Third, it highlights some context-dependent mechanisms of proven effectiveness that we suggest should play a major role in the potential research programme. Fourth, we note some aspects of research programme management that are particularly worthy of attention.

### Essential characteristics of effective research on the above themes

- **Fulfilling quality research criteria.** All research on water ecosystem services should be:
  - **Contributory** in advancing wider knowledge or understanding about policy, practice, theory or a particular substantive field
  - **Efficient** in being cost effective and enabling resources to be targeted where they are most needed
  - **Defensible** in design by providing a research strategy that can address the questions posed
  - **Rigorous** in conduct through the systematic and transparent collection, analysis and interpretation of qualitative or quantitative data
  - **Credible** in claim through offering well-founded and plausible arguments about the significance of the evidence generated
  - **Accountable** in process through open and honest reporting on progress
- **Demand led.** Research must be shaped by the demands of its potential users. This in practice often means breaking down considerable barriers that in practice exist between researchers and water ecosystem service users. ‘Demand led’ does not always mean farmer led or end-beneficiary led – key sources of demand that should be responded to include resource managers and decision-makers at local government and other levels.
- **Strategy for putting findings into use.** Policy uptake and impact strategies need to be built in and required of research. This is likely to be a function of the actors in the system concerned being involved in research design. It is key in this to recognise that governance and policy are not rational processes and that evidence is usually at best only one of the influences over decisions – and work to increase this influence.
- **Ecosystem–people interactions.** Explicit exploration of ecosystem and social system interactions is necessary in all issues – with implications for the expertise needed.

- **Installing flexibility.** Both researchers and their supporters need to expect that change will and should occur – and pay more than lip service to flexibility in research programmes and proposals. Use methods for including change, with uncertainty being expressed as a positive element of management – e.g. open sections in planning that can only be filled in after some time in operation. Reviews should welcome changes in activities, coupled with commitment to core objectives. Log-frames should be amenable to wholesale revision in the light of new learning and changes in the situation. ‘Break points’ where the initiative can be reassessed and redirected should be anticipated.
- **Breaking out of the silos.** Elite, monolithic research centres are of little value for research on ecosystem services. There is so much to be gained, for example, from reducing the separation of water and health research for sustaining water ecosystem services. Opportunities should be seized to adopt a systems approach.
- **Collaborative research approach.** Collaboration is essential for water ecosystem service research. This may include multidisciplinary teams within research organisations, which can appreciate differential powers within communities and protect the intellectual capital of institutions. It may also include a multi-sectoral approach: co-creating research with NGOs and the private sector to provide a wider vision and engagement with local/ regional actors.
- **Empowerment factored in.** Capacity-building contributing to poor people’s empowerment is a necessary part of this research agenda. Skills development at all levels generally needs support to undertake and use the results of research. Research initiatives that explicitly link more capable partners with ‘weaker’ ones, with the objective of developing capability, should be a clear focus. Research proposals should demonstrate a specific strategy through which partner capacities will be developed – and this will have consequent implications for the research – to have sufficient time and resources for such capability development to be achieved.
- **Realistic impact ambition.** Realism is required about the potential for dissemination and uptake. Site and context-specific detail may remain just that, but the processes involved, especially of successful integration, may have widespread impact if well disseminated and promoted.
- **Clear about return on investment.** Researchers and their clients should understand what the data will cost, and be transparent about the expected return on investment of the research.
- **Applying existing knowledge while breaking new ground.** Researchers should pursue opportunities for the application of existing but weakly developed knowledge in their generation of new knowledge through research. Any new research should demonstrate how it builds on foundations made by existing work, synthesised and critiqued as necessary.

## Desirable characteristics for effective research on above themes

- **Dealing with complexity.** The complexity of natural resource systems should be acknowledged and embraced – with tools and concepts of systems analysis being brought to bear in dealing with complexity.
- **Crossing scales.** Effects at higher and lower scales should be considered, with cross-scale analysis and planning routinely conducted and such analysis examined against simulations (best guesses) of long-term processes at other scales.
- **Modelling to provoke.** Systems modelling and scenario planning should be used to build shared understandings and as negotiating tools. Confront complexity with conceptual and systems models – models are needed which stimulate engagement and discussion and which can then be discarded, adapted or replaced.
- **Performance indicators for learning.** Tools for monitoring and evaluating system performance should be used – not impact assessment to then transfer technology – but information for learning and adaptive management.
- **User-determined.** More research funding resources should be put into the hands of research output users (e.g. catchment agencies, national water ecosystem service policy delivery departments) to allow them to direct the research agenda.
- **Combining scientific and indigenous knowledge.** The role of research should be not only to feed the process with scientifically based knowledge but also (through appropriate social science initiatives) to empower indigenous knowledge and experience for a knowledge-sharing process.

