From the mountain to the tap:

how land use and water management can work for the rural poor

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how land use and water management can work for the rural poor

An overview of research conducted by the Centre for Land Use and Water Resources Research at the University of Newcastle upon Tyne, and the Free University of Amsterdam with partners in Colombia, Costa Rica, Germany, Grenada, India, South Africa, Sweden, Switzerland, Tanzania, The Netherlands, the United Kingdom and the United States of America.

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This booklet is based on a series of four research projects (plus an initial scoping study), known as the Forestry and Low Flows (FLOWS) project cluster and coordinated by the Centre for Land Use and Water Resources Research at the University of Newcastle upon Tyne since 2001.

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Front cover: Collecting water in the Luvuvhu catchment, South Africa. © Rob Hope

Frontispiece: Water flow in the Kuthera Nala watershed, India. © Achraj Bhandari

Back cover: Drinking water stored on the hillside near Rambuda village, South Africa. © Rob Hope

Foreword

Every day we read, watch and listen to reports of environmental, human and economic disasters, which appear to have been caused by uncontrolled deforestation and unsupervised forest degradation. Floods and landslides, sedimentation of irrigation systems and silting of hydropower dam reservoirs are often attributed to the felling of trees. But is such simple association correct?

Some national agencies, with international co-funding, are spending immense sums of money on tree planting, soil and water conservation structures and allied measures, in the belief that they are attracting rainfall and/or facilitating recharge of groundwater. These huge schemes are found especially in the watershed development programmes in states of India and in the "environmental forestry" programmes of China. Many other countries have smaller schemes, but are impelled by the same belief, which originated in the eighteenth and nineteenth centuries when there was limited understanding of global weather patterns, cycles and variation.

The advent of improved instrumentation and data-logging, plus much more powerful computer modelling and geographic information systems, now enables these beliefs to be tested. Process hydrology enables the components of the water cycle, from atmosphere through vegetation to soil and streams, and back to the atmosphere, to be studied in linked modules. The limitations of the previous "black box" approach, with measured input (rain) and output (streamflow) but only limited quantification of what happened to water between precipitation and river flow, have been substantially overcome.

The Forestry Research Programme of the UK Department for International Development has designed a cluster of related projects to make use of the improved instrumentation, better mathematical modelling and powerful geographic information systems to produce more reliable prediction of the association between vegetation (including forests) and dry season streamflows. This booklet summarises the findings from the individual projects in this cluster and derives the following ten policy lessons:

1. If water shortages are a problem in dry countries, impose limits on forest plantations, especially of fast-growing evergreen species.
2. Implement "green water" instruments (based on data from plant transpiration) to control levels of evaporation from upland vegetation.
3. If upland forests are cleared for cultivation, provide farmers with guidelines of best agricultural practice.
4. Any market mechanism or tax system linking land management to quantified streamflow should ensure that scientific validation is possible at the scale of the operation.

5. Use decision support systems to assess the impact of alternative land management options on water resources, and alternative land-use and water management and policy options on different social groups.
6. Ensure policy instruments are equitable in terms of livelihood benefits, not just water allocation.
7. Ensure that any proposed market mechanism is adequately pro-poor.
8. Consider improvements in rain-fed farming (crop breeding, rainwater harvesting, mulching, conservation tillage, market access, capacity building) in preference to further investments in rural small-scale irrigation schemes.
9. Use negotiation support system techniques such as choice experiments to ascertain stakeholder preferences for policy agreements.
10. Tailor employment programmes to dovetail with other livelihood activities of the people which they are intended to attract.

This booklet summarises the information, some of it conflicting, which has contributed to the ten lessons. The research findings will be a disappointment to some enthusiastic promoters of schemes for payments for environmental services, which are one of the most promising avenues for putting reliable amounts of cash into the hands of upstream land managers. Unfortunately, it seems just now that models for reliable prediction of dry season streamflows in relation to the management of catchment vegetation upstream will not routinely support local payments for water services. This is because there may be too many uncertainties in the ways in which water moves through the soil and rock in any but fully leakproof catchments. So payment schemes may need to be operated on regional or national scales in order to avoid complex litigation at local scale.

The broad topic of the Forestry and Low Flows cluster is advancing with fast interactions between research and the shaping of policy. For example, by the time of publication, the debate on allocation of the benefits of water in South Africa will have moved forward significantly. These developments are affecting the livelihoods of literally tens of millions of people.

The potential implications of the research summarised in this booklet are immense, as they contradict some current tree-planting policies and environmental beliefs. Unless there is urgent action now, the looming water crisis will aggravate, and leave the most vulnerable, the rural and urban poor populations, ever more disadvantaged.

John Palmer

Manager, DFID Forestry Research Programme

June 2005

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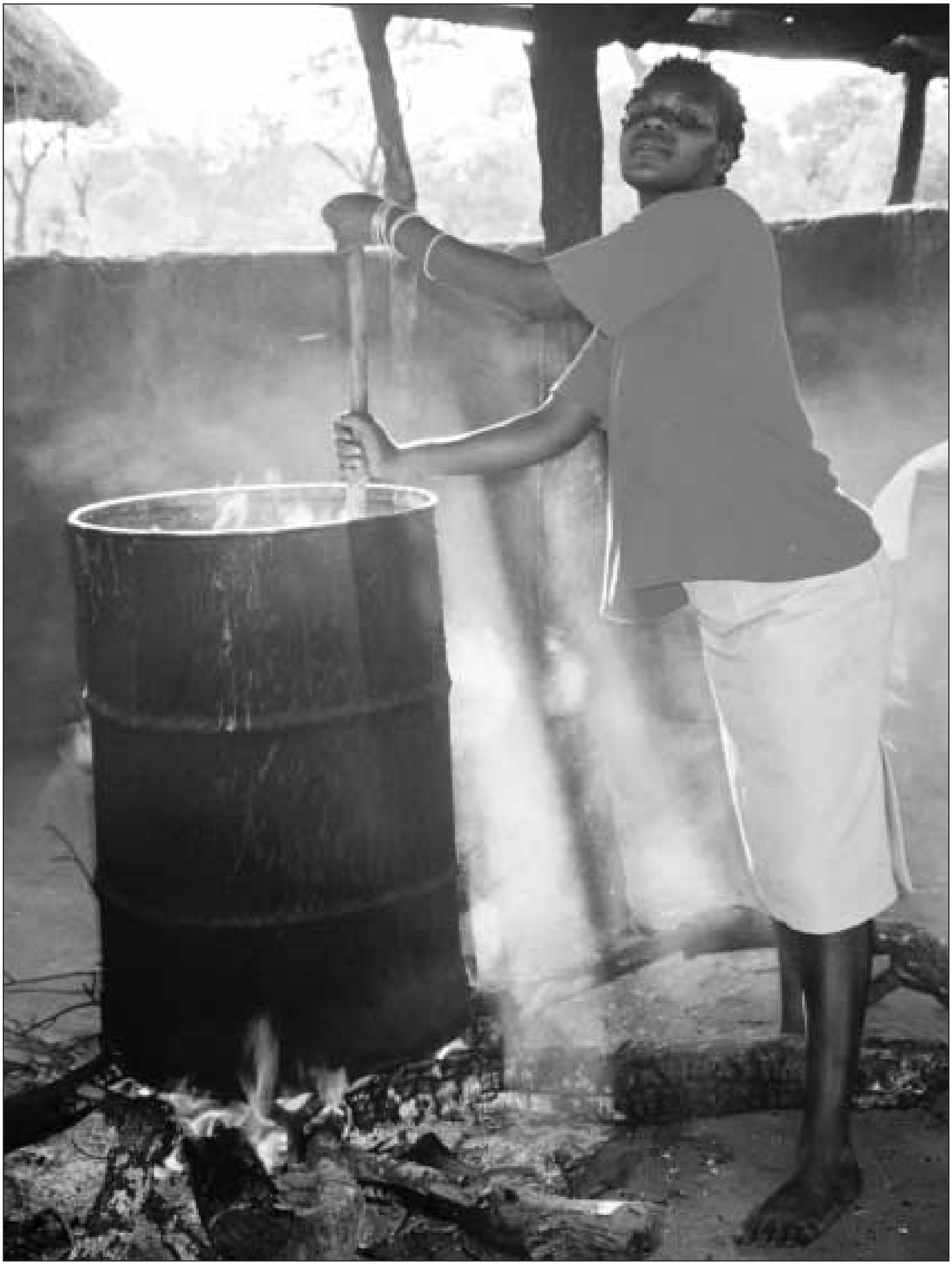


Woman in South Africa brewing beer from dryland maize. © Rob Hope

Section One **The policy problem**

Victor Torres and his four sons manage coffee terraces and promote agro-tourism on their 35-hectare farm in the Tilarán range of hills in Guanacaste province, Costa Rica.[1] Mrs Mulovhedzi is a primary school teacher who supplements her income by selling vegetables from her kitchen garden in the Limpopo province of South Africa.[2] Vijaya is a twenty-four year old migrant from one of the poorest districts in the Indian state of Tamil Nadu; she makes a meagre living from seasonal agricultural labour away from home.[3] These people have never met but one thing governs all their lives: water.

The World Commission on Water estimates that the demand for water will increase by around 50 per cent in the next 30 years and that around 4 billion people, one half of the world's population, will live in conditions of severe water stress by 2025.[4] To avert such a crisis, many countries of the developing world are implementing large-scale piped water and sanitation schemes. However, this development often fails to take proper account of water resource constraints and economic and environmental costs. As a result, several developing countries could be building up long-term problems of river pollution and environmental damage similar to that brought about in the developed world at the time of the industrial revolution.[5]

Target 10 of the UN Millennium Development Goals is to "halve by 2015 the proportion of people without sustainable access to safe drinking water". The million-dollar question for all policy makers involved in this process is how to make it happen and how to pay for it. This booklet, which brings together findings from research funded by the UK Department for International Development's Forestry Research Programme, aims to provide some answers.

Note: In this booklet, the terms "watershed" and "catchment" are used interchangeably depending on the prevalent use in the countries described. In this context, both terms mean the topographic basin that collects water from the surrounding ridges.

Sub-canal at the Khumbe irrigation scheme in South Africa. © Rob Hope

Section Two **Research in context**

Land and water links

Water resource planning tends to focus on the use and allocation of water from rivers, groundwater or storage, failing to take account of how land use upstream affects water flow downstream. This is a major weakness in the analysis of land and water interactions. Malin Falkenmark, senior scientist at the Stockholm International Water Institute, advocated in 1995 a "blue" and "green" water framework to illustrate how land-use influences hydrology in a catchment. She conceptually partitioned rainfall into two categories: that which returns to the atmosphere as evaporation and transpiration (green water) and flow to aquifers and rivers (blue water).[6]

In wet climates, forests evaporate more green water than shorter crops because of the "clothes line" effect. Just as wet clothes pegged out on a line will dry quicker than those laid out on the ground, so the very rough surface of forests assists the aerodynamic transfer of water vapour back into the atmosphere.[5] Because trees have deeper roots than other crops, they are able to tap and transpire more water during dry periods which leads to higher evaporation rates overall.

