A Multi-disciplinary Approach to Assessing the Effects of Water and Land Use Policy on Livelihoods

C J M Hewett* and **R Hope***

C.J.M.Hewett@ncl.ac.uk and Robert.Hope@ncl.ac.uk

*Centre for Land Use and Water Resources Research, University of Newcastle upon Tyne, UK

Abstract In recent years increasingly sophisticated models have transformed our understanding of hydrology and land use. However, while there has been much discussion of multi-disciplinary approaches in hydroinformatics, it is notable that few tools attempt to integrate analyses from different disciplines. The Catchment Management and Poverty (CAMP) alleviation project is an attempt to predict the effects of water and forestry policy on the livelihoods of people living in developing countries using a multi-disciplinary approach. Integral to the research is Integrated Water Resource Management at the catchment scale and the sustainable livelihoods framework for analysis at the household scale. The sustainable livelihoods paradigm conceptualises the resources available to an individual in terms of five 'capitals': natural, economic, human, social and physical. While the immediate application of the research is in the Republic of South Africa, the methods of analysis developed are intended to be applicable to a more general situation and will be validated in at least two other developing countries: Tanzania and Grenada. The methodology is intended to guide policy over water and land use issues. This paper gives an outline of the methodologies employed and a description of the sustainable livelihoods approach and discusses how they relate to the Luvuvhu catchment in South Africa. A conceptualisation of an integrated model is presented and modelling options are discussed.

Keywords multi-disciplinary, hydroinformatics, Catchment Management and Poverty alleviation (CAMP), sustainable livelihoods, Integrated Water Resource Management, integrated model

Introduction

Over the past few years the development of increasingly sophisticated mathematical models has helped to transform the scientific understanding of land use and its effect on hydrological processes. Models have played a big part in enabling practitioners to develop policy, especially in the light of the move towards Integrated Water Resource Management (IWRM) which attempts to develop water resources in a manner consistent with ecological objectives, holistic thinking and the results of stakeholder consultation. Discussions of such multi-disciplinary approaches to solving problems associated with managing water resources gave rise to the notion of hydroinformatics. However, it is notable that up to now few tools have attempted to integrate analyses from different disciplines.

The challenge of the Catchment Management and Poverty (CAMP) project is to integrate multi-disciplinary analyses at different scales to provide an assessment of water and land use policy (in particular forestry) in terms of whether or not it improves the livelihoods of the poorest people using both quantitative and qualitative information. The methodology of the CAMP project has been influenced by the recent move towards recognising the need for a more people-centred approach to deciding development policies, which has led to the development of the sustainable livelihoods (SL) framework of analysis. The SL paradigm conceptualises the resources available to an individual in terms of five 'capitals': natural, economic, human, social and physical. This approach, which builds an understanding of needs based on people's own perceptions, has to be focussed on the micro (individual or household) scale, whereas IWRM has to be at the macro (catchment) scale.

There are three target countries for the analysis: Republic of South Africa (RSA), Grenada and Tanzania. Specific policies to assess include compensation mechanisms derived from 1998 National Water Act in RSA related to stream flow reduction activities (SFRA) and the Working for Water (WfW) programme in RSA.

The CAMP project's primary research site is the Luvuvhu catchment in Limpopo Province (formerly Northern Province) RSA, covering 5940 km² and forming part of the larger Limpopo system. The catchment is characterised by a range of environments; the Soutpansberg range to the north-west has a high precipitation regime (> 1000mm) with plantation forestry and commercial agriculture as the dominant land-uses, east of this area is the main urban settlement, Thohoyandou (population 450,000) and moving further east drier (precipitation < 500mm), fragmented, rural communities lie close to the border of the Kruger National Park and at the top of the catchment the Luvuvhu river leads into the Limpopo at the Zimbabwe/Mozambique border. Limpopo Province is one of the poorest regions within

South Africa under almost every socio-economic classification (Hope et al. 2002). The secondary research sites are the Caribbean island of Grenada and Tanzania, both of which will be used to validate the methodology developed.