## Key mechanisms – context dependent

- **Action research.** Actors in a system become researchers, as researchers join them to become actors. This form of research aims at a fluid interaction between knowledge gathering, policy-related action, active tracking of action, adaptive management and concomitant development of adaptive capacity. It calls for well-understood and shared hypotheses and skilful management of multiple actors, recognising that the action research appropriate for policy research in a field that directly affects every individual in society must be inclusive and negotiated from the design stage onwards.
- **Support small-scale projects.** In spite of higher transaction costs, it is well worth supporting small-scale projects in order to ensure that all views are given a chance to be explored. Restricting support to only big initiatives and projects means that the potential for good, novel ideas may be missed, if they are being proposed by individuals or small groups who may not be part of the mainstream research community.



- **Learning groups, networks, alliances and platforms.** Learning groups and alliances are relatively new in development work but experience is sufficient to show that they can be a very powerful means to getting good research and ideas into use. Structures and approaches vary but a common focus is on innovation and scaling up in an area of common interest, involving facilitation of multiple stakeholders, disciplines and institutional levels. They enable researchers to connect with practitioners at all scales and across all sectors, and key messages to be directly transmitted to policymakers. Learning groups and alliances need effective facilitation and can be expensive in terms of transaction costs, but decision-making impact can be significant.
- **Time frames long enough for adaptive research to deliver.** There is a need for support over longer timeframes to enable research to be adaptive and responsive. Quality and depth should be the aim – with effective impact tracking – to generate useful, reliable solutions for a subset of problems rather than poor ones for many. Time and adequate resources are also needed to tailor and disseminate research. Longer-term research efforts should, however, be tasked with producing interim outputs with the potential to be picked up and used in policy.
- **Knowledge sharing mechanisms.** Information sharing between communities and disciplines, particularly in the field of risk management e.g. knowledge on how to cope with water shortages, vulnerability and disaster risk reduction and relief to provide lessons on how to cope with climate change. Support for developing country stakeholders to access knowledge resources from elsewhere in the world.
- **Key people on key issues.** Supporting key individuals with passion and contacts may well be the best research model in some circumstances e.g. on some key hydrological issues.
- **Combined research and policy consultation.** Some contexts require an explicit bringing together of national capacity in research for water management and related disciplines to set out a finite work programme to be carried out alongside a policy consultation with public fora at critical points and direct links to collaborating communities at study sites.
- **Policy dialogues.** Active consultations with policymakers and others to explore involvement in, and implications of, research are often crucial. Video or audio programmes in these contexts too can be highly effective.
- **Mass media and cultural media.** Academic papers and conferences may be important means of research dissemination, but they may not be, and are usually insufficient. Newspapers, radio and television may be used wherever immediacy and mass circulation can draw stakeholders into key lines of research or to raise the profile of findings. Theatrical groups and

cultural events can be key routes in the spread of research findings and public awareness raising.

- **Internet technologies.** As with all technologies, access is the critical issue for poor people but the nature of the 'digital divide' is changing all the time. For example, in Africa mobile phones are leapfrogging desktop computers as the means of accessing the Internet. The Internet has utterly transformed mass communication via email and websites such that research findings can be directed very specifically to people, networks and organisations that can lobby for change. Researchers must take advantage of the best tools online (RSS feeds; powerful databases; podcasts; conference webcasts; social bookmarking; social networks; etc.) and the best methods for storing, processing and sharing data, recognising the positive trends to more open access publishing and more technologies being developed as global public goods.

### Research programme management

- **Research consortia and alliances.** The joining of several research organisations, including combinations of developed and developing country organisations, to form consortia that manage and deliver outcomes that address a researchable problem, should be a major feature of the research programme recommended here. 'Triangles' of local partners (local relevance), international centres (cross comparisons) and developed-country centres of academic excellence (key science) may be needed on some themes.
- **Competitive grant facilities.** Much research on water ecosystems services and poverty reduction under climate change will best be supported through competitive grant facilities managed by effective commissioned institutions. Ability to run programmes with the above-highlighted essential characteristics should be the first consideration in selecting appropriate institutions, and the subsidiarity principle should then be applied. This may mean that both developing and developed country based institutions are selected.
- **Active database of potential lead research institutions.** Once research themes are agreed an active and transparent approach to developing and maintaining a database of potential lead institutions appropriate to the level and type of research is needed. This can be a key resource in itself for thematic networking, and is needed for managing restricted tenders (see below).
- **Open and restricted tenders.** Where funds and number of projects are restricted, it is not appropriate to put out open calls for tenders. If potential bidders realise there is only a small chance of winning a bid then they are unlikely to put in the effort needed to submit a good proposal. Guidance needs to be clear and calls restricted to a shortlist of organisations (see above).