Demand for timber, paper and other industrial forest products is driving large-scale afforestation projects, often of exotic species on upland hillslopes. Likewise, demand for food and other agricultural products is driving irrigation schemes, often using submersible electric pumps to access groundwater supplies deep underground. Both these land-use changes tend to deplete water resources, both blue and green, reducing the amount available to the rural poor living in affected catchments (see Plate 1).

Beliefs and misconceptions

Beliefs relating to water and forests are entrenched in cultural history reaching as far back as seventeenth century colonial experiences of deforestation in fragile island environments.[7] The received wisdom of the time was that agriculture flourishes in a well-watered landscape with trees and forests and that agricultural decline is associated with deforestation, tree-less landscapes, drought and eroded soils.

From these correlations, it has been all too easy to assume that the activities of hungry peasant farmers in removing forest cover for agriculture and livestock have led to the loss of soil fertility and to a decline in dry season flows. Therefore, in the conventional "desiccation" discourse, preventing forest degradation and deforestation, and planting trees in catchments should reverse agricultural decline and restore rural livelihoods (see Box 1).[8]

It was only in the latter half of the nineteenth century that hydrological records and historical studies revealed the true geographical scope of droughts in the tropics. It became clear that global weather patterns and cycles were the key cause; not trees on individual hill tops.[8] Foresters and governments have been slow to take on board these scientific revelations. In the US Forest Service, it took more than half a century for attitudes to change (see Box 2). Even today, the notion that forests regulate and even increase water flow persists in some regions, particularly in sub-Saharan Africa and the Himalayan mountains.[7] These beliefs have justified, at best, community tree-planting schemes; at worst, the eviction of indigenous people to make way for forest plantations run by large private firms, as occurred in Indonesia during the Suharto era.[9]

Box 1
Forest and water "myths"

Trees stabilise water flow throughout the year, resulting in an increase in flow during the dry season:
Received wisdom suggests that, due to the "sponge effect", tree roots retain water in the soil. Thus, water from high rainfall does not immediately wash downstream but is released gradually throughout the year. However, hydrological research shows no evidence for trees retaining water in this way. It is, in fact, the level of porosity or degradation of the soil rather than the presence or absence of tree roots that determines the stability of streamflow throughout the year.[10] Recent hydrological studies show impacts ranging from a very significant reduction of dry season flows when previously tree-less catchments are covered in plantation forests to a "no change" situation soon after indigenous forest is cleared.[5]

Trees increase rainfall:
In general, the distribution of forests is a consequence of soil and climate conditions, not the reverse. Although there may be some situations where forests do lead to a small increase in rainfall, this will nearly always be more than compensated for by increased transpiration from the trees themselves.[5]

Trees reduce flooding and erosion:
Research shows that management activities associated with forestry, for example drainage, road construction and soil compaction during logging, are more likely to influence flooding and erosion than the presence or absence of forests themselves.[5] Deep-seated landslides and extreme flood events are not affected by forest cover but are the result of climate, rainfall, geology and topography.[10]

Box 2

The wagon wheel that upset the apple cart: revelations in the United States Forest Service[7]

In the early twentieth century, policy of the US Forest Service was driven by the idea that forests regulate streamflow. Despite an absence of scientific proof to support this notion, the Weeks Act was passed. This provided the US president with authority to purchase watershed forests in order to protect commercial interests influenced by the navigability of inland waterways. This government agenda gained weight from events such as the Ohio floods of 1907.

It was only in 1910 that the US Forest Service carried out its first systematic attempt to evaluate experimentally the impact of forest removal on streamflow. This project, known as the Wagon Wheel Gap experiment, involved the monitoring of streamflow from two adjoining watersheds over a nine-year period. After this time, forest cover was removed from one watershed but left intact on the other as a control. Streamflow was then monitored for another nine years. The deforestation of the watershed resulted in an increase in run-off that was sustained throughout the year, thereby negating the twin prediction of an increase in floodwaters, and a decrease in dry season streamflow.

The Wagon Wheel Gap results overturned ideas that had long been held sacred within the US forest community. The results did not change opinions overnight but by the 1950s, a number of research stations were established to examine the relationship between forests, water and soil run-off. Results tended to support the findings of the Wagon Wheel Gap experiment and, finally, the US Forest Service abandoned claims that forests regulate streamflow.

Water rights old and new

Over recent decades, many countries have substantially reformed legislation relating to water resources and rights. In contrast to the trend towards private ownership and rights for land tenure, reforms to water legislation have seen an assertion of state control and the introduction of complex regulatory mechanisms for the allocation of administrative water rights.[4] For example, following a severe drought in 1959, the UK government created a licensing system to limit the amount of water taken from rivers and streams; previously, landowners had the right to “reasonable use” of water resources that flowed through or adjacent to their land. Now, industry, agriculture, water companies and other users must apply to draw water in greater quantities than 20 cubic metres a day.

Such administrative water rights reflect the idea that water is a public good rather than a private asset. This is in keeping with the spiritual values of many non-western countries; the Maoris in New Zealand, for example, view water as "an essential ingredient of life", "a gift handed down by the ancestors".[5] The concept of water as a public good has been taken one stage further in the legislation of South Africa. In this country, the National Water Act of 1998 not only abolished riparian rights but also stated that every person is entitled to a "basic human needs reserve" of water.[11]

International policy

Over the past three decades, the United Nations has held around 20 major water-related conferences.[5] These include the International Conference on Water and the Environment (ICWE), which was held in Dublin five months before the United Nations Conference on the Environment and Development (Rio Earth Summit) in 1992.

The ICWE established four principles.[5] Firstly, freshwater is a finite resource, sustaining life and should be managed using an holistic approach. Secondly, water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels. Thirdly, women play a central part in the provision, management and safeguarding of water and should be empowered to participate at all levels in water resources programmes. And fourthly, water has an economic value in all its competing uses and all human beings have a right to access clean water and sanitation at an affordable price.

In 1996, water activists established the Global Water Partnership as an international non-governmental organisation (NGO) with the aim of promoting and translating the Dublin-Rio principles into practice. Policies promoted by this partnership were termed integrated water resources management (IWRM).[5] More recently, the term integrated land and water resources management (ILWRM) has entered the international vocabulary (see Box 3). IWRM and ILWRM are being practised to greater and lesser degrees in different countries.

> "Although water governance and holistic and integrated approaches to water resources management feature strongly in the international water agenda, in many countries water governance is in a state of confusion".
>
> UN World Development Report, 2003[5]

Box 3
Integrated land and water resources management
ILWRM objectives encompass the principles set out at the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro in 1992 (see page 6).[5]

ILWRM strategies seek to ensure:
- A long-term viable economic future for basin dependants.
- Equitable access to water resources for basin dependants.
- The application of appropriate pricing policies to encourage efficient distribution of water between the agricultural, industrial and urban-supply sectors.
- The prevention of further environmental degradation and the restoration of degraded resources.
- The safeguarding of local cultural heritage and ecology as they relate to water management, and the development of links between tourism and conservation.

ILWRM should recognise that:
- Solutions must focus on underlying causes, such as inequitable land tenure, not merely symptoms.
- Issues must be approached in an integrated way.
- Development of sound resource management and collective responsibility should take place at a local level.

ILWRM implementation programmes should:
- Clearly define management objectives, a range of delivery mechanisms and a monitoring schedule.
- Recognise that management strategies may require research to assess the resource base and, through the use of models and decision support systems, to determine the links between water resource development and impacts on the environment, socio-economics, equity and ecology.
- Establish mechanisms providing long-term support to programmes of environmental recovery.

Rationale for FRP-funded research

Advocates of integrated land and water management recognise that management strategies may require research to assess the resource base and, through the use of models and decision support systems, to determine the links between water resource development and impacts on the environment, socio-economics, equity and ecology (see page 7). For this reason, managers at the DFID Forestry Research Programme identified land-use change and streamflow as a priority area for its research and, in autumn 2000, funded LTS International to carry out an initial scoping study.

The scoping study was co-ordinated by Kirsti Thornber in Edinburgh and involved two workshops with potential research contractors and DFID staff.[12] The study identified that costs and benefits should be linked upstream and downstream, and that decision support systems could help land managers to value water catchments holistically. Decision support systems had previously assisted European policy makers working on forestry and other competing land uses; a similar system could be equally effective for water policy in developing countries.

As a result of the scoping study, FRP established the forestry and low flows (FLOWS) project cluster (see Box 4). This cluster includes four research projects established primarily in three contrasting locations in South Africa, India and Costa Rica which span a notional altitudinal and aridity gradient (see Plate 2).

The FLOWS research complements the work of other organisations, notably the International Institute for Environment and Development (IIED) and the World Agroforestry Center (ICRAF). IIED's programme on markets for environmental services and ICRAF's rewarding upland poor for environmental services (RUPES) project both explore how market-based approaches to managing environmental resources (including watersheds) can help reduce poverty, as well as satisfy economic and environmental aims. Both projects include the development of negotiation support systems to help inform policy decisions. Unlike decision support systems, which incorporate a relatively simple linear procedure, negotiation support takes account of the complex relationships between a whole range of stakeholder views and biophysical factors. Whereas decision support deals with a single outcome, negotiation support puts forward a range of management possibilities.

Like the work of ICRAF and IIED, the FRP-funded FLOWS research is geared towards providing a negotiation support system for policy makers and development workers. However, FLOWS differs in that it takes a formal experimental approach including rigorous statistical analysis of local people's responses to a range of management deals, all of which involve some degree of trade-off.

The following pages follow the work of the FLOWS researchers, beginning in South Africa and Tanzania, and continuing to India, Costa Rica and Grenada. In each country, working under different ecological, political and socio-economic situations, research teams have collected pieces of a puzzle that will eventually form a coherent picture. The penultimate section of this booklet brings together some of the lessons learned, and translates them into policy recommendations for the project countries and beyond. Finally, the last section looks at the latest and future developments in the field of integrated land and water management.

Box 4
The FRP-funded FLOWS project cluster

Project No.	**Project Name**	**Location**	**Lead Research Body**
R7937	Catchment management and poverty	South Africa, Grenada and Tanzania	CLUWRR, University of Newcastle upon Tyne
R7991	Management of upper water catchments	Costa Rica	Faculty of Earth and Life Sciences, Free University of Amsterdam
R8174	Socio-economic opportunities of upper water catchment environmental services	Costa Rica	CLUWRR, University of Newcastle upon Tyne
R8171	Low base flows and livelihoods in India	India	CLUWRR, University of Newcastle upon Tyne

South African widow with gourd drinking vessel. © Rob Hope

Section Three **Laying down the law: statutory control of water resources in sub-Saharan Africa**

Water is scarce in South Africa. Average rainfall is 497mm over the whole country[13] and tree plantations, sugar cane and non-irrigated agriculture all compete for this valuable resource. Forests require at least 800mm of rainfall to grow at economic rates so foresters have tended to plant trees in relatively wet mountainous areas.[5]

Recurrent fires destroyed much natural forest in southern Africa and, from the nineteenth century, foresters planted and managed plantations of alien species such as wattle and pine. By the 1920s, it was clear that many of South Africa's rivers were drying up. There was suspicion about the forester's myth that forests increase water flows, and concern about the contemporary drive for planting alien tree species.

