Forestry and low flows, spatial modelling and open GIS dissemination of the science perception- India

LOWFLOWS

FINAL TECHNICAL REPORT

Forestry Research Programme (FRP)

Renewable Natural Resource Knowledge Strategy (RNRKS)

UK Department for International Development (DFID)

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CLUWRR Centre for Land Use and Water Resources Research
DFID Department for International Development
WINROCK INTERNATIONAL INDIA
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Executive summary

Watershed Development Programmes are the main policy instrument for improving the livelihoods of poor people in rural India. In dry zone regions, water availability is recognised as a major and often the primary constraint on development. The water related components of Watershed Development Programmes have concentrated mainly on improving water "supply" through the construction of new surface water reservoirs, by desilting existing tanks and by the construction of rainwater harvesting structures, such as check dams and contour bunding, designed to increase aquifer recharge. However there is a limit to the benefits which can be gained from these "supply side" interventions as well as significant potential for associated negative impacts on downstream of these initiatives. Perhaps the most serious consequence of schemes involving increasing the intensity of surface and groundwater storages, and the exploitation of water from these schemes, is the reduction in surface water flows out of the catchment, which can in the most severe cases result in catchment closure. In this context, agricultural irrigation water is usually the highest consumer of water. Forests and forestry will also place high demands on the resource and will, on an area basis, actually consume considerably more water than dryland farming.

The role of forestry in relation to the maintenance of dry season flows remains a contentious subject and may warrant further research. Set against the higher water use of forests are the generally higher infiltration rates of forest soils and It is theoretically possible that in certain circumstances the higher infiltration rates may counterbalance the extra evaporation resulting in increased dry season flows. But evidence for forests increasing dry season flows are rare. Calder (Blue Revolution, Earthscan, 2005), from consideration of current knowledge on the subject, states 'From theoretical considerations it is possible that reduced infiltration in degraded soils following forest clearings might outweigh the extra evaporation from forests but it is becoming increasingly clear that if this situation exists it must only apply in the relatively rare situation of severe degradation – a situation that could be remedied by good land management which would not necessarily warrant afforestation. It cannot be assumed that afforestation will increase dry-season flows; the available evidence indicates that it is more likely to reduce dry season flows.'

The purpose of this project was to convey knowledge relating to land-use and forest decision making for the benefit of small-scale farmers within the Forest/ Agriculture Interface. The specific research objectives of this project were to establish a better understanding of forest impacts on low flows and the social impacts relating to water resources management in dry zone regions of India, and to develop tools which allow this improved understanding to be disseminated directly to stakeholders. Several lines of activity were pursued in parallel. Modelling studies were undertaken using data from watershed development projects in the Indian states of Himachal Pradesh (HP) and Madhya Pradesh (MP). At the same time a web-

based GIS tool was developed to disseminate the findings of the modelling studies, illustrating the water resource and livelihood impacts of watershed development interventions. Another line of activities were directed towards improving the implementation of forest and water policies in the context of watershed development projects. This involved a detailed analysis of the watersheds chosen for the modelling studies. Perceptions surrounding forest and water linkages were examined through the analysis of policy documents and by conducting interviews and focus groups with communities, Government officials, experts and policy makers. This line of research was also used to develop an active interface with user groups through interviews and presentations and by the application of the dissemination tools. The project was particularly active in regards to engaging policy-makers at the highest level, including co-organisation with the Government of HP and MP of 'state-level' workshops attended by the respective Chief Ministers.

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CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

APRLP	Andhra Pradesh Rural Livelihoods Project
CLUWRR	Centre for Land Use and Water Resources Research
DEM	Digital Elevation Model
DFID	Department for International Development
EXCLAIM	EXploratory, Climate, Land, Assessment, Impact, Management
FAWPIO	Forest, Land and Water Policy: Improving Outcomes
FRP	Forestry Research Programme (DFID)
GIS	Geographic Information System
GoI	Government of India
GSIWIS	a GIS based Watershed Information System
HP	Himachal Pradesh (HP)
HYLUC	Hydrological Land Use Change Model
ICFRE	Council of Forestry Research & Education
IIT Delhi	Institute of technology Delhi
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
JSYS	Jala Samvardhane Yojana Sangha (JSYS is responsible for implementing the Karnataka Community Based Tank Management Project)
MP	Madhya Pradesh
MPRLP	Madhya Pradesh Rural Livelihoods Project
NGO	Non Government Organisation
RAPID	Research and Policy in Development
RRL	Madhya Pradesh (MP): Regional Research Laboratory
SL	Sustainable Livelihoods
SWAT	Soil Water Assessment Tool
UNCED	United Nations Conference on Environment and Development
WB	World Bank
WORLP	Orissa Watershed Mission

1. Background

The United Nations Agenda 21, Chapter 8 - Integrating Environment and Development in Decision-making, and Chapter 10 - Integrated Approach to the Planning and Management of Land Resources, has led to widespread acceptance of an integrated approach to natural resource management. This approach is particularly necessary in relation to the management of forests and water. Indeed, the largest changes in land use occurring on the planet today are the result of deforestation and afforestation activities which are, arguably, responsible for some of the largest hydrological and water resource impacts. Integrated Water Resources Management (IWRM) for land and water management is usually applied at the catchment scale. It is implemented by resource-centred organisations, operating at national or regional scales with impacts ranging from the multi-national to local scales. The UK Government White Paper on International Development (November 1997) committed to UNCED principles but reinterprets them in relation to world poverty reduction, an approach now encapsulated within the people-focussed Sustainable Livelihoods (SL) approach. DFID now promotes both SL and IWRM. However their practical application in real world situations is still a work in progress and remains problematic as illustrated by the Andhra Pradesh Rural Livelihoods Project (APRLP) India.

Watershed Development Programmes, aimed at improving the livelihoods of poor people, have been implemented extensively throughout India. In dry zone regions water availability is recognised as a major and often the primary constraint on development. The water related components of Watershed Development Programmes have concentrated mainly on improving water “supply” through the construction of new surface water reservoirs, or by desilting existing tanks, and by the construction of rainwater harvesting structures, such as check dams and contour bunding, designed to increase the aquifer recharge. However there is a limit to the benefits which can be gained from “supply side” interventions as well as significant potential for associated severe impacts downstream. Perhaps the most serious consequence of increasing intensity of surface and groundwater storage schemes, and exploitation of water from these schemes, is the reduction on surface water flows out of the catchment, which in the most severe cases has resulted in catchment closure. The International Water Management Institute (IWMI) describes this situation, when essentially no water flows out of a catchment except in high rainfall years as a “closed” system. Many catchments in India are rapidly approaching ’closure’ and some are already “closed”, such as the Krishna in Southern India.. As catchments approach “closure” two effects are evident: the cost effectiveness of engineering constructions reduces to nil and surface water flows out of the catchment, which may be required for ecological purposes and for the benefit of downstream users, are lost. When, in this state of “closure”, when virtually all the resource is utilised there can be no overall benefit gained by the construction of additional rainwater harvesting structures or other interventions aimed at increasing aquifer recharge. Upstream users can only “capture” water at the expense of reduced availability of supply for downstream users, within the catchment.