- **Concept note process.** Calling for short concept notes in response to thematic priorities is the right approach to running the core of a research programme. Going too early to full proposal stage restricts creativity and accessibility of research funds and creates management burdens for both applicant and funder.
- **Include users and policymakers in proposal review process.** It would be useful to include users and policymakers in the proposal review process – as well as subsequent reviews of outputs – more explicitly. This will help to ensure research activities are designed appropriately for end users' needs and will increase engagement and acceptance of outcomes by such end users.
- **Project preparation facilities, capability scoping and inception periods.** For some types of theme and approach, where the concept is worthy but the specifics on the issue and institutional role identification are at an early stage, support for project preparation and an inception period is appropriate. Scoping studies prior to full-blown proposals can be an important approach – where a lead partner carries out an analysis of local capability among institutions and designs an appropriate strategy with some of them. In addition to the vital space thus given to prepare the research proposal, such a process can be charged with developing an appropriate type and level of stakeholder commitment (buy-in) to the work.
- **Innovation and flexibility funds.** Relatively small proportions of research programmes (10–20 per cent) set aside for innovative research ideas and one-off initiatives that meet programme aims should be considered.
- **Between-project funding.** Ways in which funding can be made available between projects, to maintain networks in priority research areas and avoid 'feast and famine' research cycles among key institutions, should also be a priority.
- **Advisory committees – independent but including stakeholders.** The screening and selection of projects may usefully involve an independent advisory committee with an open approach to scoring proposals. Representation on such a committee of some of the stakeholders in the issue at hand is an important mechanism to ensure credibility and accuracy.

## Way forward for DFID

DFID should consider structuring a research programme around the fields identified in Section 4, phasing in the issues identified over time according to the descending order in which they appear and enabling context-specific research on these issues to be identified and pursued. Guidance for DFID in setting up this programme is provided in Section 5 – with the identification of the essential characteristics of effective research in these fields and on research programme management. These characteristics can be developed to guide potential programme applicants, who should be encouraged to design their research around some further desirable characteristics and key mechanisms also identified above.



# Appendix 1.

## List of annexes available separately

Annexes to this report are listed below and are available to download as pdfs from the links provided.

**Annex 1.** Gosain, A. (2007) *Assessing policy influences on people's relationship to water ecosystem services: The Indian experience*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02514](http://www.iied.org/pubs/display.php?o=G02514)

**Annex 2.** Quibell, G. (2007) *Assessing policy influences on people's relationship to water ecosystem services: The South African experience*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02515](http://www.iied.org/pubs/display.php?o=G02515)

**Annex 3.** Awuor, C. (2007) *Assessing policy influences on people's relationship to water ecosystem services: The Kenyan experience*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02516](http://www.iied.org/pubs/display.php?o=G02516)

**Annex 4.** Asquith, N. and Vargas, M.T. (2007) *Assessing policy influences on people's relationship to water ecosystem services: The Bolivian experience*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02517](http://www.iied.org/pubs/display.php?o=G02517)

**Annex 5.** Cortina, S. (2007) *Assessing policy influences on people's relationship to water ecosystem services: The Mexican experience*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02520](http://www.iied.org/pubs/display.php?o=G02520)

**Annex 6.** Mortimore, M. (2007) *The interaction between freshwater ecosystem services, climate change and poverty in the Sahel*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02521](http://www.iied.org/pubs/display.php?o=G02521)

**Annex 7.** Reid, H. (2007) *Climate change and development: Results from a 2005 consultation on key researchable issues and priorities that have evolved since Climate change, development and the water sector*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02518](http://www.iied.org/pubs/display.php?o=G02518)

**Annex 8.** Hope, R. (2007) *Assessing poverty implications of climate change: Impacts on water ecosystems*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02519](http://www.iied.org/pubs/display.php?o=G02519)

**Annex 9.** Bond, I. (2007) *Payments for watershed services: A review of literature*. Report prepared for DFID scoping study. IIED, London. Available at: [www.iied.org/pubs/display.php?o=G02522](http://www.iied.org/pubs/display.php?o=G02522)

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The following reference list includes all the main sources assessed in this scoping study. It does not, however, include references consulted and assessed in the course of the five country policy and practice analyses – these can be found in the relevant annexes to this report.

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## Water ecosystem services and poverty under climate change: Key issues and research priorities

Benefits to people from water ecosystems like rivers, swamps, floodplains and groundwater systems are central to human well-being. But ecosystems are in trouble and the Millennium Ecosystem Assessment, the Comprehensive Assessment of Water Management in Agriculture, and the Intergovernmental Panel on Climate Change have each shown that freshwater ecosystem services are particularly vulnerable. Water problems for poor people are exacerbated by the abuse of ecosystems and global climate change looks certain to increase the stresses and variability they face.

To help shape a research programme proposed by the UK Department for International Development (DFID), this report seeks to highlight some of the critical issues facing water ecosystem services in Africa, South Asia and Latin America and makes recommendations on the research that is needed to fill the current gaps in knowledge and practice.

The views expressed in this study do not necessarily represent those of the institutions involved, nor do they necessarily represent official UK Government and/or DFID policies.

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