As a result, hydrologists started looking at the effects of forestry on water resources. This research revealed that, compared to natural "baseline" vegetation (usually grassland or fynbos shrubland, which is unique to South Africa), forestry consumes a relatively large amount of water. Commercial plantations, which are located on the 10 per cent of land that generates 60 per cent of runoff, are now estimated to reduce surface run-off by 3.2 per cent nationally.[14] In response to these findings, the South African government finally established in 1972 a system whereby timber growers must apply for permits to establish new commercial tree plantations.[5]

Water equity

South Africa's apartheid history has left a legacy of inequality, not least in terms of water allocation. During apartheid, 83 per cent of agricultural land was in the hands of white farmers and the majority of water for irrigated agriculture was controlled through white-dominated irrigation boards.[4] The Water Act of 1956 linked water use to land ownership and contained no reference to environmental protection of this resource.[15] Even today, rotating irrigation systems squirt jets of water into the air just over the hill from dry areas where many households have no domestic water supply in or nearby their homes.

But there has been a move forward: today, the South African government treats water as a basic human right and puts great emphasis on equity in its legislation. One of the most important principles underpinning the National Water Act of 1998 is that there must be "equitable allocation" of water, fulfilling the "human needs" and "ecological" reserves, the latter to sustain the ecological functioning of aquatic ecosystems. The reserves must be set aside before water uses such as industry or agriculture can be authorised.[16]

The Department of Water Affairs and Forestry (DWAF) is now in the process of developing allocation equity mechanisms as a key component of South African water policy. Under these mechanisms, water uses with high levels of public benefit do not require a licence and take precedence over those with low levels of public benefit which may require careful consideration before a licence is granted.[5]

> "For us, water is a basic human right, water is the origin of all things – the giver of life."
>
> South Africa Water Policy White Paper, 1997[5]

Integrated land and water management in action

The South Africa National Water Act of 1998 is arguably the leading worldwide example of water legislation based on ILWRM principles.[5] South Africa is the first country to implement integrated land and water management through its own-originated "user pays" principle and mechanism. Under this system, forestry, as a high water-user, or "streamflow reduction activity", must pay an "interception levy".[5] By penalising forestry as a high user of water that results in relatively low streamflow, South Africa is the first country to address the green (evaporation) and blue (flow) water concept in its legislation.[5]

South Africa is also innovative in its approach to controlling invasive alien plants. The Working for Water programme, which was established in 1995, has two aims: to remove non-native invasive plants for ecological and water conservation purposes[5, 14, 17] and to address the severe problems of unemployment that exist in rural South Africa. The programme has an annual budget of US$50 million, which is distributed to more than 300 projects creating more than 20,000 temporary jobs per year.[14]

Implementation of the National Water Act has met with some resistance from landowners. For example, the South African government has identified sugar cane as another potential streamflow reduction activity, but growers are contesting this, arguing that variation in climate, soil, water demand and economic and social conditions make such a designation nearly impossible to validate scientifically.[5]

The view of the rural poor

The DFID Forestry Research Programme funded a team led by Ian Calder at the Centre for Land Use and Water Resources Research (CLUWRR) in Newcastle upon Tyne to work with the Department for Water Affairs and Forestry (DWAF) in South Africa on the catchment management and poverty (CAMP) project. This project compared and contrasted resource-focused integrated land and water management, and people-focused sustainable livelihoods approaches within the Luvuvhu catchment of the Limpopo Province in South Africa.

Working with the University of Kwa-Zulu Natal, CSIR-Environmentek and DWAF, hydrologists and economists at CLUWRR identified activities that both improve the livelihoods of poor people and protect land and water resources. Household-scale sustainable livelihoods assessments, co-ordinated by Rob Hope at CLUWRR, were combined with large-scale hydrological and economic modelling to examine the effects of alternative policies on forestry and water allocation.[18, 19]

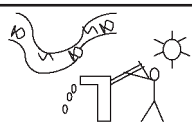
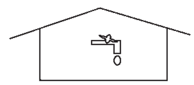
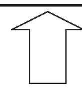
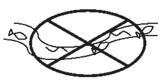
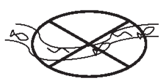
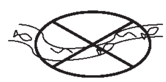
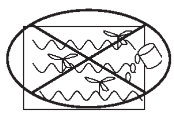
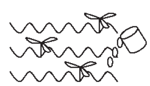
Figure 1:
Project location: Luvuvhu catchment, Limpopo Province, South Africa

Rural people in the downstream zone of the Luvuvhu catchment of South Africa were invited to take part in a “choice experiment”: a simple yet scientifically rigorous way of analysing, in this case, household trade-offs between domestic water quantity, quality, source, productive use and river flow (see Figure 2). This experimental procedure, which is used widely in other disciplines such as marketing, transportation planning, psychology and environmental valuation, involves complex statistical analysis of the trade-offs people are willing to make; it is not simply a ranking of services in an order of preference.[13, 20]

Results from the choice experiment indicated that, of all the potential changes that could be made to domestic water supplies, upgrading to a private home supply made the greatest impact on the welfare of the poor.[13, 21] Only a minority (12 per cent) of the households surveyed preferred the benefits provided by improved water for kitchen garden irrigation.[13]

Rob Hope and his team found similarly limited pro-poor impacts from irrigation in the Khumbe area, which has a long-standing small-scale irrigation scheme. By conducting a livelihoods analysis, the team found that water allocation to this scheme enabled a few farmers to increase their crop productivity and income. However, water allocations were inequitable and inefficient at a local level; only a handful of farmers benefited whilst elsewhere in the catchment, others struggled unsupported with the challenges of rain-fed farming.[2]

Figure 2
A choice experiment dummy card: designed to check that participants understand the experiment concept

Attribute	**Status Quo**	**Option 1**	**Option 2**
Household Domestic Water Source			
Household Daily Domestic Water Use (25 litre containers)	Current	3	18
Household Domestic Water Quality	=	=	
River Floor Failure in October	 1 in 10 Years	 1 in 3 Years	 1 in 10 Years
Irrigate Kitchen Garden Crops in Dry Season	Current		
Tick <u>One</u> Box	☐	☐	☐

South African government policy states that every citizen should have access to 25 litres of potable water per day within 200 metres of the home. However, the FRP-funded research indicates that this will not necessarily improve the livelihoods of local people. Firstly, unreliability of supply is a problem; as many as 2 million of the water taps installed do not work properly. Secondly, the benefits to poorer social groups are limited because these people may not have land, money for seed, or their own livestock.[2]

Taxing streamflow reduction activities and allocating more streamflow to rural households is, in the absence of other development initiatives, unlikely to reduce poverty. For the poorest in society, dryland resources such as seasonal wild fruits and woodfuel, which in contrast to irrigated agriculture are fed by rainfall alone, provide more livelihood benefits. For example, one of the few income-generating activities available to women in rural South Africa is brewing beer from dryland maize and millet (see Box 5).[2, 21]

Box 5

Mrs Mbedzi: the shebeen[i] queen[2]

Mrs Mbedzi left her native village of Makuya in the 1950s to marry the "makoma" (deputy headman) from a neighbouring village, Mutele A. The couple's livelihood activities revolved around Mr Mbedzi's employment as a livestock herder for one of the seven other families in the village. They had no livestock of their own, so Mrs Mbedzi made a living from dryland farming and brewing a 200-litre barrel of "mahafhe" beer a week. The cash they made from the mahafhe paid for their five children's education; Mrs Mbedzi's eldest son and current makoma is now a nurse.

The CAMP socio-economic evaluation revealed that the Working for Water programme also has limited pro-poor impacts. Although the jobs it offers pay high local wage rates (if bonuses and holiday allowances are taken into account), these positions are very limited in number and are not necessarily taken up by the very poor. Only 0.5 per cent of catchment households work for the programme and the criteria for applications do not prioritise the poorest in society. For example, an unemployed person with 5 hectares of irrigated land, 10 cattle, US$1,000 in the bank, two working children and a tractor would qualify for selection. An additional problem is that person employment days are erratic throughout the year, ranging from 11 to 15 days per month. This creates cash flow problems and stress for workers in managing their income.[14]

i Places where predominantly men gather to drink traditional beer

> "Reform of traditional authority structures and land tenure are required in a manner consistent with wider democratic ideals and liberties to prevent pro-poor policies being blunted by a legacy of past inequalities."
>
> Rob Hope, 2004[2]

Modelling impacts and developing a decision support system

Ian Calder and his team of hydrologists used two models, ACRU[ii] and HYLUC[iii], to simulate the effects of changing land cover and management, rainfall, streamflow, evaporation and sediment yield in the Luvuvhu catchment of the Limpopo Province in South Africa. ACRU was also used to simulate various alien invasive plant scenarios.[19]

The team fed into the models 44 years of daily hydrological data, and simulated six major land uses: commercial forestry, commercial irrigation, commercial dryland (rain-fed) agriculture, rangeland, urban development and water bodies. The models showed that land-use change from natural grassland to seasonal dryland cropping is likely, in most cases, to increase run-off downstream.[2] An evaluation of three Working for Water projects identified that removal of tall invasive alien plants such as black wattle was an efficient means of conserving water in situ and downstream.[17]

Ian Calder and his colleagues used the hydrological model, HYLUC, and a socio-economic modelling system, to support the EXCLAIM[iv] tool, a web-based geographic information systems (GIS) tool designed as a decision support system for non-specialist policy makers. EXCLAIM provides access to the technical modelling systems through a user-friendly computer interface. By entering land-use and rainfall data using on-screen sliders (see Plate 6) users can predict the impact of land management decisions on streamflow, economic productivity and job opportunities in a year with a particular amount of rainfall. To give a broad indication of whether a change will have a positive, negative or negligible impact, a "smiley" (a happy, sad or impassive face) shows whether there is a significant change from the base state.[22]

An EXCLAIM tool set up for the Luvuvhu catchment in South Africa is accessible online at www.cluwrr.ncl.ac.uk.

ii Named after the Agricultural Catchments Research Unit of the University of Kwa-Zulu Natal where the model was originated

iii Hydrology and land-use change

iv Exploratory climate, land assessment and impact management

> "EXCLAIM is a very useful interface for demonstrating to policy makers and stakeholders the hydrological effects of land-use change."
>
> Holger Hoff, consultant to the international sustainable development organisation, GTZ