Sadly this is a situation which is already evident in some Indian catchments being considered under the DFID funded APRLP project. When “supply side” options are exhausted, improvements in economic and “livelihood” benefits can only be achieved though encouraging higher value usage of the existing, (nearly 100% utilised), resource (possibly though the use of water pricing and other demand management measures). We need to think carefully about how we value the resource in regards to different types of water use: water supply and drinking water, irrigation for agriculture or forestry or other amenity, recreation and environmental requirements.

In APRLP catchments, irrigation water for agriculture is the largest consumer of water, however, contrary to the implied expectations of the Government of Andhra Pradesh, Department of Rural Development, Water Conservation Mission’s Strategy Paper on Neeru-Meeru, forests and forestry will also place high demands on the resource and will, on an area basis, consume considerably more water than dryland farming. Research in Karnataka (ODA Forestry series no. 6) has shown that both indigenous forests and eucalypt forest plantations, growing on soils of average depth (~2.5 m), will evaporate at similar annual rates and at rates that are approximately 2 times that of dryland agricultural crops such as ragi. Forests and forestry will also place high demands on the resource and will, on an area basis, actually consume considerably more water than dryland farming.

The role of forestry in relation to the maintenance of dry season flows remains a contentious subject and may warrant further research. Set against the higher water use of forests are the generally higher infiltration rates of forest soils and It is theoretically possible that in certain circumstances the higher infiltration rates may counterbalance the extra evaporation resulting in increased dry season flows. But evidence for forests increasing dry season flows are rare. Calder (Blue Revolution, Earthscan, 2005), from consideration of current knowledge on the subject, states ‘From theoretical considerations it is possible that reduced infiltration in degraded soils following forest clearings might outweigh the extra evaporation from forests but it is becoming increasingly clear that if this situation exists it must only apply in the relatively rare situation of severe degradation – a situation that could be remedied by good land management which would not necessarily warrant afforestation. It cannot be assumed that afforestation will increase dry-season flows; the available evidence indicates that it is more likely to reduce dry season flows.’

The strategy paper proposals for “compulsory plantation of trees and their maintenance all along highways, canals water courses etc.” and for “all agriculturists to plant trees in five percent of their land holdings” can therefore only serve to reduce water availability when applied to catchments which are “closed” or close to “closure”.

To improve decision making in relation to assessing the benefits of forests compared with their impacts on water flows for catchments which are approaching, or are already in, a state

of “closure” - the development and calibration of spatial (GIS linked) hydrological modelling studies linked with economic and “livelihood” analyses is required. These GIS linked models will need to take into account the “connectivity” of surface and groundwater flows at micro and village level scales, to the district and to the macro catchment scales and will need to take account of land use (and it’s consequent water use) from regions of the catchment of highest to the lowest altitudes. Management tools, such as these, will assist rational and integrated land use and water management and have a direct effect on improving livelihoods.

It is also proposed that the knowledge outputs of these GIS linked water-quantity modelling tools be disseminated through a Web Browser. This would enable the information to be used to support the SL participatory approach, by alerting local communities to both the micro and macro water resource implications of decisions made at the local level. It is envisaged that this will contribute to a ‘whole catchment analysis’ of costs/benefits of forests in relation to erosion, sedimentation and flooding.

It should be noted that unless effective IWRM and resource management can be achieved water resources will not only be used inefficiently but also that excessive power resources will also be required in the course of pumping groundwater from ever increasing depths. It is understood that in some Indian states two thirds of the power generated is being used for pumping groundwater for irrigation. For sustainable livelihood approaches at the village level, to succeed in rural livelihood project areas it will be required that a) land and water management decisions are based on the scientific understanding of hydrological processes and not, as is presently the case, on forest and water myths and b) village level planning must be linked to the wider catchment and to integrated water resources management and planning.

With the focus on poverty centred at the village and local scale, there are concerns that exploitation of natural resources in rural livelihood projects may lead to “tragedy of the commons” type impacts on natural resources at wider scales, particularly where the natural resource impacted is water. In addition, implementation of presently defined IWRM concepts, although aiming to improve the net socio-economics for basin inhabitants, may not always be paying due regard to socio-economically differentiated impacts on livelihoods at local scales, especially where the livelihoods concerned are those of the poorest in society.

2. Project purpose

Knowledge relating to land-use and forest decision making promoted for the benefit of small-scale farmers within the Forest / Agriculture Interface. The project contributes directly to FRP Programme Output objectives as a strategy developed and promoted to maximize the benefit of small-scale farmers and landless families and the urban and peri-urban poor accruing from current global issues and generic tools. Livelihoods of poor people will be improved through

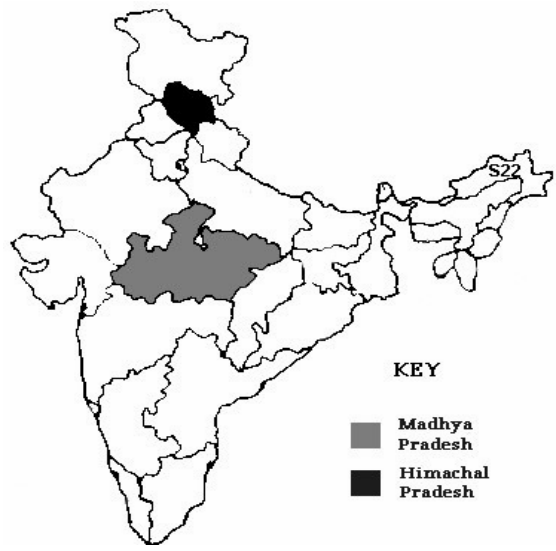
improved methodologies for whole catchment management leading to greater access to water by poor people.

The specific research objectives of this project are to establish a better understanding of forest impacts on low flows and the social impact of water resources management in arid zone regions of India, and to develop tools which allow this improved understanding to be disseminated directly to stakeholders.

3. Research activities

This section is structured following the order of activities listed in the Project Memorandum Form. Figure 1 show the location of the states that were chosen as case studies for the project. Figure 2 illustrates how the research activities are linked to the project outputs in a flow diagram.