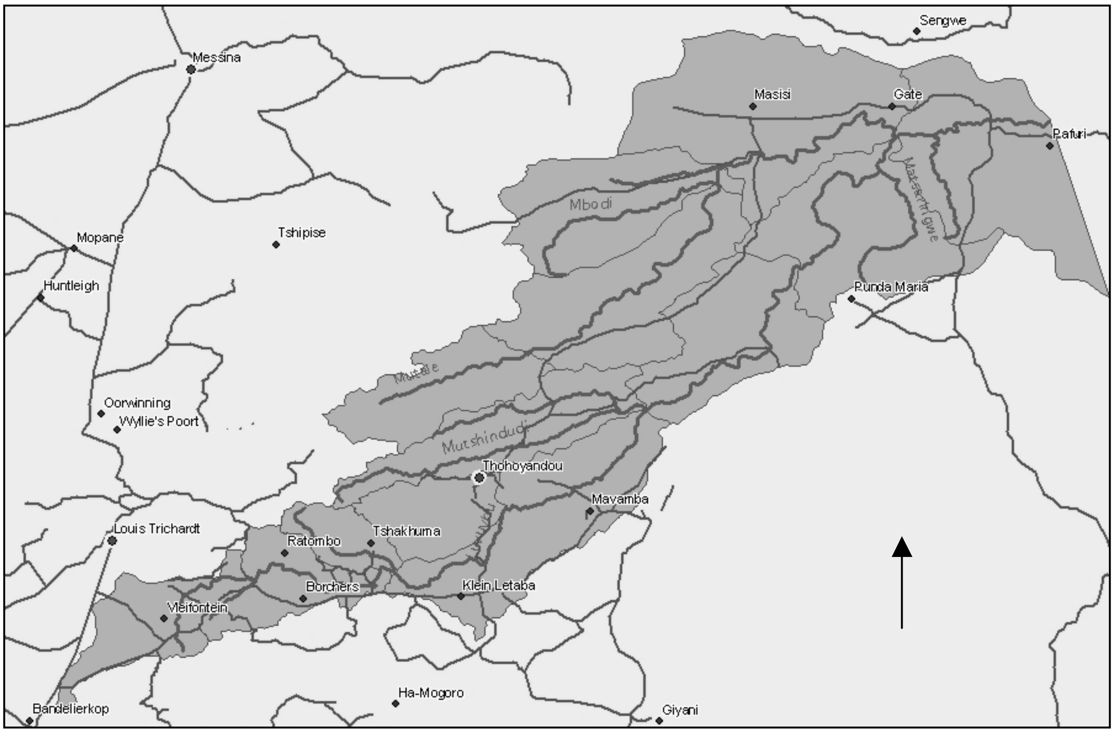

Figure 1 Luvuvhu catchment, Northern Province, RSA

The methodology currently being pursued is to develop analyses from different disciplines and to use these analytical components to attempt to reconcile the application of IWRM and SL approaches to land and water management within catchments in the target countries. This is intended to lead to the identification of policy instruments, which both improve the livelihoods of poor people and protect the natural resource base.

The CAMP project team consists of a number of people from different fields in the UK and in the target countries RSA, Grenada and Tanzania. The component analyses are: livelihoods analysis, hydrological models, a spread of alien species model and a natural resource economics model (based on net rainfall value/productivity). A powerful output of these analyses would be to combine them in a single integrated model, which would allow the research team to explore the linkages between the analytical components. The purpose of this paper is to discuss the component analyses and to outline the form an integrated model might take.

Sustainable Livelihoods

Sustainable Livelihoods (SL) has become one of the most common diagnostic tools employed in development planning and interventions. SL promotes poverty eradication, protection and better management of the environment, and places emphasis on people rather than resources (Carney 1998). Chamber and Conway's (1992:7-8) definition of livelihoods states that "a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the long and short run."

The roots of SL can be traced to the work of the economist Amartya Sen (1981) and his analysis of entitlements in relation to famine and poverty. Linking individual relationships to ownership bundles of commodities within an exchange economy Sen argues that consideration of individual entitlements to resources (biophysical, human, social, etc) provides a powerful explanatory framework for why some people are poor and may starve. Sen's analysis has been further developed to include political, economic, environmental and social interactions and influences (DFID 1999).

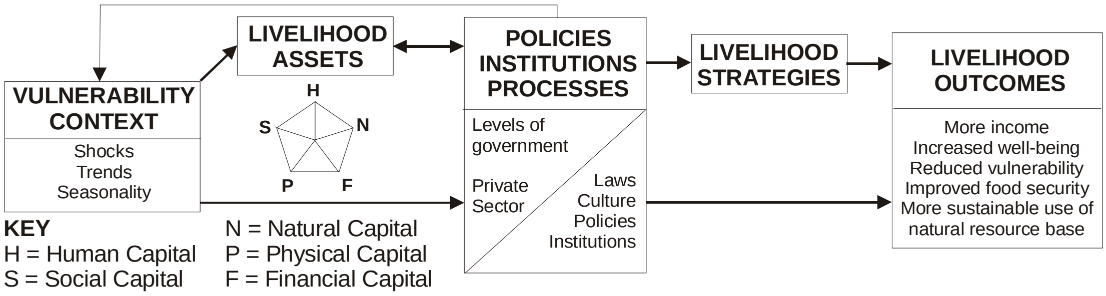

Figure 2 Sustainable Livelihoods Framework (DFID 1999)

Principles guiding the SL paradigm may be characterised by the following components:

- People-centred;
- Holistic;
- Dynamic;
- Aim for sustainability;
- Build on strengths;
- Use micro-macro links (FAO 2000).