Transferring findings to Tanzania

As part of CAMP, the University of Newcastle upon Tyne worked with the University of Durham, the Natural Environment Research Council's Centre for Ecology and Hydrology, CSIR-Environmentek and the Sokoine University of Agriculture to investigate whether the South Africa findings could be transferred to the Mkoji sub-catchment in the Usangu Basin of Tanzania. Activities included livelihoods assessments and an economic assessment of water in relation to agriculture and brickmaking.[19, 23]

Agriculture is the foundation of Tanzania's economy, accounting for 50 per cent of national income and 80 per cent of employment. The government aims to increase agricultural production whilst reversing current loss and degradation of environmental resources. However, policies and plans frequently fail to deliver an integrated approach.[23]

Although the new draft water policy for Tanzania includes elements strongly influenced by the South African National Water Act of 1998, the concept of streamflow reduction activities is not present. The FLOWS research team concluded that statutory legislation in Tanzania is unlikely to lead to the provision of environmental services unless more integrated land-use and water management policies that incorporate the concept of streamflow reduction activities are introduced.[23]

A temple built around a natural spring in Himachal Pradesh, India. © Achraj Bhandari

Section Four **More trees, more water: watershed development programmes in India**

> "As far as investment priorities are concerned, water management has to take the highest priority."
>
> Manmohan Singh, prime minister of India[24]

India is home to around 16 per cent of the global population but holds only 4 per cent of the world's total water resources.[25] As more and more groundwater is extracted, water tables are dropping in most Indian states; at rates of a metre or more a year in many arid and hard rock regions.[26] Irrigated agriculture is the main culprit. In some southern Indian states, about two thirds of power is used solely for pumping ground water to the surface to irrigate crops. There is no licensing system and electricity for this purpose is either subsidised or free.[5]

Excessive use of groundwater creates particular problems in catchments that are approaching closure, a condition in which supply is equal to demand and all available water resources are fully allocated, with no ecological reserve to ensure that aquatic ecosystems are maintained. This often has the perverse and inequitable effect of reducing the availability of "public" water in communal village tanks yet increasing the "private" water available to farmers with access to deep groundwater resources via electric pumps (see Box 6).[27]

The Indian government has recognised water as a critical limiting resource and, in 1987, adopted a national water policy, which it later revised in 1992. This policy is based on the premise that forest cover conserves water in the catchment.[28] Large tree-planting schemes have therefore been implemented for the purpose of increasing and stabilising water supplies downstream.

Indian water policy is reiterated in the Hariyali guidelines for watershed development, the first objective of which is to "harvest every drop of rainwater…" in order to create "sustainable sources of income for village communities and provide drinking water supply". While this approach could provide benefits at a local level, the ramifications to communities downstream in the water catchment could be severe.[29, 30]

Box 6

The water lords of Ramnad in Tamil Nadu[3]

Ramu does not spend too much time on agriculture these days. True, he is one of the biggest landowners in Keelathooval village, but he is into a business that pays far better. Ramu owns a borewell and an electric pumpset. That makes the young entrepreneur one of several "water lords" in Ramnad. This is a chronically drought-prone district that has suffered an average rainfall deficiency of around 112mm per year in the last decade.

Close to 90 per cent of the irrigated area in Ramnad depends on water in 1,841 rain-fed tanks. That means that Ramnad's inhabitants live at the mercy of the monsoon. The district does not have a single perennial river; even its share of wells is 20 per cent below the Tamil Nadu average. Farmers who do not have access to water resources and pumpsets have to buy water from those who do.

Ramu charges per hour for the use of his three-horsepower electric pumpset during the agricultural season. Two factors favour Ramu in his deals. One, he has few overheads; as an agriculturist, he gets electricity free. Two, a low voltage is the norm here. This leads to the pumpset running twice the number of hours it should, increasing Ramu's profits.

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Confusion reigns

Since the mid 1950s, the Indian government has supported watershed development programmes, which advocate the planting of trees to conserve streamflow. In 1990, common guidelines called for the hitherto top-down regulatory approach to be replaced by a community-based bottom-up approach, and transformed the way in which watershed development programmes were implemented in the country.[30] But although this deregulated approach enables rural communities to participate in decision-making, it also provides significant challenges to the holistic and integrated management of water resources at the catchment scale.

An additional problem for policy makers involved in watershed management programmes is that research responsibilities are spread between various technical government departments, many of which use different data sets. Although large amounts of physical, institutional and socio-economic data have been and are being collected in rural areas, these data are of variable quality, are not always easily accessible and are stored in a wide range of formats including maps, tables, remotely-sensed images, text and graphs.[31] This makes it very difficult for scientists to work together and get an integrated picture of what is happening at the watershed scale. It can also result in a plethora of scientific findings conveying mixed messages to government ministers working on land-use and water management policies.

Implementation of integrated land and water management policies is also hindered by disparate administration. Several central government ministries including the Ministry of Agriculture, the Ministry of Rural Development and the Ministry of Environment and Forests, as well as departments at national, state and local level are involved in the planning and implementation of watershed management policies.[25]

Approximately US$500 million per year has been spent on watershed management in India since the mid 1990s.[28] Despite this, the Indian government and the World Bank, which funds several watershed development programmes, have commissioned very little quantitative evaluation of how their management approach affects water flow downstream.

Research funded by the Overseas Development Agency (the predecessor to DFID) provides some insights. A study in Karnataka demonstrated that rates of evaporation from both indigenous forest and eucalyptus plantations growing on soils of average depth (around 2.5 metres) is around twice that from unirrigated dryland agricultural crops such as ragi (finger millet).[32] This evidence suggests that tree-planting leads to reduced water flows downstream, and does not bode well for policies underpinning watershed development programmes.

Modelling forest-water relationships

The DFID Forestry Research Programme funded Ian Calder at the University of Newcastle upon Tyne to work with Ashvin Gosain at the Indian Institute of Technology (IIT) in New Delhi on rationalising data sets and developing hydrological models to assess the impact of changing forest cover on water flow. Jaime Amezaga, also based at Newcastle, is working with the NGO Winrock India International, to analyse the impact of water myths in Indian watershed development policy and to improve communications between scientists and policy makers.[28, 33] Field research is taking place principally in micro-watersheds in the states of Madhya Pradesh and Himachal Pradesh, where local communities have been asked for their views on watershed development programmes and the relationship between forests and water.[29]

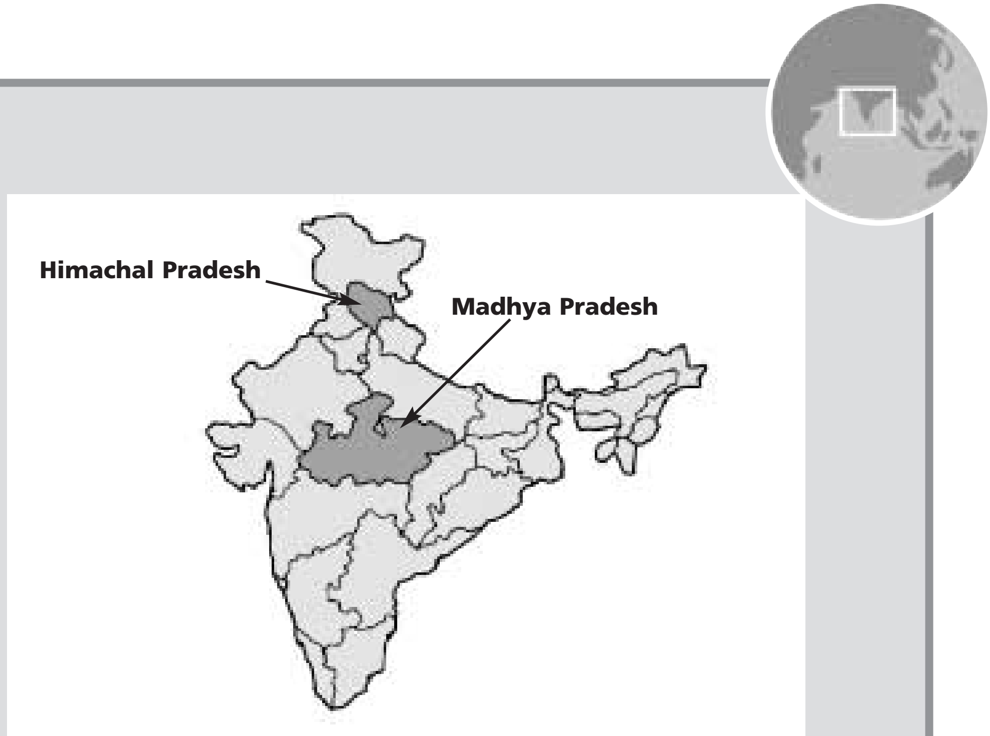


Figure 3:
Project location: the states of Himachal Pradesh and Madhya Pradesh in India

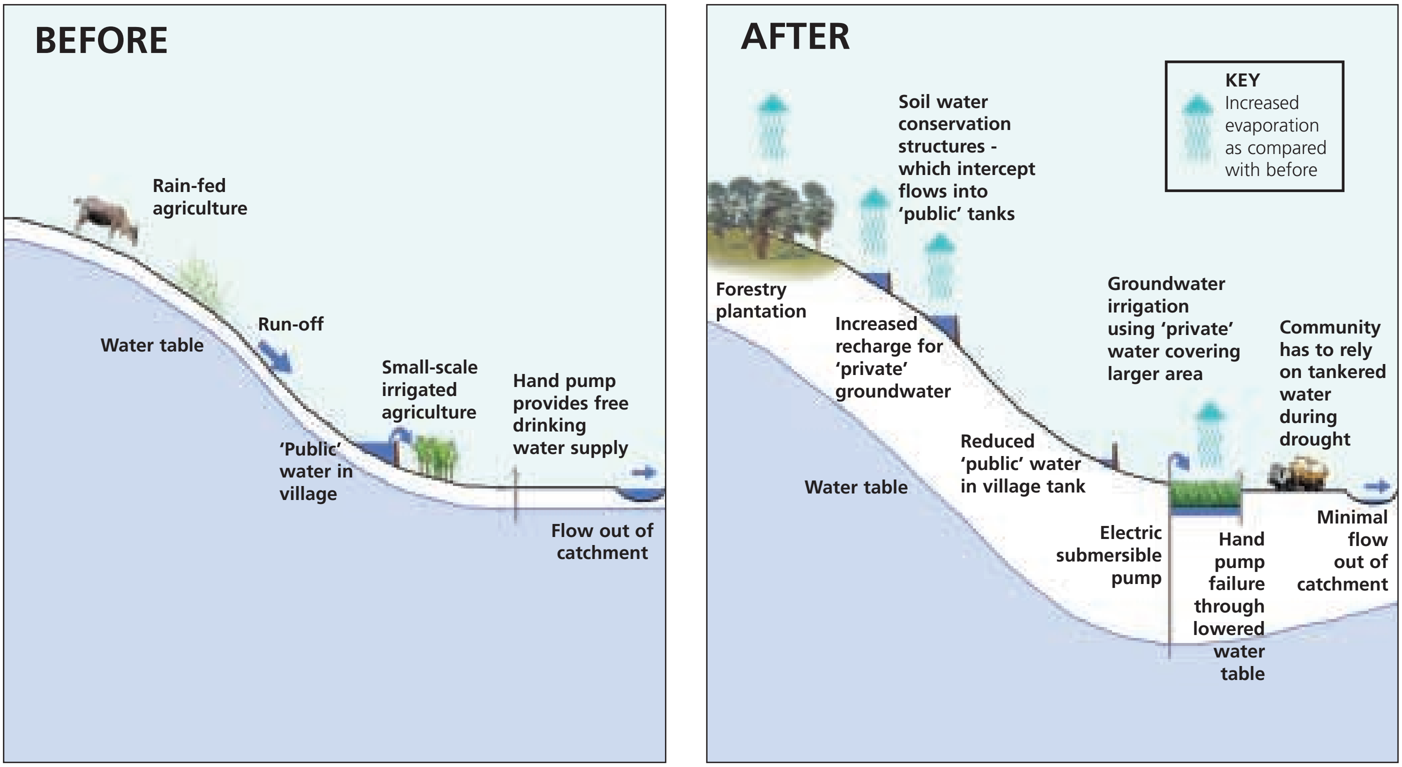
In the same Indian states, hydrological experts collated biophysical data relating to streamflow. Ian Calder at CLUWRR in Newcastle upon Tyne then fed these data into the hydrological modelling system, HYLUC. Meanwhile, Ashvin Gosain at IIT Delhi entered the data in an alternative modelling system, SWAT.[v] Results from the two models are being rigorously analysed and reconciled. Initial results from this complex process indicate that increased forestation causes a reduction in water yields in Himachal Pradesh and Madhya Pradesh.