Figure 1. Location of case study areas

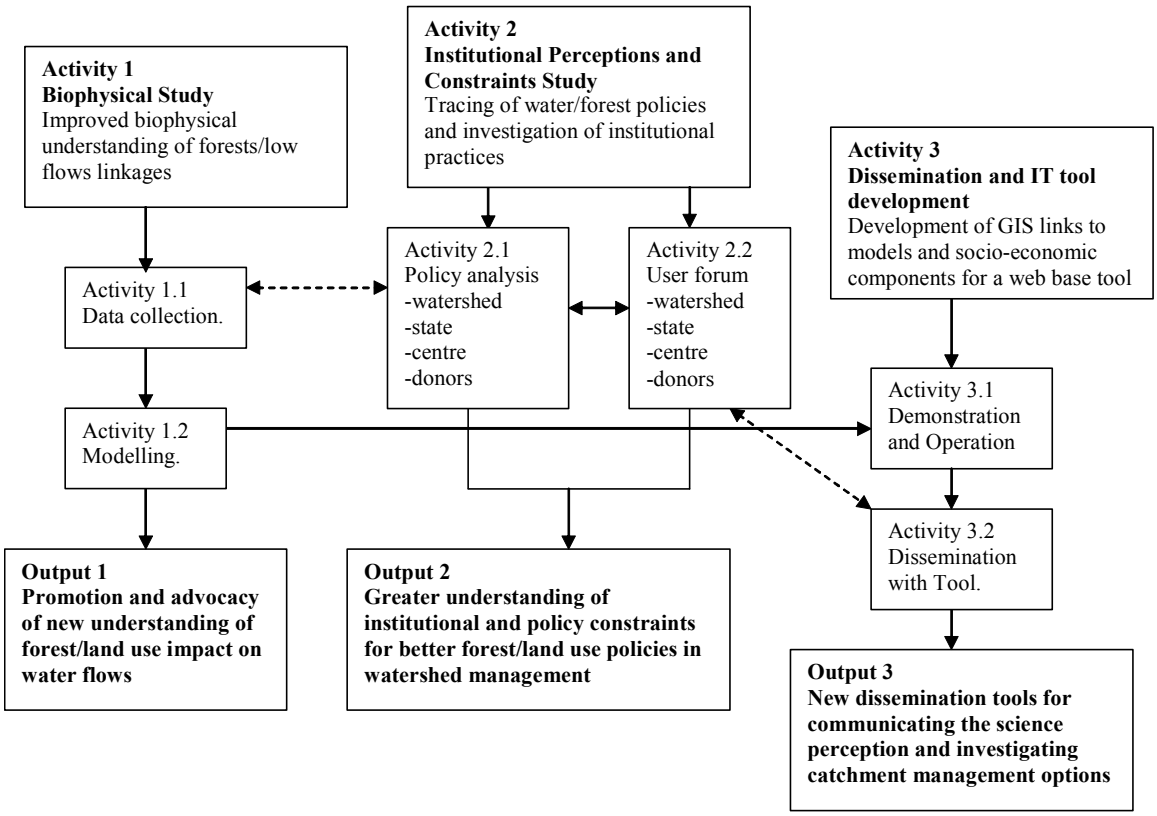


Several lines of activity were pursued in parallel. Modelling studies were undertaken using data from watershed development projects in the States of Himachal Pradesh (HP) and Madhya Pradesh (MP) (Activity 1). At the same time a web-based GIS tool was developed to disseminate the findings of the modelling studies, illustrating the water resource and livelihood impacts of watershed development interventions (Activity 3).

Another line of activities were actions directed towards improving the implementation of forest and water policies in the context of watershed development projects. This involved a detailed analysis of the watersheds chosen for the modelling studies. The perceptions about forest and water linkages were examined through the analysis of policy documents and by conducting interviews and focus group meetings with communities, officials of government departments, experts and policy makers. This line of research was also used to develop an active interface with user groups through interviews and presentations using the tools

developed in the Activity 3. The project was particularly active in regards to engaging policy-makers at the highest level, including the co-organisation with the government of HP and MP of 'state-level' workshops attended by the respective Chief Ministers.

Figure 2. Research activity flow diagram



Project formation and initiation

An electronic Virtual Forum was constructed to host on-line discussions and documents from the projects initiation, and used throughout the project's duration. The project inception workshop, held at IIT Delhi in January 2003, provided the background for assessing the information needs of the project and, accordingly, to select the locations of the case studies. The State partners, the National Institute of Technology, Hamirpur, HP State Department of Science and Environment and RRL Bhopal, helped to identify appropriate watersheds within their jurisdictions. In HP, a micro-watershed within the Hamipur Block of the Hamipur District known as Salasi Khud was selected. Of the 11 micro-watersheds of this area, the Chabutra Nullah I would be a focus area. The selected areas in MP were the Dudhi and Bevas micro-watersheds within the milli-watershed area of Begumganj, in the Raisen District.

Activity 1. Biophysical Study

After extensive collation and assemblage of relevant hydrological and spatial data from the two selected catchments in HP and MP, GIS integrated biophysical models were produced. Within project R8171, two modelling approaches were developed independently in order to investigate the effect of land use change on stream flows, in two locations in India. The first modelling approach (undertaken by the IIT Delhi modelling group) applied the Soil Water Assessment Tool (SWAT) model. This model requires a Digital Elevation Model (DEM), which is then converted to a grid, which is used to determine the direction of water flow within the watershed. Each cell of the grid has a defined set of soil and vegetation parameters. Water flows between neighbouring cells according to the relative altitude of the cells.

The second modelling approach (by the CLUWRR modelling group) used the model Hydrological Land Use Change (HYLUC) model. Within the HYLUC model each land use type within the watershed is treated as a distinct hydrological unit, with all of these units contributing to the watershed outflow.

In both approaches, the models were parameterised to represent the watershed in terms of the soil and vegetation conditions. Water was assumed to enter the watershed as rainfall, and lost to the catchment via evaporation, surface runoff and runoff mediated by shallow aquifers. A series of scenarios was derived in order to assess the effect of potential land use change on the hydrology of the watershed.

Both models predicted that any increases in forested areas would reduce the average annual flows in the watershed. The reduction was calculated to be between 2 and 17 % for both catchments, in both models and in all relevant scenarios. When forestry was reduced and replaced by dryland agriculture, there was an increase in the predicted flow. The effect is expected to be marginal in the Chabutra watershed (~ 2% increase in flow), where the total forested area is small. However, larger increases in runoff (5 - 9%) are possible where the potential evaporation is greater than the rainfall, as shown in the calculations for the Dudhi watershed. There is a coherent indication from both models that an increase in forestry will lead to a reduction in flows and vice versa.

Irrigation will consume more water than dryland agriculture. According to the predictions of HYLUC (for both watersheds), if irrigation was widely adopted on existing dryland agricultural land, then a reduction in stream flows of 12-37% is predicted.

HYLUC predicts that an increase in water-harvesting structures will lead to a reduction of flows in the watershed. The reduction is predicted to be relatively small (around 3%) unless

irrigation is considered. However the method used to represent and include the effects of water harvesting features was rudimentary, and further refining of the model will be required to clarify the true effect of these features on the total evaporation.

In both of the test catchments studied, rainfall is relatively high compared with much of dry zone India (1300-1800 mm per year in Chabutra and 1300 mm per year in Dudhi). Therefore it is possible to institute land-use change, install water harvesting structures and increase irrigation without seriously diminishing the availability of water in these catchments. However, changes to the land use will lead to significant reductions in flows leaving the catchment, with potentially serious consequences for downstream users.