The SL framework distinguishes those economic, political, environmental and social factors that influence the strategies that people employ and the possible set of outcomes that may be achieved. The vulnerability context acknowledges the shocks and trends that may trigger famine from natural or man-made disasters. The recent floods in Mozambique or the political instability in Zimbabwe highlight the vulnerability context that can have devastating impacts on the poorest members of a developing country.

The SL framework describes the asset portfolio of a livelihood as consisting of five capitals:

- Human (e.g. health, education);
- Financial (e.g. income (stored as cattle or money));
- Social (e.g. kin, associations);
- Physical (e.g. schools, roads);
- Natural (e.g. forests, rivers).

These five livelihood capitals provide the matrix from which an individual has the means to make a living. It is possible to increase, decrease, maintain or even substitute within the portfolio. Asset substitution or sequencing is an area of research that attempts to understand why some configurations of capitals breakout of poverty and others do not (Scoones 1998). Social capital embodies the norms, values and networks that establish on-going patterns of social interaction. Social capital least embraces quantitative measurement though progress has been made in this area (Uphoff and Wijayarathna 2000; Krishna and Uphoff 1999).

Livelihood capitals *per se* are uninformative in terms of mapping poverty as they provide no context to the political economy that pervades any livelihood and that may offer an enabling or limiting environment to livelihood development. The SL framework encapsulates this area as Policies, Institutions and Processes (described as the PIP box, shown in the centre of Figure 2). Within the CAMP project in RSA, two water policies are being investigated: Stream Flow Reduction Activity (SFRA) and the Working for Water (WfW) programme (DWAF 1996; Calder 2002a). At present SFRA refers specifically to commercial forestry but the definition is likely to be extended to certain types of commercial agriculture, in particular sugar cane plantations. It addresses the upstream-downstream dynamic pivotal in water flow in any catchment. In water-scarce areas the allocation and efficient and equitable use of a limited but essential resource is critical in both individual and collective development pathways and livelihood security. WfW is a public works programme that synthesises ecological and human security imperatives. It addresses the negative impacts of alien species on the ecological integrity of the natural resource base by employing people on poverty alleviation criteria (women, youth, disabled) to remove the alien species from riparian zones across RSA.

Given the interaction of the capital assets with the vulnerability context and the PIP box, various livelihood strategies may come to the fore in singular and in combination. These strategies may rely on the natural resource base directly or indirectly or may result in migration. Livelihood outcomes are derived from these strategies and can be measured by criteria such as income level, food security, increased well-being and reduced vulnerability.

The SL framework provides a useful diagnostic tool to map and scope development interventions. It is, however, no 'silver bullet' and has a number of weaknesses. First, the SL framework does not shed any light on where the most effective poverty alleviation intervention may be located. Second, it is extremely 'data hungry'. Third, it is static. Fourth, it is very much a western, developed world construct, which leaves it open to criticism as to its relevance and applicability to developing countries, their development workers, and local communities. Finally, it has been criticised for failing to address fully the issue of power relations (Baumann 2000). The pervasive issue of power and society is rooted in Marxist theory of class struggles and highlighted in feminist theories of gender roles and equity in society. Development interventions are frequently hijacked by local elites (men, wealthy, kin groups) as a non-disaggregated approach to social structure may fail to alleviate the poverty of the poorest or consolidate the existing inequitable social structure (Kothari 2001).

The CAMP SL methodology encompasses survey research and action research. The methods that have and will be employed include a catchment level household survey and participatory research amongst one or more communities. The household survey is designed on a factorial structure to isolate water-poverty linkages using three criteria: precipitation (> or < 700mm p.a.), irrigation infrastructure and reticulated supply to communities. Eight communities have been randomly selected using this purposive design to try and tease out inter-community, intra-community and inter-household water-poverty differences and relationships. The participatory research will identify one or more communities to attempt understand the 'why' behind the quantitative data. Techniques such as Pressure-State-Response, focus groups and Semi-Structured Interviews (SSIs) are proposed methods. Key considerations will be to understand the impacts of the water-poverty from a disaggregated (gender, age, class) perception. The role and significance of water institutions at the community level will also be explored in order to assess their impact at the water-poverty interface.