Bridging the gap between science and policy

In order to facilitate the formulation of policy decisions based on sound scientific evidence, Jaime Amezaga worked with colleagues in India to initiate a communication network between researchers and policy makers. This initiative was developed in accordance with the BRAP (bridging research and policy) framework developed by the Global Development Network, and the RAPID (research and policy in development) framework developed by the Overseas Development Institute (ODI).

v Soil and Water Assessment Tool

Plates for Section Two: Research in context



Plates 1a) and 1b) How catchment interventions affect water flow and availability

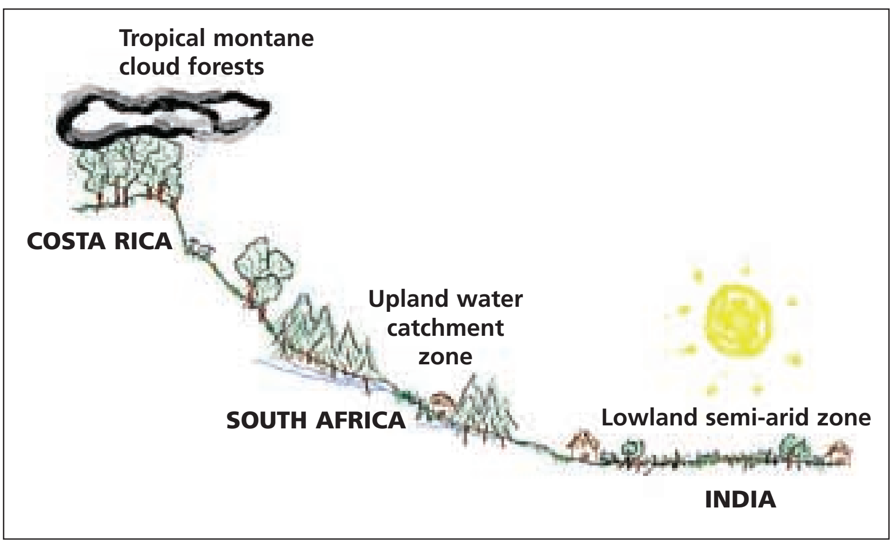


Plate 2) The contrasting altitudinal locations of the FRP-funded FLOWS projects

Plates for Section Three: Statutory control of water resources in sub-Saharan Africa

Plate 3) The poorest people in rural communities do not have livestock. © Rob Hope

Plate 4) A working groundwater pump near Gogogo, South Africa. © Rob Hope

Plate 5) The CAMP socio-economic team carry out scoping work in the Luvuvhu catchment, South Africa. © Ian Calder

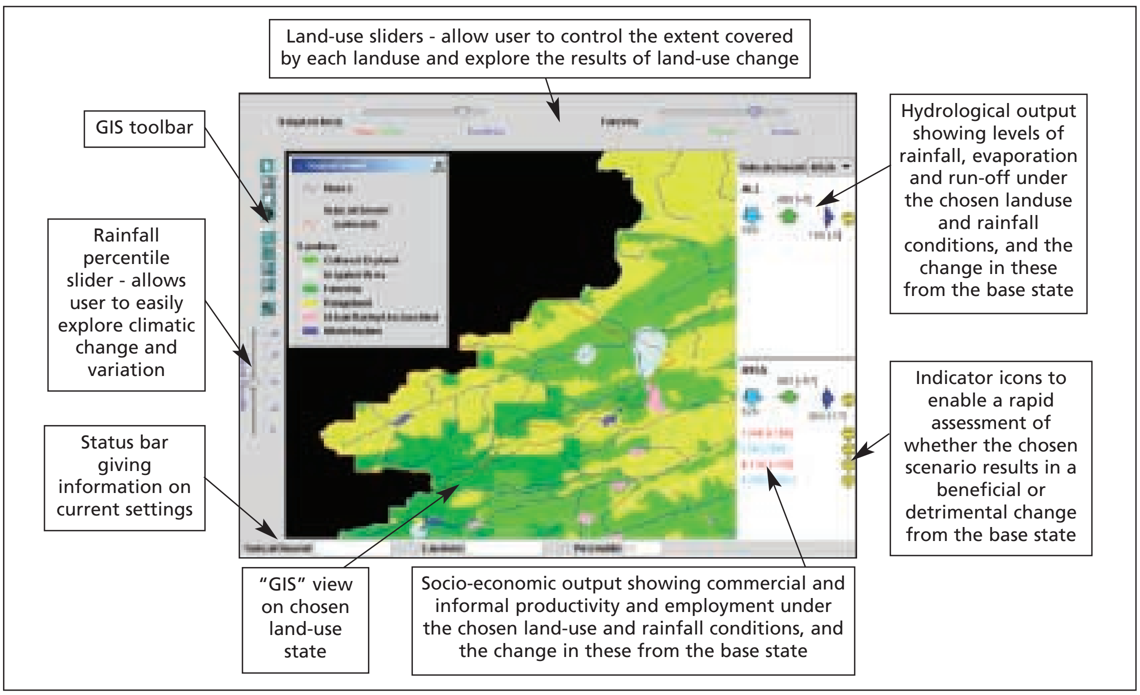


Plate 6) A screenshot of the EXCLAIM GIS tool set up for the Luvuvhu catchment, South Africa.

Plates for Section Four: Watershed development programmes in India

Plate 7) Constructing field bunds to slow rainwater run-off in Bihar, east India. © John Sanchez

Plate 8) A rehabilitated village pump in Bihar, east India. © John Sanchez

Plate 9) A water level recorder near Baldook in Himachal Pradesh, India. © Achraj Bhandari

Plate 10) The chief minister of Himachal Pradesh, India, with other speakers at the Shimla workshop. © Achraj Bhandari

Plates for Section Five: Market mechanisms in Costa Rica and Grenada

Plate 11) Mosses and lichens thrive in Costa Rican cloud forests. © Arnoud Frumau

Plate 12) A farm in the lower reaches of cloud forest near Guacimal, Costa Rica. © Ina Porras

Plate 13) Cloud forest cleared for agriculture in the Rio Chiquito catchment, Costa Rica. © Ina Porras

Plate 14) A landslide in the Rio Chiquito catchment, Costa Rica. © Arnoud Frumau

Plate 15) Measuring soil moisture in the San Gerado cloud forest catchment, Costa Rica. © Arnoud Frumau

Plate 16) A “harp” type rain gauge for measuring fog and mist in the Rio Chiquito catchment, Costa Rica. © Arnoud Frumau

The team organised two workshops to bring together policy makers and scientists. The first, held in New Delhi in February 2004, was organised in conjunction with ODI and focused on introducing participants to the objectives of the FRP-funded project and to the ODI RAPID framework. Participants included project staff and policy makers working in the water sector in New Delhi and the states of Madhya Pradesh and Himachal Pradesh.[34]

The second workshop, held in Shimla, Himachal Pradesh in August 2004, was co-organised with the state government, hosted by the State Council for Science, Technology and Environment and chaired by the chief minister of Himachal Pradesh, Vibhadra Singh, who is charged with overseeing the state watershed development programme. The state government circulated a press notice about the event and it was broadcast on television and reported in several national and regional newspapers.

Communication between government departments is usually rare, but at the Shimla workshop, more than 40 state and central government departments were represented. Delegates agreed that management decisions should be more integrated, with government departments sharing data and other information. They also advocated that policy should be informed by science using modern analytical tools such as hydrological simulation modelling.[35]

To aid future communications between the scientists and policy makers, Ian Calder and his team at CLUWRR have used the hydrological model, HYLUC to create EXCLAIM modelling tools for Himachal Pradesh, and also Madhya Pradesh, now accessible online at www.cluwrr.ncl.ac.uk. And since policy makers met in Shimla, the state government of Himachal Pradesh has taken steps to create the Water Resource Management Council, chaired by the chief minister, to ensure that an integrated approach to watershed management is adopted in the state. IIT Delhi is also working closely with the State Department of Irrigation and Public Health, and is developing a GIS modelling framework, relating to flow irrigation and water supply systems, which can inform the EXCLAIM tool for Himachal Pradesh.

All these are important first steps towards evidence-based watershed management policy in Himachal Pradesh, which can potentially be replicated in other Indian states. Indeed, CLUWRR and IIT Delhi are planning a workshop for autumn 2005 to discuss water management in Madhya Pradesh.

Maintenance of hydro-meteorological instruments in Monteverde, Costa Rica. © Arnoud Frumau

Section Five **Payments for environmental services: market mechanisms in Costa Rica and Grenada**

In 1950, more than half of Costa Rica was covered by forest. As farmers colonised tropical upland areas by clearing virgin cloud forest for agriculture, especially pasture, forest cover declined rapidly, falling to 29 per cent by 1986. Conversion was driven by rapid expansion of the road system, cheap credit for cattle, and land titling laws that rewarded deforestation.[36]

By the 1970s, Costa Rica had become the fourth largest exporter of beef to the United States.[1] More recently, the country has come to recognise the importance of forests, and montane cloud forests in particular, both ecologically and as an attraction for increasing numbers of tourists. For this reason, cloud forest is now protected by law (see Box 7).