A study of the potential impacts of land-use change in other weather regimes was able to be made from the weather data from Madhya Pradesh. As expected, the study indicated that runoff will be lower in dryer climates and in dryer years. Importantly, if irrigation is widely adopted in dryer climates then there is the potential for the runoff to be reduced by more than 100%, i.e. for total catchment closure to result.

These activities were reported in Internal Reports 12, 13, 14 and 15.

Activity 2 Institutional Perceptions and Constraints Study

2.1 Policy Analysis

The first activity for this component was the production of an initial policy review by CLUWRR, WII and IIT Delhi. The objective of this review was to present an initial assessment of the current land and watershed policies, strategies and related land and water problems in India (Internal Report 1).

This was followed by two Watershed Case Studies of the areas selected for the modelling exercise. The case studies involved: field visits to Himachal and Madhya Pradesh sites to identify stakeholders, interviews and village level focus group meetings, collection of various socioeconomic data from relevant agencies, secondary sources and through primary data collection and a first-cut socio-economic assessment of case study sites in light of national level contexts and learnings. The findings of the case studies are summarised in Internal Reports 2 and 3.

Winrock International and CLUWRR analysed historical and current policies to establish predominant assumptions on land use and hydrology made by stakeholder institutions and to identify gaps in water management, focussing on watershed projects. The analysis showed that most of the land and water management policy documents and guidelines carry inherent assumptions of the positive linkages between forests and water flows. In turn, these assumptions strongly influence the suggested approaches for managing land and water

resources and the benefits that these policy documents hope to achieve. These deeply embedded assumptions also restrain and undercut the need for their scientific validation. The results of this analysis can be found in the Internal Report 5.

In the field work for the watershed case studies, interviews and village focus groups allowed the identification of key narrative issues on the role of forest water within watershed management as perceived by communities and civil servants in the relevant departments at district and state level (see Internal Reports 2 and 3). Two other lines of research were pursued to ascertain institutional perceptions at the national level. First the Winrock team participated in two key events: the 'National Workshop on Forests and Water Conservation – Myths and Realities' organised by the Indian Council of Forestry Research & Education (ICFRE) through the Forest Research Institute (FRI), which is one of its subsidiary organizations, between the 8th - 10th June 2004 at Dehradun, Uttaranchal; and a two day National Seminar on 'Forests, Water & People' in Belgaum on the 29th - 30th of July 2004 organised by the National Institute of Hydrology (NIH) (see Annex A.5.4 and Annex A.6.4). After the analysis of the discussions in these two events the team designed a programme of interviews with senior officials of the Ministry of Forestry and Environment, the Ministry of Rural Development, other senior officials, hydrologists, water engineers and foresters. The findings from these interviews were that, overall, there seem to be positive steps taken towards debating and improving understanding of forest – water linkages. A general feeling gained from the discussions was the underpinning assumption that forest-water linkages were a universal phenomenon; however the need for scientific proof to establish this was equally recurrent (Internal Report 4).

As complementary research, the team examined donor policies in forest and watershed development. WII and CLUWRR reviewed relevant portions of policies, guidelines and past / ongoing experiences related to forest, water and watershed management of five donors, namely, the Asian Development Bank (ADB), the World Bank (WB), the European Commission (EC), the German Agency for Technical Cooperation (GTZ) and the Swiss Agency for Development and Cooperation (SDC) in order to get a feel for their approach to forests / land use – water linkages, with a focus on India. Though donor agencies have appropriate policies and guidelines, can offer funds for implementing new approaches to land and water management and provide access to international experience, they also have limitations. As in the case of the efforts of the Government of India, the problem of the 'gap' between policies and implementation remains, with the exception of a few scattered 'special cases'. Probably, what is required from donor agencies is a combined and concerted effort rather than individual efforts, a concept which is in accordance with their own various individual programmes (see Internal Report 6).

The strong local demand for methodologies to integrate socio-economic data with biophysical modelling in watershed development was supported by a transfer of knowledge on socio-economic data analysis to and from other FLOWS projects (R7937 South Africa and R8174 Costa Rica) and a further exploration of institutional analysis tools. An open workshop was organised in the premises of Winrock to disseminate the methodological findings of those projects (see Annex A.4.3). Based on this training the IIT Delhi team undertook a first analysis of socio-economic data in the GIS tool (Internal Report 8). CLUWRR produced a Social Impact Assessment methodology based on MP analysis and informed by existing World Bank guidelines and an International Food Policy Research Institute (IFPRI) report on Watershed Development in India. This was applied to the socioeconomic data from MP for the evaluation of impacts of watershed development projects (Internal Report 7). CLUWRR had meetings with the DFID India funded Western Orissa Rural Livelihoods Project (WORLP) and the Orissa Watershed Development Mission for the piloting of the Choice Experiment methodology developed in South Africa under R7937 in Orissa. CLUWRR produced proposals for design of a Choice Experiment in collaboration with both organisations but final approval and the required complementary funding was not awarded by the Government of Orissa within the lifetime of the project (see Annex A.3.16). However, IIT Delhi was commissioned by the Orissa Watershed Mission through WORLP to help them develop in-house GIS capacity of the type developed by this project (see Activity 3). This is a clear example of the uptake of project findings by DFID's local partners.

Furthermore, the experience gained under this project was also used to produce an analysis of the institutional constraints for negotiation approaches in watershed management from the perspective of environmental services. This analysis provided an input to the production of a Negotiation Support Manual with the FLOWS project R8174.

Another innovative methodological development was the application of the approach to interfacing research and policy promoted by the Overseas Development Institute RAPID (Research and Policy in Development) programme, sponsored by DFID. In collaboration with the RAPID team, the project organised a seminar at IIT Delhi attended by national level policy-makers and a workshop for all the project partners and associates (see Annex A.4.1). WII and CLUWRR applied the RAPID "Context, Evidence, Links, External Influences" model to the analysis of the research-policy interface in water management in MP as a background to the policy support activities in that State (Internal Report 9).

2.2 Establishment of a user forum with key stakeholder institutions

The project took the engagement of stakeholder institutions and actors as a central activity. In the first months of the project the teams produced a shared map of national (Internal Report 1), state (Internal Reports 2 and 3) and donor (Internal Report 6) stakeholder institutions.

The teams conducted semi-structured interviews with key staff in stakeholder organisations to identify institutional perceptions on land use/hydrology and on gaps in water management. As explained in the previous section, the programme of interviews covered watersheds, districts, State Governments in HP and MP, experts and high level officials of the Government of India and donors. The results of these interviews informed the policy studies and helped spread information about the projects objectives and achievements.

Both IIT Delhi and Winrock International incorporated the promotion and dissemination of the project within communications with their substantial institutional networks in India. IIT Delhi was particularly active promoting the project in meetings and presentations to Indian authorities and donors. Examples of some of the formal presentations where the project was mentioned can be found in the Annex A.5. They include a presentation to the Deputy Chairman of the Planning Commission (August 2003) and at the World Bank-sponsored Watershed Summit in Chandigarh (December 2004).