The SL analysis aims to provide meaningful analysis of the significance of the linkages between water and poverty disaggregated by the relevant social divisions. The local perceptions and understandings that emerge will be key project outputs that will be disseminated to the relevant RSA institutions (notably the Department for Water Affairs and Forestry and the International Water Management Institute) and the wider academic and development community.

Integrated Model

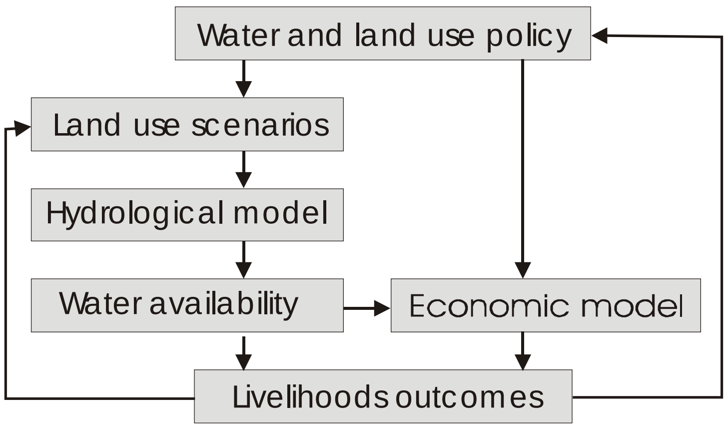

Figure 3 Idealisation of Integrated Model

One way to synthesise the analyses performed in the CAMP project would be to produce a computer simulation tool which combines the component analyses in a single integrated model. This would allow the research team to explore in much greater detail the linkages between the four analytical components. Ideally, the integrated model would combine the analysis of hydrological, economic, alien species and livelihoods data, have predictive capability, have time dependence, be self contained and be as general as possible since it is intended to be applicable in other countries. It is beyond the scope of this three year project to produce something quite so general and thus the likelihood is that not all of the analyses will be included in a single computer program, but it is worth considering the requirements of such a model to provide the flexibility to extend it at a later date.

There are a number of challenges implicit in producing an integrated model; There are problems of scale; from livelihoods information at the individual or household level, through micro- and macro-economic data to the level of water and land use policy, for which the appropriate scale is the catchment; understanding and modelling the interactions between different factors in the model (hydrological-economic-social) is highly complex; Identifying critical indicators to enable simplifications to be made to make modelling manageable; Consideration of different ways in which people use water – consumptive (domestic) and productive use.

A fully integrated model would have to contain

- either a parameterised hydrological model using parameters obtained from an existing, more sophisticated model or be able to interrogate hydrological (probably time dependent) data from an external source such as ACRU (Schulze et al., 1998) or HYLUC (Calder 2002b),
- a spread/removal of alien species model which would have to include some form of information loop with the hydrological model,
- a natural resource economics model
- a livelihoods model which incorporates both quantitative and qualitative information

Some form of graphical output would also be required to enable interpretation of model results. This may involve an interface with a Geographical Information System (GIS).

Figure 3 represents an idealisation of such a fully integrated model. In the time scale of the CAMP project it is unlikely to be possible to develop an automatic tool which could perform all of the analyses and to feed information back as indicated in the figure. However, the figure can be considered as an overview of the project itself, some components of which will be simulation models and some elements of which will be performed by human brains (i.e. the project team).

Careful thought will have to be given as to how the model relates to the policy options under investigation. For example, assessment of the Working for Water (WfW) programme will necessitate considering both the economic/livelihoods outcome and the hydrological impact.

Two approaches to generating an integrated model have been considered

1. A systems dynamics-type model
2. An object-oriented model

The advantages of the systems dynamics approach are that it is quite intuitive, making it relatively easy to visualise the interconnections between variables and relatively straightforward for the non-expert to understand and augment models – this would be most significant if the model were intended for use as a participatory tool. However, it has the disadvantage that it is not as flexible as writing code from scratch – the developer is restricted by what the systems dynamics software has been designed to do.

The advantages of using an object-oriented programming environment are that it is easy to make programs user friendly, the systems are more flexible, linking models with other programs is more straightforward and, most importantly, object-oriented methodology is well-suited to the type of modelling in question – starting with an individual as the basic object with a hierarchy going up through household to village/town to the catchment scale. Objects could own associated variables some of which contain quantitative data and some of which have qualitative states. Inheritance may be a useful property to employ in the model.