> "When people started to settle down here [cleared cloud forest], they came from the central valley, from San Ramón. It was about survival, they cultivated food to nourish their families. Life at that time was quite difficult, there were no streets, no access. People sowed to eat, basically."
>
> Don Hubert, Farmer, Monteverde, Costa Rica

In the Arenal watershed of Costa Rica, cloud forest (protected since the creation of the Arenal National Park in 1994) competes mainly with livestock and coffee farming. Run-off from the watershed is collected and stored in the Arenal perennial reservoir, which feeds three hydroelectric plants. These plants together provide over a third of the electricity used in Costa Rica.

From the hydroelectric power system, water flows through a private fish farm and 6,000 hectares of intensively irrigated land mainly dedicated to rice and sugar cane plantations, before draining into the Palo Verde National Park, an important wetland that hosts a large population of migratory birds. The wetland serves as a filter for water that drains into the Gulf of Nicoya, one of the most productive estuary ecosystems in the world accounting for approximately 20 per cent of the total fisheries harvest in Costa Rica.[1] With such rich natural assets, the Arenal area is a prime destination for eco-tourists and in 1993, tourism became Costa Rica's single largest source of foreign exchange.[1]

Box 7

Cloud forest ecology[37]

Cloud forests, the mountainous brothers of lowland tropical rainforests, are treasure houses of biodiversity, filled with tree ferns and rare species of frogs, toads, birds and primates. They occur in tropical countries including Malaysia, Tanzania, Venezuela and Costa Rica, at elevations from 1,500 to 3,000 metres in continental situations and at 500 metres on mountainous islands.

The air surrounding cloud forests has a very high moisture content. As a result, epiphytic organisms such as lichens, mosses and liverwort abound on the trees' branches. These epiphytes act like a sponge, holding water and releasing it gradually, either by drip to the ground or by evaporation back into the atmosphere. The high humidity and reduced solar radiation in these dark cloudy forests means that the trees themselves have low levels of transpiration and evaporation. They also pick up water from the wind-driven horizontal rain, cloud and fog that passes over and through them. Cloud forests are therefore highly water-productive compared with other types of land cover, and with forests in less cloudy environments.

Population pressure and loss of fertility on previously farmed land has led to large areas of cloud forests being destroyed to make way for cattle ranching and cultivation of vegetables, flowers and coffee. Tropical cloud forest has been cleared to such a devastating extent that only 2.5 per cent remains worldwide.[37] In some areas, wildlife populations have fallen dramatically as a result. The golden toad, for example, may now be extinct.

To raise awareness of the biodiversity in Costa Rican cloud forests, Sampurno Bruijnzeel worked with Halsundbeinbruch Film in Switzerland to produce an educational documentary. *Mountains in the mist*, which is aimed at students, scientists, teachers, eco-tourists and the general public, is now available on DVD in German, English and Spanish. It is sold to eco-tourists in the Monteverde Cloud Forest Preserve to help in its management and can also be ordered at www.halsundbeinbruch.ch.[37]

How the payments work

In 1996, the government set up a national forestry finance fund (FONAFIFO) and introduced the payment for environmental services (PES) programme to compensate upland farmers for the preservation and sustainable management of forests and for reforestation.[1, 36] This programme is one example of several initiatives that come under the umbrella term, markets for environmental services, and are evolving in countries around the world. This trend is partly in response to international drives to combat climate change, through the clean development mechanism of the Kyoto Protocol, and to reduce poverty, as crystallised in the United Nations Millennium Development Goals.[1]

Costa Rican forestry law recognises four environmental services provided by forests. One, carbon fixation, or mitigation of greenhouse gases; two, hydrological services, or stabilisation of streamflow and reduction of sedimentation for downstream beneficiaries such as domestic water-users in urban areas and hydroelectricity-generating companies; three, biodiversity protection and four, provision of scenic beauty.[1, 36]

In the PES programme, FONAFIFO acts as an intermediary selling carbon sequestration and watershed protection services to domestic and international buyers. It also distributes funds from a domestic fuel tax of 3.5 per cent. Payments are distributed over a five-year period and vary according to the activity undertaken: US$450 per hectare for reforestation, US$320 per hectare for sustainable forest management and US$200 per hectare for forest conservation. As such, payments may vary from US$40 to US$90 per hectare per year. By 2001, landowners in Costa Rica had registered onto the PES programme approximately 284,500 hectares of land, the majority of which (84 per cent) was classified under forest conservation.[1]

Part of the rationale behind the Costa Rica PES policy, with respect to watershed services, has been that cloud forests collect and maintain water from the surrounding atmosphere leading to the stabilisation or even increase of water flows downstream (see Box 7). Cloud forests were also believed to reduce the likelihood of landslides and erosion, which can lead to sedimentation, blocking turbines and reducing reservoir capacity in Costa Rica's hydropower plants.[37] However, in 1996 when PES was established, only scanty scientific data or analysis existed to prove that these beliefs were true.

> "The [payments for environmental services] incentives are a source of money which helps us to protect the forest and the water. They give us the possibility not to harm the forests."
>
> Don Francisco, Farmer, Monteverde, Costa Rica

The science behind payments for environmental services

To clarify the relationship between cloud forests and water flow, the DFID Forestry Research Programme funded a team of hydrologists from five European countries led by Sampurno Bruijnzeel at the Free University of Amsterdam and working with colleagues in Latin America and the United States.[37] The team collected two years of biophysical data from the Rio Chiquito catchment of the Arenal watershed in the Tilarán range of northern Costa Rica. Mark Mulligan at Kings College London worked with colleagues using this data to create the FIESTA[vi] modelling system.[38, 39]

To identify how hydrological changes and the payments for environmental services scheme affect poor communities, FRP funded a team of economists to carry out a livelihoods analysis of rural people on the Pacific slope of the northern Tilarán range. This team included Rob Hope at the University of Newcastle upon Tyne, Ina Porras at the Environmental Economics Programme of the International Institute for Environment and Development (IIED) in Edinburgh and Miriam Miranda at the National University of Costa Rica.

The biophysical field experiments suggest that annual streamflow from forested catchments is, at the local scale, similar to that from catchments where cloud forest has been cleared for cattle pasture. However, during prolonged dry periods, streams in pasture areas tend to have lower flows than streams in forested areas and even dry up completely. Also, after rainstorms, water flow in pasture areas is typically twice that in forested areas, with peak flows more than tripling.[40]

These changes in streamflow are mainly due to the greater absorptive capacity of soil under cloud forest, compared with soil compacted by the hooves of cattle in the pastures.[8] As cloud forests appear to regulate water flow throughout the year, their existence is likely to reduce erosion and consequently sedimentation in downstream water resources including reservoirs and hydropower plants.

The field research carried out in Costa Rica sheds light on a problem that had previously perplexed hydrologists. Why is streamflow from cloud forest areas higher than one might expect, given the amount of rain going into the system upstream and even considering low levels of evaporation and the extra inputs of intercepted cloud water, or fog?

An innovation that helped solve this problem was a new type of rain gauge. Previously, hydrologists had used standard rain gauges but these failed to capture horizontal wind-driven rain. Using the modified Juvik gauge, the FLOWS hydrologists discovered that wind-driven rain is more significant in cloud forest areas than was previously thought and may be the missing quantity in catchment calculations (see Plate 16).

Informed by knowledge gained in the Rio Chiquito field experiments, Mark Mulligan and his team developed a series of models applicable at scales from the small catchment through to the national level. These models predict the amount of water produced by forests and other types of land use throughout Costa Rica and are designed to inform water resource managers and planners working on the payments for environmental services programme.[37, 38, 40]

By focusing on water production rather than streamflow, Mark Mulligan's national-scale model (the FIESTA fog delivery model) overcomes some practical

vi Fog interception for the enhancement of streamflow in tropical areas difficulties. Depending on the properties of the soil, water might leave an upland area as run-off, be stored in the soil or percolate downwards. And in highly fractured bedrocks, which are common in tectonically active mountain chains, deeply penetrating water, or “leakage”, can cross watersheds underground. This multitude of possible routes presents great challenges in tracing water flow downstream back to a specific location upstream.

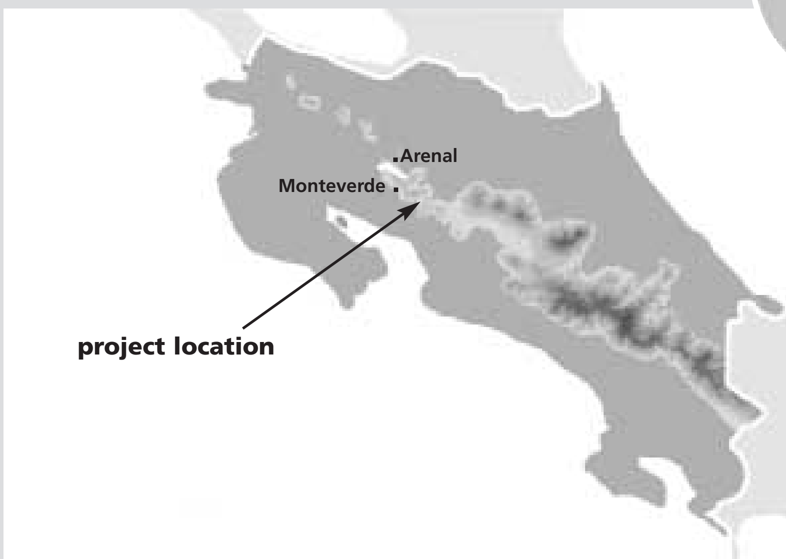


Figure 4:
Project location: the Rio Chiquito catchment in Costa Rica

In the absence of comprehensive soil and sub-surface data, hydrologists cannot be sure exactly where harvested cloud water is destined. However, they do know that the water will appear somewhere in the region’s run-off or groundwater resources, as opposed to, in the case of Costa Rica, simply passing over as cloud from the Pacific to the Atlantic oceans. The national-scale FIESTA model allows policy makers to locate “hotspots” of water-productive upland areas and management practices, in the knowledge that, although the water produced may not be traceable to specific downstream users, it will reach communities somewhere downhill of the production site.

The economics of payments for environmental services

Parallel research carried out by the FLOWS socio-economic team indicated that the PES market mechanism system does provide the four environmental benefits specified by the Costa Rican government (carbon fixation, hydrological services, biodiversity protection and provision of scenic beauty). However, the economic link between those who are paid to manage land in a certain way and those who benefit from the improved environmental services is less clear.

The economic theory behind PES says that environmental service providers should be financed by environmental service users. These users include: companies wishing to offset carbon emissions by either purchasing certified tradable offsets through the clean development mechanism or by trading carbon credits through a voluntary initiative; beneficiaries of improved water supplies (hydroelectricity companies or domestic water users) and beneficiaries of biodiversity and scenic beauty (eco-tourists).[36] However, in practice, the bulk of the funds in Costa Rica come not from the direct beneficiaries of environmental services but from a domestic fuel tax.

The most concerted effort so far to link environmental service users and providers are arrangements negotiated between hydroelectricity companies and upland farmers, mainly with FONAFIFO acting as the intermediary distributor of funds. The first hydroelectricity company to enter into such an agreement was Energía Global. In this example, Energía Global pays for the service of a more regular and stable water flow when forests are conserved within its catchments.