The project also established contact with DFID India and the relevant staff to inform them of the evolution of the project through e-mail, phone and meetings at IIT Delhi and the DFID India offices. The DFID-sponsored WORLP project facilitated the field visit of the team to the project area and the organisation of meetings with high level Government of Orissa officials (see A.3.16). DFID India was invited to all the workshops organised by the project and to send representatives to the key events.

The main activities in this line of work were the organisation of workshops with national and state authorities. The RAPID workshop, mentioned in the previous section, was attended by, amongst others, representatives of the Planning Commission, Central Water Board and the Department of Science and Technology (see A.4.1). Notably, the project succeeded to conduct two very successful State Workshops. The organisation of these workshops was only possible thanks to IIT Delhi's efforts to establish excellent links for collaboration within key departments in HP and MP. The HP workshop (see A.4.2) was co-organised with the HP Council for Science and Technology and took place in Shimla in August 2004. It was attended by Shri Virbhadra Singh, the Chief Minister of HP, and Thakur Kaul Singh, Irrigation and Public Health Minister HP, and more than 100 participants connected with watershed and water resources development. The meeting produced a number of consensual recommendations for action in HP (Policy Brief 3). The MP workshop (see A.4.3) was co-organised with the Department of Land Resources of the Ministry of Rural Development HP and the Rajiv Gandhi Mission for Watershed Management. It took place in Bhopal in February 2006. It was attended by the Chief Minister of MP, Shri Shivraj Singh Chouhan, the Minister of Panchayat and Rural Development, Shri Narendra Singh Tomar and more than 300 of participants connected with watershed and water resources development, including several

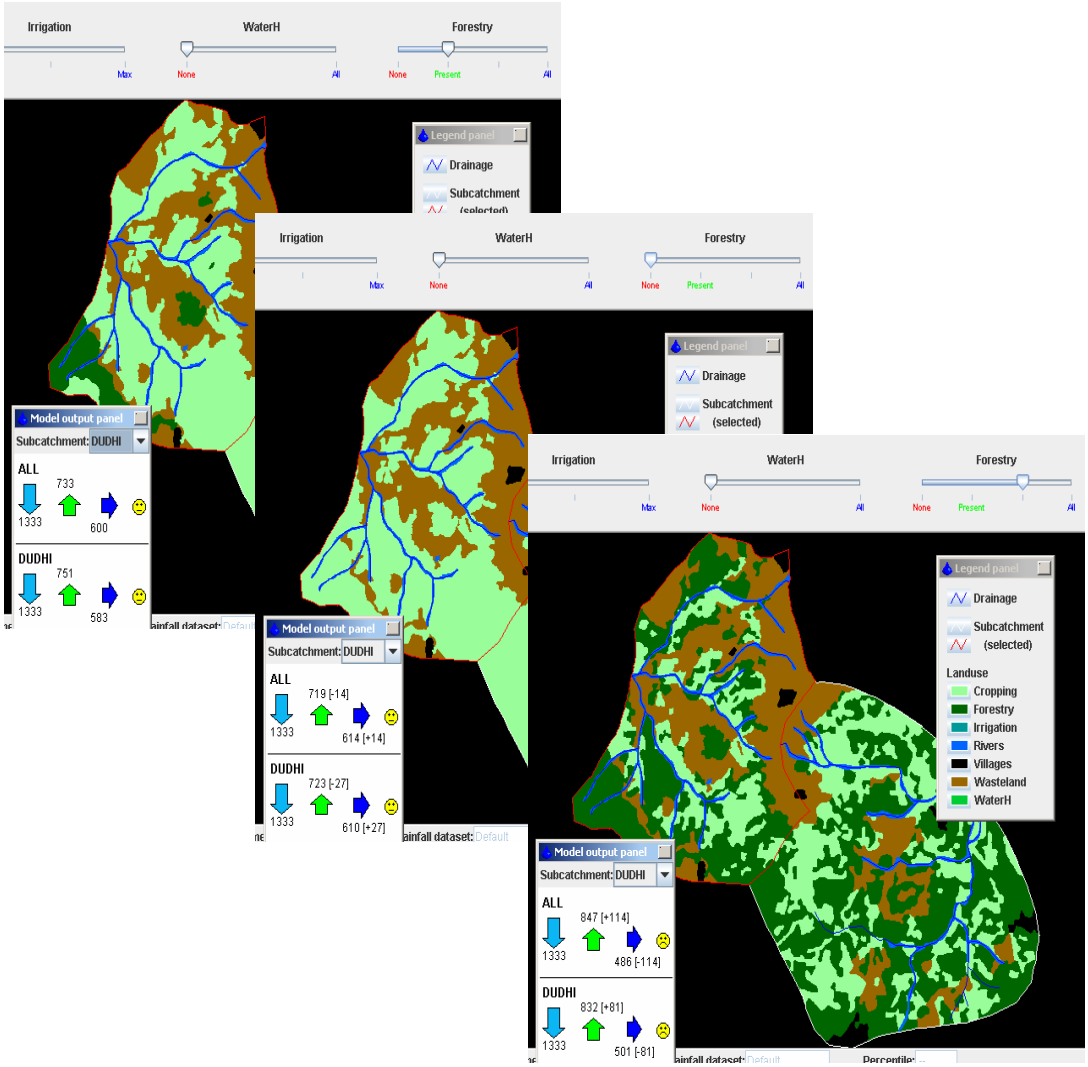
well-known social workers and activists. The meeting also produced a number of recommendations for action at the state level (Policy Brief 4).

Activity 3 Dissemination and IT tool development

Within this project, the EXCLAIM tool was developed to allow managers to evaluate the effects of their policy decisions (in terms of land use) on the hydrology of the catchment, and the consequential effects on the livelihoods of people living in the catchment (Internal Reports 13 and 14). The most recent version of EXCLAIM can be found at: http://www.needs.ncl.ac.uk/exclaim. At the core of EXCLAIM is a graphical view of the catchment, showing the current land uses (See Figure 3). Additional data can be linked to EXCLAIM to show the effects of land use change on the hydrology and livelihoods. EXCLAIM is not dependent on any specific hydrological or economic model Users of the tool can quickly learn to use the interface to interrogate the outputs of the models and determine the likely outcomes of policies concerning land use.