Bearing this in mind it should be noted that the most recent GIS systems have been built on object-oriented methodology utilising Visual Basic for Applications (VBA) and thus could provide a powerful tool for developing an integrated model since spatial representation comes as standard in such a system and developing the model within the GIS framework would preclude the need to develop software links. However, it should also be noted that some of the tools (for example the hydrological models) already exist and thus it may be more practical to consider how best to develop communication between existing models than to attempt building a system from scratch.

Discussion

Using the object-oriented programming paradigm would seem to be the most appropriate approach to generating an integrated hydrological-economic-livelihoods model. The model would incorporate objects which contain livelihoods information (preferable supporting quantitative and qualitative information derived from the livelihoods analysis) and which hold data required by the natural resource economics model. This will require great care in defining the variables and methods belonging to an object.

Considering the ideal solution, writing all of the component models in a single system would clearly be the best solution, but the practical reality of a fixed term project, limited resources and the existence of analytical tools makes this unrealistic. This highlights a dilemma which will arise over and again in the field of hydroinformatics, where compromises will often have to be made in order to achieve short term goals. However, it is always worth keeping an eye on the bigger picture and attempting to develop tools which have the potential to be extended and developed in a truly multi-disciplinary fashion in the future.

References

Baumann, P. (2000) Sustainable livelihoods and political capital: Arguments and evidence from decentralisation and natural resource management in India. ODI, Working Paper 136, October 2000.

Calder, I.R. (1998) *The Blue Revolution, Land Use and Integrated Water Resource Management*, Earthscan

Calder, I.R. (2002a) Forest Valuation and Water – the need to reconcile public and science perceptions. Paper presented at the Tropenbos International Seminar on Forest Valuation and Innovative Finance Mechanisms for conservation and sustainable management of tropical forests, March 2002.

Calder, I.R. (2002b) Assessing the water use of vegetation and forests – development of the HYLUC, Hydrological Land Use Change model. In preparation.

Carney, D. (1998) Implementing the Sustainable Rural Livelihoods Approach. In D. Carney (ed.) *Sustainable Rural Livelihoods, What contribution can we make?* Papers presented at the Department of International Development's Natural Resource Adviser's Conference, London, July 1998

Chambers, R. and Conway, G. (1992) Sustainable rural livelihoods: Practical concepts for the 21st century. IDS Discussion Paper **296**.

DFID (1999) Livelihoods Approaches Compared. At http://www.livelihoods.org

DWAF (1996) *The Working for Water Programme*, Ministry of Water Affairs and Forestry, Cape Town, South Africa

FAO (2000) Inter-agency Experiences and Lessons. From the Forum on Operationalizing Sustainable Livelihoods Approaches. Pontigano (Siena) 7-11 March 2000. FAO, Rome, 2000.

Hope, R. and Hewett, C.J.M. (2001) Catchment Management and Poverty alleviation (CAMP) At: http://www.cluwrr.ncl.ac.uk/projects/camp

Hope, R., Calder, I.R., Gowing J.W., Laurie, N., Dixon P-J., Sullivan C.A.,Jackson N.A., von Maltitz G., Bosch J., LeMaitre D., Dye P., Netshiluvhi T., Hatibu N., and Paterson, G. (2002)Saving the trees and the poor? Catchment Management and Poverty (CAMP) European Tropical Forest Reseach News **35**. At: http://www.etfrn.org/etfrn/newsletter/news35/index.html

Kothari, U. (2001). Power, Knowledge and Social Control in Participatory Development. In B. K. Cooke and Kothari,U. (ed.) Participation: The New Tyranny? London, UK, Zed Books: 139-152.

Krishna, A. and Uphoff, N. (1999) Mapping and Measuring Social Capital: A Conceptual and Empirical Study of Collective Action For Conserving and Developing Watersheds in Rajasthan, India. World Bank, Social Capital Initiative, Working Paper **13**.

Rosegrant, M.W., Ringler, C., McKinney, D.C., Cai, X., Keller, A. and Donoso, G. (2000) Integrated economic-hydrologic water modeling at the basin scale: the Maipo river basin. *Agricultural Economics* **24**, 33–46.

Scoones, I. (1998) 'Sustainable Rural Livelihoods: A Framework for Analysis', IDS Working Paper **72**.

Schulze, R.E. et al. (1998) Hydrological impacts of land use practices in the Pongola-Bivane catchment, Phase 3 impacts of afforestation and of irrigation abstractions on Paris Dam. University of Natal ACRUcons Report **26**.

Sen, A. (1981) Poverty and Famines. An Essay on Entitlements and Deprivation. OUP.

Uphoff, N. and Wijayaratna, C.M. (2000) Demonstrated Benefits from Social Capital: The Productivity of Farmer Organizations in Gal Oya, Sri Lanka. World Development **28** (11), 1875-1890.