Although this trading arrangement does create a direct link between water users and water providers, whether it reflects a quantifiable hydrological relationship between specific landowners and specific downstream users is less certain. In fact, private hydroelectricity companies' motivation for contributing to PES may have more to do with improving their image among local communities than any real hydrological benefits.

In order to quantify the implications of land-use change, Ina Porras looked at the economic impact of regulated annual streamflow due to cloud forest cover upstream in the Rio Chiquito catchment. She concluded that in terms of water supplied to hydroelectricity plants, the economic impact was minimal as, regardless of the conversion of cloud forests, the Arenal reservoir tended to maintain a stable flow throughout the year, and from year to year. This confirms results from an earlier study carried out by the International Institute for Environment and Development.[41] Further FRP-funded analysis in the adjacent Peñas Blancas watershed, where cloud forest covers 30 per cent of the land, may yield more significant results, which will be published later in 2005.

How payments for environmental services affect the rural poor

Although Costa Rica cannot be described as a poor country in global terms, poverty is still a problem in rural areas; in 1999, 30 per cent of rural households were living below the poverty line.[1] To find out how rural people were affected by PES, and what motivated them to clear or maintain forest areas, the FLOWS sociologists conducted surveys, interviewed farmers and villagers, and analysed social and economic data records.[1, 42] The team also conducted a choice experiment, similar to that employed in the South African CAMP research (see page 13).[43]

The Costa Rican PES programme states that parcels of land between 1 and 300 hectares in size can qualify for payments. However, the FLOWS team observed that, in practice, FONAFIFO adopts a qualification threshold of 10 hectares, to be consistent with the minimum area of a "forest" as defined by Costa Rican forestry law.[1] This effectively excludes small farmers so FONAFIFO tends to allocate grants to large farms often owned by relatively wealthy absentee landlords.[8]

To qualify for PES, farmers must have a government-authorised right to the land but few small traditional farmers have such a land title. Coffee farmers are particularly disadvantaged as, in the study area, only one in three households had land titles, with average holdings less than 10 hectares in size.[1] Another problem is that small farmers often do not have the education or resources to deal with an application to the scheme. This problem has been partly addressed by NGOs such as the Foundation for the Development of the Central Volcanic Range (FUNDECOR), which in exchange for a fee, mediates between farmers and FONAFIFO, handling paperwork, supervising projects, drawing up management plans, monitoring client performance and providing technical assistance.[36] However, for most small farmers, complex administration remains an insurmountable obstacle to the scheme.

The payments for environmental services scheme is heavily oversubscribed so two thirds of farmers who apply do not get the money. In 1999, Ken Chomitz, an economist at the World Bank, noted that the formal waiting list for the scheme could be in excess of 70,000 hectares.[36] Rob Hope, Ina Porras and Miriam Miranda identified low financial returns as another constraint to the wider uptake of PES payments (see Box 8). Estimates of land-use productivity for coffee and livestock suggest higher returns per hectare compared to PES payments from FONAFIFO of around US$42 per hectare per year for forest conservation.[1] All these constraints mean that PES at best excludes the rural poor, and at worst may lead to farm evictions as wealthier elites are provided with incentives to gain control of land.

> "The most restrictive legal requirement for PES qualification is to have a land title."
>
> Forest engineer, Rio Chiquito watershed, Costa Rica

The FRP-funded field research in Costa Rica confirms the findings of an earlier desk review of market mechanisms worldwide, carried out by Natasha Landell-Mills and Ina Porras at IIED.[44] This study concluded that constraints to market mechanisms fall hardest on the poor. Firstly, costs associated with market mechanism transactions are relatively high for poor people who tend to hold small plots of land, remote from government administration offices. Secondly, insecure property rights prohibit poor people from entering the trade game of market mechanisms. Thirdly, the poorest countries of the world are those most likely to lack a comprehensive regulatory framework, cost-effective intermediaries and scientific information on forest-water links. Fourthly, in negotiations around market design and payments, poorer individuals and groups are often the most vulnerable to exclusion because of weak civil association. Finally, poor people tend to be least well-educated about market opportunities for watershed protection services.

Box 8

A farmer's view of payments for environmental services[1]

Mr Quetzal has managed a 76-hectare farm for more than 25 years in an isolated zone of the Caño Negro watershed, which is only accessible by foot or horseback. The land consists of 60 hectares of primary and secondary cloud forest with 16 hectares cleared for rearing livestock. Mr Quetzal's father converted the forest to pasture in the 1950s.

Mr Quetzal successfully applied for PES in 1998 and received US$42 for each hectare of forested land. The five-year contract for forested land prohibited any productive uses. Each year, Mr Quetzal had to submit full documentation to the Liberia office of FONAFIFO in Guanacaste province which as an overnight trip, created additional costs of time, travel, paperwork, accommodation and other expenses. Whilst payments have benefited Mr Quetzal, he has now decided to sell the farm. He believes this is the only practical solution to the prohibition for productive land uses, and state conservation interests. In addition, when Mr Quetzal applied to renew his PES contract with FONAFIFO in 2003, he was rejected due to a new clause, which requires participants to have a land title. Like many small settler families, Mr Quetzal does not possess such a title.

Mr Quetzal believes the programme is not a flexible instrument. Reforesting pasture would effectively return the land to its original state permanently as costs to re-convert the land back to pasture, if the contract was not renewed, would be prohibitive. Mr Quetzal considers that the programme only functions for landowners already pursuing a conservation or productive forest-use policy such as the private nature reserves and commercial forest companies. Productive landowners have no financial incentive to change their current land-use strategies of coffee, milk or beef in preference for the lower returns offered by PES.

Additional studies in Grenada

As part of the CAMP project, and complementary to the research in Costa Rica, the FLOWS team also looked at the potential for payments for watershed services on the Caribbean island of Grenada. In this small country, upstream farmers apply pesticides, herbicides and fertilisers, which can be washed into watercourses during times of heavy rain. In addition, when farmers clear and tend land adjacent to rivers, soil can be washed away thus decreasing soil fertility. These problems are leading to reduced and contaminated water flow, which increases costs of water purification, degrades aquatic ecosystems including areas of mangrove and offshore reefs attractive to tourists and reduces productivity in offshore fisheries; an important economic activity in Grenada.[45]

Caroline Sullivan and Dermot O'Regan of the Natural Environment Research Council's Centre for Ecology and Hydrology (CEH) in Wallingford, together with Grenada's Forestry and National Parks Department, investigated socio-economic and environmental requirements for a payments for watershed services scheme.[45] The team conducted stakeholder consultations with government officials and representatives of NGOs involved in land-use and water sectors, and carried out livelihoods assessments, GIS mapping and water demand assessments in the Beausejour and Black Bay sub-catchments on the western coasts. Based on this research, the team developed two economic mechanisms providing a financial incentive for upper catchment farmers to carry out best management practice such as reducing the use of pesticides and leaving riparian buffer zones alongside watercourses.

In the *riparian compensation mechanism*, upper catchment farmers demonstrating best practice receive a reduction in their water bills, on the basis that their actions will result in lower water treatment costs downstream. The alternative *watershed sustainability fund* provides to upper catchment farmers grants made up of donations supplied by tourists at airports, on the basis that tourism is a beneficiary of improved water quality downstream. The main drawback with this mechanism is that the donation system is unreliable with no guaranteed level of finance.[19, 45, 46]

These two market mechanisms have been approved by the Grenadian government. However, the devastation caused by Hurricane Ivan in September 2004 has seriously delayed any efforts to implement the schemes. It therefore remains to be seen whether the schemes are capable of delivering hydrological and biodiversity services in practice as well as theory.[19, 45]

A check dam in the Chabutra Nala watershed, India. © Achraj Bhandari

Section Six **Lessons from the research and implications for policy**

The FRP-funded FLOWS research, which makes use of technological advances in hydrological modelling, is a thorough examination of the scientific grounding for integrated land and water management. Using experimental data, it assesses whether government legislation, voluntary schemes and market initiatives are likely to reduce poverty, or are simply a means of protecting environmental resources and raising the funds to do so. This section brings together the various strands of biophysical and socio-economic research into a series of lessons and implications for policy makers in the project countries and beyond.

Lesson One: In arid and semi-arid catchments, there is no scientific evidence to support the view that forests increase or stabilise water flow.

This view is only supported in tropical regions where cloud forests tend to regulate water flow throughout the year and thus increase dry season flows. In all parts of the world, higher rates of water use through transpiration and evaporation are normally associated with fast-growing and deep-rooting trees such as eucalyptus, pine and acacias.[10]

Policy implication: If water shortages are a problem in dry countries, impose limits on forest plantations, especially of fast-growing evergreen species.

Lesson Two: Modelling based on "green water" data is an efficient and usable means of predicting the impact of land-use change on water flow.

The HYLUC model provides a measure of evaporation from alternative types of upland vegetation. The annual amount of blue water (streamflow) is calculated by subtracting evaporation from rainfall in the year in question.[22]

Addressing the "water loss" function of land use rather than the "streamflow regulation" function is important for two reasons.[5] Firstly, once water is lost from a catchment through evaporation, it cannot reappear in the stream. By contrast, any impact of land use on streamflow regulation can be adjusted through other interventions such as reservoirs or check dams. Secondly, in arid and semi-arid conditions, rainfall is more likely to leave the catchment through evaporation (green water) than to flow downstream as blue water. For example, in South Africa, typically, only 10 to 30 per cent of rainfall generates run-off in rivers.[27]

Policy implication: Implement green water policy instruments to control levels of evaporation from upland vegetation.

Calculating the primary evaporative differences from alternative vegetation types is much easier than predicting secondary impacts on streamflow. The green water approach is therefore more readily usable in terms of policy and legislation. Figures for green water loss from, for example, forestry, can be used to calculate a value, or "green water index", for that land use. This means of quantification makes it easier to put an economic, social or ecological value on a particular form of land use and can thereby aid the development of tax systems or market-based compensation mechanisms.[5, 47] In South Africa, discussions within DWAF are now moving towards a green water index as a more workable alternative to the streamflow reduction activities system.

Lesson Three: Soil degradation can cause localised flooding during rainy periods, and reduced dry season flows.

Soil degradation can be caused by compaction from agricultural machinery or intensive grazing, or a loss of soil depth through wind and water erosion. Soil degradation is a cumulative problem so may not be adequately accounted for in the limited time-scale of data sets used for hydrological modelling.

Policy implication: If upland forests are cleared for cultivation, provide farmers with guidelines on best agricultural practice.

Reducing stock densities, ensuring good ground cover during rainy seasons and breaking up plough pans with a chisel plough can all help maintain a porous soil capable of storing, and gradually releasing, water throughout the year.

Lesson Four: Uncertainty surrounding hydrological processes within and beneath the soil makes it difficult to quantify the amount of water provided by a specific land manager upstream to a specific water user downstream.