EXCLAIM was used in combination with HYLUC, a hydrological model designed to predict the effect of land-use change on river flow. At its core are routines for predicting the amount of rainfall interception and evaporation from various land uses, and these calculations feed into a routing function to predict the shape of the hydrograph. HYLUC has been tested in several locations worldwide as part of the “FRP Flows” cluster of projects, and has been found to be an effective tool to investigate the link between land-use change and river flow. EXCLAIM is used to manipulate the land cover occupied by the various land uses, in order to investigate the link between land use change and runoff. Additional analyses were performed to investigate the link between climate and runoff, through the use of meteorological data from other locations within Madhya Pradesh and Himachal Pradesh

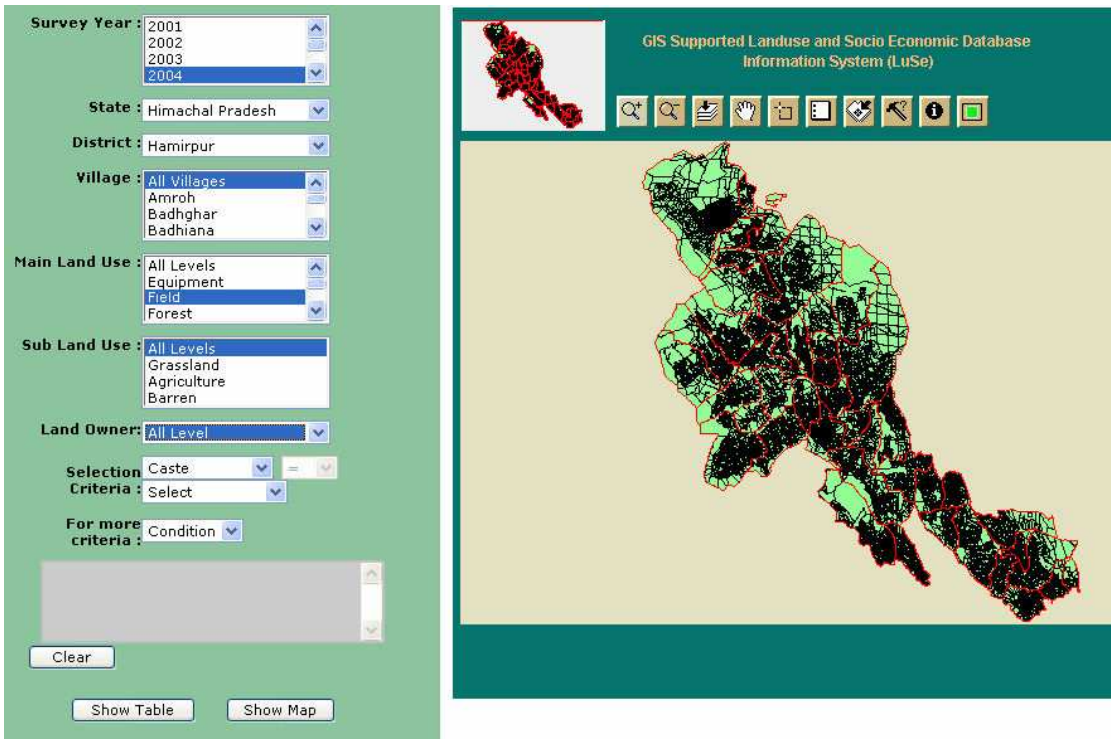
Figure 3. EXCLAIM output for scenarios of decreased and increased forestry with respect to the baseline scenario. The red rings show the forestry slider. The blue dotted rings show the outputs for the Dudhi watershed.



IIT Delhi developed GSIWIS, a GIS based Watershed Information System (Internal Report 11). GISWIS is designed to geographically view the linkage between Watershed Development and the Socio-economic status of the people affected by watershed interventions. The Geographical Information System (GIS) combines layers of spatial information and its attributes to provide a better understanding and analysis capability. Presently it includes land use information at the cadastral level. The land use information is attached to each plot of the village. Also, the socio-economic information of the people who own the plots is attached. GISWIS uses the Open GIS tool to link this information with the cadastral / watershed map and thus provides a cost effective tool, which can be disseminated at the local level. It has the basic GIS functionalities like querying and viewing. It has the capabilities to map the layout up

to the desired level (plot / village / district / watershed level). Once this layer is captured, the attributes attached to the layer can be analyzed and viewed. The GISWIS has been designed to perform the basic analysis of visualizing the impacts of watershed interventions. Figure 4 shows the main user interface.

Figure 4 GISWIS interface



4. Outputs

The project achieved all the outputs that were originally proposed:

1. Promotion and advocacy of:

a) New knowledge derived by the project of the bio-physical processes which determine how forests and other land use influences seasonal flows and groundwater recharge, particularly in dry zone regions.

1.1) New Bio-physical knowledge encapsulated within better calibrated land use hydrological models such as HYLUC and SWAT which are useable at district level in science and technology centres (and internationally). This output has been of direct relevance to the work of IIT Delhi, the leading water modelling group in India. The improved models have been used by ITT Delhi and CLUWRR in research and consultancy commissioned by the Indian institutions and external funding bodies such as the World Bank and are available for use by the local partners.

b) The importance of considering both supply and demand side options in whole catchment management and the cross sectoral (forests, irrigation, food, water, power, environment, people) implications of land and water management policies to avoid perverse policies and perverse livelihood outcomes.

1.2) A GIS based green and blue water presentation framework for indicating the water resource impacts of land use (forest and irrigation) change has been developed. The output has been used to demonstrate land and water management implications to Government of India officials in State level workshops, presentations to GoI officials and to donor supported projects.

2) Greater understanding of institutional perceptions and constraints relating to the role of forests and water in watershed management and what impacts policies based on these beliefs have had and may have on the poor.

2.1) An analysis of historical and current forest/agriculture and water policies, including the investigation of institutional perceptions regarding land-use / hydrological interactions and requirements for watershed management, and how they shape water policies affecting livelihoods of forest-dependent poor. The new understanding was incorporated in the activities of WII as leading R&D consultants in watershed development and forest policy and discussed directly with high level officials in the relevant Ministries.

2.2) Development of a ‘users forum’ where key staff from stakeholder institutions discuss the above issues and identify possible improvements. The findings of the project were presented to State authorities in MP and HP. The project team engaged

with the World Bank in Delhi and Karnataka (Jala Samvardhane Yojana Sangha which is implementing the Karnataka Community Based Tank Management Project and the Sujala Watershed Project) and DFID funded Rural Development projects (WORLP and MPRLP).

3. New "Dissemination and IT Tools" for communicating the "science perception" and for investigating catchment management options created and ready to be used by NRDMS, stakeholder organisations and NGOs.

3.1) The operation of the tool was demonstrated to stakeholders and is accessible through http://www.needs.ncl.ac.uk/exclaim.

3.2) A technical note on the effectiveness of this GIS tool, and recommendations for using it as a basis for a web based/standalone decision support system for whole catchment management was produced.