Water travelling downstream can move between basins, remain underground or leak through fractured rock and deep soil. Although satellite remote-sensing can provide hydrological modellers with useful data on surface processes, in many environments an absence of adequate soil and subsurface data leads to scientific uncertainty in tracing water from producer to consumer. The larger and more well-defined the catchment, and the fewer and larger the downstream users, the less this is a problem since the users will eventually receive all the water produced.

Policy implication: Any market mechanism or tax system linking land management to quantified streamflow should ensure that scientific validation is possible at the scale of operation.

Local biophysical relationships are too complex to be translated into direct economic trading relationships and because of the difficulty in providing absolute proof, could be challenged legally. Regional schemes may be workable if reliable minimum estimates, rather than statistical mean values, of downstream water flow are taken as the basis for payments, and long-term trading arrangements are guaranteed. However, a nationally collected payment, such as a central government tax on domestic water supplies, which recognises the national benefit of a positive hydrological outcome in a specific region, could be a more workable, secure and equitable financing mechanism for payments to watershed service providers.

Lesson Five: Integrated land and water resources management can only be achieved if governance is holistic and evidence-based.
The decentralisation of watershed policy, as has occurred in India, is important for democracy and local participation but it must be combined with a macro-scale topographic catchment management plan. If this is not the case, policies could be implemented that provide local benefits but degrade water resources for downstream communities. Closer consultation between scientists, policy makers and farmers is required to ensure that management decisions are based on the best available evidence.

Policy implication: Use decision support systems such as the EXCLAIM web-based GIS tool to assess the impact of alternative land management options on water resources, and alternative land-use and water management and policy options on different social groups.
The EXCLAIM model is underpinned by more complex hydrological and socio-economic models but demonstrates simply to non-specialist users the impact of changing land-use on evaporation and run-off, and on different social groups.

Lesson Six: Water alone cannot pull people out of poverty.
Beyond what in South Africa is termed the human needs reserve, water is a necessary but not sufficient condition for rural poverty reduction.[21] Statutory legislation and market mechanisms may be a way of protecting environmental resources and tackling global climate change and economic development but they will not pull people out of poverty unless underlying problems are addressed. Land rights is a problematic issue that results in the inequitable distribution of assets in many Latin American and African countries. The poorest in society do not have land, livestock or other assets and therefore do not reap much benefit from increased water flows downstream or market mechanism grants for land management upstream.

Policy implication: Make sure policy instruments are equitable in terms of livelihood benefits, not just water allocation.
By addressing water and land distribution policies side-by-side, policy makers can make sure that the rural poor are able to use increased water supplies for crops

and livestock, which can provide an income for housing, schooling and other livelihood benefits. The allocation equity policy currently being developed by the South African government could serve as a useful model.

Lesson Seven: Market mechanisms linking land management and watershed services do not tend to address rural poverty.

The majority of the world's poor live as dispersed, unorganised and weak rural multitudes on the extensive catchments and floodplains of sub-Saharan Africa and South Asia.[1] These areas simply do not have the institutional infrastructure to successfully manage a payments for environmental services programme. Plus, the majority of the rural poor do not have an agricultural land right and, for this reason, can be excluded from environmental services trading.

Policy implication: Make sure that any proposed market mechanism is adequately pro-poor.

If land tenure is preventing the very poor from accessing market mechanism payments, the money could instead be channelled into a community fund. If the funds are used for communal improved land management programmes (as piloted by CSIR in South Africa) the mechanism is still giving "water provider" benefits.[5] Another approach might be to create local organisations that mediate between the government and landholders, in effect wholesaling services from collections of individual projects or plots of land. It may also be necessary to accompany any market mechanism scheme with training and education programmes, market support centres and credit schemes.[44]

Lesson Eight: Small-scale irrigated agriculture is unlikely to reach the majority of the rural poor.

In Africa, 95 per cent of agricultural land is dryland rather than irrigated.[2] Providing irrigation for all would lead to a situation where upstream farmers hoard or excessively exploit water during the dry season, to the detriment of downstream farmers.

Policy implication: Consider improvements in rain-fed farming (crop breeding, rainwater harvesting, mulching, conservation tillage, market access, capacity building) in preference to further investments in rural small-scale irrigation schemes.

Allocating water resources to small-scale irrigation schemes can provide high economic returns for "water-rich" farmers with land and livestock but can also lead to increasing inequalities between households. By contrast, rain-fed farming is accessible to a greater number of social groups, including women, in rural areas.[2,17]

Lesson Nine: What rural people want and what policy makers think they want are not necessarily the same thing.

In the Luvuvhu catchment in South Africa, what matters to rural people is convenience of water supply. Although communal taps may increase the amount of water available overall, it does not address the issue of accessibility; the limiting factor for many people remains how much water they can carry to their house, not how much water comes out of the tap (see front cover).

Policy implication: Use negotiation support system techniques such as the choice experiment to ascertain stakeholder preferences for policy agreements.

The experimental design of the choice experiment allows intangible benefits, such as the spiritual value of traditional homelands and holy springs, to become, if not economically tangible, then at least accountable in the negotiation process. Rigorous statistical analysis of stakeholder preferences can help minimise any room for disagreement between governments, farmers, villagers, water companies and other industries when formulating land-use and water management policy. Any agreements reached through negotiation support must be substantiated by a contract, legally binding all stakeholders to their commitments regarding land and water use and, if appropriate, any financial payments involved.

Lesson Ten: Pro-poor benefits should not be an after-thought.

South Africa's Working for Water programme is designed primarily as an environmental conservation scheme. It is not designed first and foremost as a pro-poor measure and may not be maximising benefits to the rural poor through its employment programme.

Policy implication: Tailor employment programmes to dovetail with other livelihood activities of the people they are intended to attract.

In order to ensure that the rural poor are effectively self-selected, any pro-poor employment programme should set daily wage rates to match local minimum wage rates and should provide short-term contracts during seasonal "hungry periods".[17]

A natural spring near Gogogo village, South Africa. © Rob Hope

Section Seven **Future scenarios: working towards a shift in water governance**

The lessons learned in the FRP-funded research are influencing a number of new projects relating to environmental protection and poverty reduction across the developing world. The CAMP research carried out in South Africa and Grenada, for example, has contributed directly to six projects (see Box 9).[19] In addition, the EXCLAIM GIS tool is likely to be used by the Center for International Forestry Research (CIFOR) in Indonesia and the German Agency for Technical Cooperation (GTZ) in India for analysing and communicating the hydrological impacts of land-use change.

The DFID Forestry Research Programme is itself providing initial funding to the FLOWS research team for a new project known as FAWPIO.[vii] FAWPIO's core challenge is to improve water governance: the way in which water and land-use policy decisions are made.[27] The project will have three main outputs.

Firstly, the FLOWS team will continue to promote face-to-face networking between scientists and policy makers, interactive workshops and electronic communication via e-fora and on-line journals such as *Land Use and Water Resources Research* (www.luwrr.com). The project will continue work with policy makers in South Africa and India, where it will contribute to improving water management through the US$71 million DFID and EU-funded rural livelihoods project in western Orissa and World Bank-funded watershed development and reservoir rehabilitation projects in Karnataka.

The research team will make new connections in China, where large-scale afforestation is taking place under national environmental forestry schemes such as the sloping lands conversion programme, and will influence policies of the World Bank, the European Union, the Food and Agriculture Organization of the United Nations and the Consultative Group on International Agricultural Research (CGIAR). It will also inform bilateral programmes such as the Danish International Development Agency (Danida), the Japan International Cooperation Agency (JICA) and the Swedish International Development Cooperation Agency (Sida).

Secondly, the FLOWS team will develop an improved toolbox of methodologies for integrated land and water management. This will include water-resource impact assessment methodologies for environmental scientists and a negotiation support system toolkit for policy makers, tailored for local use. The negotiation support toolkit will include methodologies for analysing the forest and water beliefs underlying existing policy, web and GIS-based tools such as EXCLAIM, an

vii "Furthering land and water policies: improving outcomes" allocation equity guide and methodologies for assessing socio-economic, environmental and poverty reduction impacts. Thirdly, the team will test and adapt the toolkit of improved methodologies in South Africa, India and China.[27]

Box 9

Projects following on from the FRP-funded CAMP research

Project organisations	**Project title**
DFID-SA and the South African Department for Water Affairs and Forestry	Water and forestry support programme: water resource management component
Water Research Commission RSA, CLUWRR and University of KwaZulu-Natal	Low flows modelling and policy aspects relating to streamflow reduction activities
International Water Management Institute RSA	CGIAR Challenge Program on Water and Food investigating the multiple uses of water for poverty reduction
UNESCO-IHE Institute for Water Education, Stockholm University, KwaZulu-Natal University, International Water Management Institute RSA and Sokoine University of Agriculture	Smallholder systems innovations: upgrading rain-fed agriculture through water system innovations
A multi-national proposal to the European Union	Clean development mechanism toolkit: for evaluating CDM interventions in relation to carbon sequestration, economic, environmental (including water resources) and social (poverty alleviation) indicators
Government of Grenada, IIED Forestry and Land Use Programme	Payments for environmental services scheme

As a result of the FRP-funded FLOWS research, the movement for bridging the gap between science and policy is gaining ground in several countries. In India, the World Bank is considering the implications of its massive support for watershed development programmes and DFID India is developing a new project promoting evidence-based policy using decision support systems in the state of Orissa. In addition, DFID South Africa is funding new work on engagement with policy shapers and DFID China is also showing interest in the approach. And in Japan, the Japanese Science Council is communicating the hydrological effects of land-use change in its "blue revolution" project.

Despite these advances, many current watershed management policies and practices remain largely ineffectual or counter-productive. Since the sums being invested, by the World Bank amongst others, in good faith in these practices are so vast, there is an urgent need for a major policy shift to convince policy analysts and practitioners to change to more evidence-based strategies.[8]

Negotiation support systems, which incorporate tools ranging from visual manuals to computer modelling systems, are invaluable in identifying the often intangible values and preferences of all those affected by land-use and water management decisions: people like Victor Torres, Mrs Mulovhedzi and Vijaya, whom we met at the start of this booklet. Only through negotiations on a level playing field can governments and communities reach equitable agreements for natural resource management, whether this is through statutory legislation, voluntary schemes or the market trading of environmental services.

Whatever the route chosen, one fact remains. The science surrounding water resources and land-use change is constantly evolving. Therefore, to maintain integrity and maximise impacts, governments and development organisations should regularly review all policies in the light of new evidence. This reiterates the need for ongoing communications between the scientific community and policy makers at all levels.

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The Luvuvhu River, South Africa. © Rob Hope

For further information on the Forestry Research Programme contact:

Katelijne Rothschild-Van Look
FRP Senior Administrator
Forestry Research Programme
NR International Ltd, Park House,
Bradbourne Lane, Aylesford, Kent
ME20 6SN UK

Email: k.rothschild@nrint.co.uk
Web: www.frp.uk.com