Table 1. Mapping project outputs against indicators of achievement and means of verification

Project outputs	Indicators of achievement	Project verifying outputs (see appendix)
1) Promotion and advocacy of:		
a) New knowledge derived by the project of the bio-physical processes which determine how forests and other land use influences seasonal flows and groundwater recharge, particularly in dry zone regions and b) The importance of considering both supply and demand side options in whole catchment management and the cross sectoral (forests, irrigation, food, water, power, environment, people) implications of land and water management policies to avoid perverse policies and perverse livelihood outcomes.	1.1) New bio-physical knowledge encapsulated within better calibrated land use hydrological models such as HYLUC and SWAT which are usable at district level in NRDMS centres (and internationally). 1.2) GIS based green and blue water presentation framework for indicating the water resource impacts of land use (forest and irrigation) change.	A.2.3 Policy Brief 3 A.2.4 Policy Brief 4 A.3.12 Internal Report 12 A.3.13 Internal Report 13 A.3.14 Internal Report 14 A.3.15 Internal Report 15 A.6.2 Gosain et al.
2) Greater understanding of institutional perceptions and constraints relating to the role of forests and water in watershed management and what impacts policies based on these beliefs have had and may have on the poor.	2.1) An analysis of historical and current forest/agriculture and water policies, including the investigation of institutional perceptions regarding land-use / hydrological interactions and requirements for watershed management, and how they shape water policies affecting livelihoods of forest-dependent poor	A.2.1 Policy Brief 1 A.2.2 Policy Brief 2 A.3.1 Internal Report 1 A.3.2 Internal Report 2 A.3.3 Internal Report 3 A.3.4 Internal Report 4 A.3.5 Internal Report 5 A.3.6 Internal Report 6 A.3.7 Internal Report 7 A.3.8 Internal Report 8 A.3.9 Internal Report 9 A.3.10 Internal Report 10 A.6.1 Wilson et al.

	2.2) Development of a users forum involving key staff from stakeholder institutions to discuss the above issues and identify possible improvements.	A.6.3 Calder et al. A.6.4 Sunandan et al. A.6.5 Sunandan & Amezaga A.4.1 RAPID Workshop A.4.2 HP Workshop A.4.3 WII Workshop A.4.4 MP Workshop A.5.1 Presentation 1 A.5.2 Presentation 2 A.5.3 Presentation 3 A.5.4 Presentation 4 A.5.5 Presentation 5 A.5.6 Presentation 6 A.5.7 Presentation 7 A.5.8 Presentation 8 A.5.9 Presentation 9 A.5.10 Presentation 10
3) New "Dissemination and IT Tools" for communicating the "science perception" and for investigating catchment management options created and ready to be used by NRDMS, stakeholder organisations and NGOs.	3.1) Demonstration and operation of the tool. 3.2) A technical note on the effectiveness of this GIS tool, and recommendations for using it as a basis for a web based/standalone decision support system for whole catchment management which takes account of the needs of the poorest in society.	http://www.needs.ncl.ac.uk/exclaim. A.3.11 Internal Report 11 A.3.13 Internal Report 13 A.3.14 Internal Report 14

5. Contribution of outputs

5.1 Contribution to DFID's developmental goals

The project has contributed to the UK Department for International Development's (DFID) goals of the elimination of poverty and encouragement of economic growth, which benefits the poor, in the following ways:

- A more evidence-based understanding of the biophysical constraints for watershed development projects which are the key policy instrument for rural development in deprived areas. This has direct application to DFID's Rural Livelihood Projects (eg WORLP, MPRLP), other donors Rural Livelihood Projects (eg the World Bank's JSYS and Sujala Watershed Projects) and multiple Government of India watershed development programmes.
- Increased policy awareness of the impacts of inadequate forest and water policies on small-scale farmers, landless families and the urban and peri-urban poor.
- Web based tools to convey the above findings.

5.2 Promotion pathways to target institutions and beneficiaries

There are three central organisations involved in the dissemination and promotion of the project outcomes; the Centre for Land and Water Resources Research (CLUWRR), the

Indian Institute of Technology Delhi (IIT Delhi) and Winrock International (India). A secondary role was played by the state partners of the project: a) Himachal Pradesh (HP): National Institute of Technology (NIT) Hamirpur and HP State Council for Science, Technology and Environment (HPSCSTE), b) Madhya Pradesh (MP): Regional Research Laboratory (RRL-CSIR) and the Rajiv Gandhi Mission for Watershed Management. At the central level the project collaborated with the Department for Science and Technology GoI.

The project has actively sought to converge as much as possible with the long term interests of the collaborators and partners, and concentrate their efforts in areas where they can increase their own know-how and capabilities. This is the best guarantee for the knowledge transfer after the project's completion.

IIT Delhi: LOWFLOWS helped IIT Delhi in their long term task of establishing a collaborative information and decision-making framework for water resources management at a central and state level. The project allowed IIT to acquire new skills for dealing with forest, water and livelihood issues relating to watershed projects. It has also provided a platform for interfacing research and policy. WII developed new insights on forest/water interactions and their impacts on livelihoods; and acted as a dissemination agent amongst key institutions in that area. HPSCSTE is a direct user of the findings of the project and has used the project as a platform to promote the creation of a common information framework in HP. Capacity building is the main benefit for NIT and RRL. Both groups acted as recipients and transfer agents of the findings of the project in their state. NIT will utilise the study watershed for their future training programmes. Both sites will be demonstration sites of the State Government. The Rajiv Gandhi Mission and the Department of Rural Development have linked the dissemination of the project to the launching of a new State wide initiative for water conservation (Jalabhishek). LOWFLOWS worked in close partnership to DST, who is a direct recipient of project findings. The project has used DST's standards and promoted their use by others for information applications at the national and state level.

The project carried out activities specifically designed to engage target institutions in India. These included:

- Mapping of stakeholder institutions
- Development of a user forum with state partners
- Semi-structured interviews of key staff
- RAPID research and policy workshop and seminar
- Stakeholder workshops

The strategy of convergence with our partners and collaborators allowed the active use of their existing contacts, which cover most of the target institutions, for mutual benefit. Key stages of the process were:

- Watershed case studies in the two states including interviews with local and state level decision-makers
- Promotion of LOWFLOWS within the other projects of our partners (mainly IIT and WII). This gave the occasion for high level presentation amongst policy makers (e.g. Deputy Chairman of the Planning Commission; World Bank Hydrology Project II)
- RAPID workshop in Delhi with central-level policy-makers with attendance from Planning Commission, Central Water Commission, DST and CAPART.
- Workshop at Winrock International India
- State level workshops co-organised with state partners and involving a wide range of state-level stakeholders. The state workshops were profusely reported in the state media.

Central to the project was the dissemination of scientific findings on forest and water interactions. For this purpose:

- The project developed GIS and web-based dissemination tools to demonstrate forest-water interactions in the context of the study watersheds. These tools were actively used in interactions with stakeholders.

- WII were involved and gave presentations in key national events such as:
    - Forests, Water and People; FORWAP 2004. Hard Rock Regional Centre of National Institute of Hydrology, Belgaum, Karnataka
    - 'Forests and Water Conservation - Issues in Sustainable Development' Indian Council of Forestry Research & Education (ICFRE),. Dehradun, Uttaranchal, India
    - International Workshop on Impacts of Reforestation of Degraded Lands on Landscape Hydrology in the Asian Region, UNESCO / National Institute of Hydrology / Indian National Committee on Hydrology, Roorkee, India.

The project included one activity specifically oriented toward donors. This activity involved interviews with India-based officers to discuss their views of forest, water and watershed development projects. LOWFLOWS interfaced with the DFID India office and direct contact was established with the Delhi office staff. Their collaboration was sought for all of the key events listed above. In particular LOWFLOWS transferred some of the findings of the project to the DFID India funded Western Orissa Rural Livelihoods Project and is actively discussing the transfer to the MP Rural Livelihood Project and the Rajiv Gandhi Mission.

Promotional material will be prepared for ODI's RAPID webpage and the policy and modelling research will be published in three journal papers.

5.3 Follow-up research to achieve developmental benefit

In order to achieve developmental benefits a follow-up research project is urgently needed to provide support for application of the project findings to the Governments of HP, MP, Karnataka and Orissa. Unless this happens the partnership will dissolve without the opportunity to exploit the links of trust established with key governmental actors in India.

Appendix

Project bibliography

Code	Outputs (pages)
A1.	Final Technical Report (pp25)
A2. Policy briefs	
A2.1	POLICY BRIEF NO. 1: Promoting a Scientific Approach to Land and Water Management in India: Identifying Policy & Application Opportunities (pp2)
A2.2	POLICY BRIEF NO. 2: mapping perceptions on forests-water linkages in India (pp2)
A2.3	POLICY BRIEF NO. 3: integrated framework – key to sustainable watershed and water resources management (pp2)
A2.4	POLICY BRIEF NO. 4: integrated framework – key to sustainable watershed and water resources management (pp2)
A3. Project reports	
A3.1	A review of water management, watershed development and forestry policy in India (Internal Report I) (pp24)
A3.2	Himachal Pradesh Watershed Case Study (Internal Report II) (pp42)
A3.3	Madhya Pradesh Watershed Case Study (Internal Report III) (pp36)
A3.4	Perceptions Regarding Forests – Water Flows Interactions at the National Level (Internal Report IV) (pp27)
A3.5	A Review of Forest, Water & Watershed Management Policies, Guidelines and Related Documents in India (Internal Report V) (pp21)
A3.6	A Review of Donors' Policies and Guidelines Regarding Forest, Water & Watershed Management with a Focus on India (Internal Report VI) (pp26)
A3.7	Evaluating social impacts of watershed development using a propensity score matching method. Application to Dudhi Watershed, Madhya Pradesh.(Internal Report VII) (pp24)
A3.8	Socio Economic Analysis – Himachal Pradesh (Internal Report VIII) (pp33)
A3.9	Water Management in Madhya Pradesh Examining Research – Policy Interactions (Internal Report IX) (pp17)
A3.10	An Institutional Analysis of Negotiation Support Systems for Watershed Environmental Services. A Case Study of the Bhoj Wetlands, Madhya Pradesh.(Internal Report X) (pp18)
A3.11	GIS based Watershed Information System (GISWIS) User's Manual (Internal Report XI) (pp10)
A3.12	Hydrological modelling with SWAT model in the Micro-watersheds of Madhya Pradesh and Himachal (Internal Report XII) (pp 48)
A3.13	The influence of water harvesting, irrigation, forestry and climate on the

	hydrology of a central Indian catchment: studies with HYLUC and EXCLAIM (Internal Report XIII) (pp 20)
A3.14	Demonstrating the hydrological effects of water harvesting measures and forestry using HYLUC and EXCLAIM in a northern Indian catchment. (Internal Report XIV) (pp 18)
A3.15	Using SWAT and HYLUC to predict the effect of climate and land use change on catchment hydrology in India (Internal Report XV) (12)
A3.16	BACK TO OFFICE REPORT: Linking FLOWs socio-economic research and introducing Stated Choice Methods to Western Orissa Rural Livelihoods Project (WORLP) (pp8)
A4. Project workshop reports	
A4.1	Bridging the Research-Policy Gap in the Water & Forest Sectors in India A Seminar & Workshop Delhi 3rd / 4th February 2004 (pp 39)
A4.2	Towards Implementing Environmentally Sustainable Water Policy for Himachal Pradesh WORKSHOP REPORT 28th August 2004, Shimla (pp 32)
A4.3	Synthesis Report: Half-Day Seminar on "Developing Evidence-based Policy for Improved Pro-poor Watershed Management – Findings from India, Costa Rica and South Africa" - 2nd November 2004 Low Base Flows & Livelihoods in India (pp 82)
A4.4	Towards Implementing Sustainable Watershed Management Strategy for Madhya Pradesh WORKSHOP REPORT 6-7 February 2006, Bhopal (pp 36)
A5. Powerpoint presentations	
A5.1	National Level Framework for Integrated Watershed Management (pp 34)
A5.2	Watershed Development; Political Challenges & Recommendations. The India Context (pp15)
A5.3	Low-flows and livelihoods (R8171) POLICY OBJECTIVES (pp19)
A5.4	Low Base Flows & Livelihoods in India (pp11)
A5.5	FAWPIO Forest, Land and Water Policy: Improving Outcomes (pp 15)
A5.6	Towards an Improved State Water Policy for Himachal Pradesh (pp16)
A5.7	Sustainable Watershed Management (pp 46)
A5.8	Watershed Development in India Beliefs and Policy Narratives (pp 16)
A5.9	Land (Forests) & Water Management: Policy Environment & Madhya Pradesh's Watershed Development Program (pp 12)
A5.10	Integrated and Sustainable Watershed Management (pp14)
A6. Journal and conference papers	
A6.1	Wilson, V., Amezaga, J., Gosain, A., Gupta, R. and Saigal, S., August, 2003.

	Watershed Development; Policy Challenges & Recommendations, The India Context. Submitted For Fao/Icimod Workshop In Nepal On; "Preparing The Next Generation Of Watershed Management Programmes" 11th-13th September, 2003, Katmandu, Nepal.
A6.2	Gosain A.K., Calder, I.R Sandhya Rao, Yadav R.N., And Amezaga J., New Efforts For Effective Watershed Management In India. In Proc. International Conference on Water and Environment, Bhopal, Madhya Pradesh, India, 15-18 December 2003.
A6.3	Calder I. Amezaga J. Aylward B. Bosch J. Fuller L. Gallop K. Gosain A., Hope R. Jewitt G. Miranda M. Porras I. and Wilson V., Forest And Water Policies. The Need To Reconcile Public And Science Perceptions, Geologica Acta, Vol.2, Nº2, 2004, 157-166 Available Online At Www.Geologica-Acta.Com
A6.4	Sunandan Tiwari, Borgoyary, M Amezaga J. And Wilson V. The Forests – Water Interface Questioning The Assumed. National Seminar on 'Forests, Water & People', Belgaum, 29th - 30th of July 2004
A6.5	Sunandan Tiwari & Amezaga J, Mapping Perceptions on Forest-Water Linkages and Identifying Opportunities for Improved Land and Water Management in India. International Workshop on Impacts of Reforestation of Degraded Lands on Landscape Hydrology in the Asian Region, UNESCO / National Institute of Hydrology / Indian National Committee on Hydrology, Roorkee, India, 6^{th}-10^{th} March 2006.