Assessing policy influences on people's relationship to water ecosystem services: The Bolivian experience

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Executive Summary

The aim of this analysis is to understand how, and to what extent, policy and planning related to water ecosystem services impact on practice in Bolivia, and to identify how research efforts might improve the situation in future. The emphasis is less on policy and planning influences on delivery of water, and more on their influence over on-the-ground practices that affect the quantity and quality of water available and poverty. The impact of climate change thinking and evidence on relevant policies and practices is also analysed. The analysis explores the relative impacts, links and relationships between different policies and planning priorities over time and in different places. It explores the impact of research in these fields and concludes with assessment on where research is most needed and how its impact might be optimised.

In terms of provision of water ecosystem services there is no "one" Bolivia. Rather, the country is split along a series of fault lines, the most important of which are geographical and biophysical. The altiplano highlands are a low precipitation desert with most available water coming from summer glacier- and snow- melt. Given that most of the altiplano's water comes from glaciers, land use and land use change can affect such flows only minimally. At the other extreme, lowland Bolivia is humid with high year-round rainfall. The human activities that impact water ecosystem services in the Amazon are usually diluted by the metres of rain that fall on the area every year. Thus it is only the area between the high Andes and the Amazon—the transitional inter-Andean valleys and slopes—where human activities can define the scope of water ecosystem services. The majority of the policy interventions that affect water ecosystem service provision in Bolivia thus have their impact in the country's inter-Andean valleys.

The underlying water law is supposed to govern the provision of water and water ecosystem services throughout Bolivia, but this 1906 law is outdated and disarticulated from Bolivia's reality. Many policy makers have tried and failed to update and modify this law. Faced with legal gridlock in the water legislation itself, various sectors, upon observing the insufficiencies of the law, have developed new sectoral laws and policies. Many of these laws affect water service provision, but contradict, strengthen, oppose or ignore the articles of the water law itself. Fundamental legal contradictions and super impositions of jurisdiction and rights characterise the different sectoral laws, the constitution and the water law. For example the Civil Code and the INRA Land Law recognize geographic jurisdiction over water conflict resolution, while sectoral laws, such as the Electricity Law, recognize authority of the relevant Superintendent. The net result is a confused, unmanageable system of contradictory laws. Added to this is the general inability of the Bolivian state to reach into its more remote areas, which leaves a jurisdictional vacuum that at least in the short term will most likely be filled by locally developed activities and policies.

Given upland Bolivia's large food dependence on rain fed agriculture, the melting of the mountain glaciers and its susceptibility to drought or floods, the country is extremely vulnerable to climate change. Spring and summer glacier- and snow melt drive the altiplano water cycle, so the likely impact of climate change will be to increase extreme flows. There will likely be higher spring and summer flows and floods in the short term, while long term increased temperatures may serve to reduce summer base flow.

The likely impact of climate change in the mid altitude valleys is an increase in extremes. Under the scenario of 'permanent' El Niño-like conditions caused by climate change, rainfall and flooding extremes will likely increase. Empirical and modelled data suggest that the Amazon basin is at particular risk to climate change effects. Warmer temperatures and decreased precipitation during already dry months could manifest in more severe droughts. Coupled with land use changes, these changes could lead to increased erosion, degradation of freshwater systems, loss of ecologically and agriculturally valuable soils, loss of biodiversity, decreased agricultural yields, increased insect infestation, and spread of infectious diseases.

Climate change effects on agricultural yields will vary by region and by crop. Under certain conditions, the positive physiological effects of CO_2 enrichment could be countered by temperature increases—leading to shortening of the growth season and changes in precipitation, with consequent reductions in crop yields. However, it should be noted that there are relatively few agricultural climate change impact studies have been done in South America, especially the Amazon. What does appear clear is that subsistence farming in the Amazon is particularly threatened by potential consequences of climate change.

Many of the legal policy interventions that currently affect the provision of water ecosystem services are more 'paper laws' than effective policing instruments. Despite the apparent importance of these laws-as-written, the real impact of these policies on water ecosystem service provision is close to negligible. Given the minimal impact that such laws actually have on the provision of water ecosystem services, the above table will differ little under climate change scenarios. Even if central government laws and policies were actually implemented, biophysical realities mean that such policies will affect water ecosystem service provision only in the mid altitude valleys. Elsewhere, policies can have minimal effect on the hydrological cycle.

There is a clear need for research that can help Bolivian policymakers to develop appropriate institutions, policies and laws that to ensure the provision of water ecosystem services. However, a traditional research program is unlikely to succeed. For example it is clear that Bolivia needs a new water law, and any research analysis will likely propose just that. However, the 32 attempts to pass such a law suggest that such a policy solution is not feasible.

If we want to ensure that limited research resources make a difference, we must accept that testing hypotheses about what policies and interventions protect water environmental services requires the same scientific rigor and state-of-the-art methods that we invest in testing ecological hypotheses. Our understanding of the ecological aspects of ecosystem conservation rests, in part, on well-designed empirical studies. In contrast, our understanding of the way in which policies can prevent ecosystem loss rests primarily on case-study narratives from field.

This must change. Moreover, if research is to be effective, it will need to be led by local institutions if socially and politically important lessons are to be learned. However one of the greatest bottlenecks in Bolivia is the lack of human capacity. It thus seems likely that the most cost-effective donor research investments will be to build local capacity to undertake effective, analytical studies of the potential impacts of the different policy interventions that may affect the provision of water ecosystem services.

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Introduction

The aim of this analysis is to understand how, and to what extent, policy and planning related to water ecosystem services impact on practice in Bolivia, and to identify how research efforts might improve the situation in future. Initial assessments suggest that while much is already known about the immediate influences of policy and planning on water delivery, far less is known or recognised about policy influences on the water and land use practices that ultimately affect the wider range of benefits to people from freshwater ecosystems. Thus the emphasis in this analysis is less on policy and planning influences on delivery of water, and more on their influence over on-the-ground practices that affect the quantity and quality of water available and poverty. The impact of climate change thinking and evidence on relevant policies and practices is also analysed. The analysis explores the relative impacts, links and relationships between different policies and planning priorities over time and in different places. It explores the impact of research in these fields and concludes with assessment on where research is most needed and how its impact might be optimised[1].

In reading this paper, it is worth bearing the following in mind:

- 'Policy' is used as shorthand in this document to mean the range of signals that stem from laws, regulations, policies, subsidies, incentives, institutional arrangements and major programmes and initiatives – primarily steered by government but not exclusively so (non-governmental and private sectors develop and use policies and institutions too)
- Policy often sends very mixed and conflicting 'signals' yet their effectiveness, efficiency, equity and sustainability can, with some effort, be judged.
- Water ecosystem services include: water quantity and quality for drinking and domestic use; water for agriculture and industrial use; water for non-consumptive use (e.g. hydro-electric power, transport); food and medicines from aquatic organisms; natural filtration for water quality, buffering and mitigation of floods and sources/sinks for greenhouse gases (regulatory services); recreation, option values and existence use values; and nutrient cycling and ecosystem resilience (supporting services).
- Although policy arenas are messy, there are often some reasonable prospects of 'rational' intervention. Evidence from changes over time suggest that there are ways of linking sound information and experience to well-wielded policy argument and key political moments to hasten change in the right direction for improved local livelihoods and sustainability.

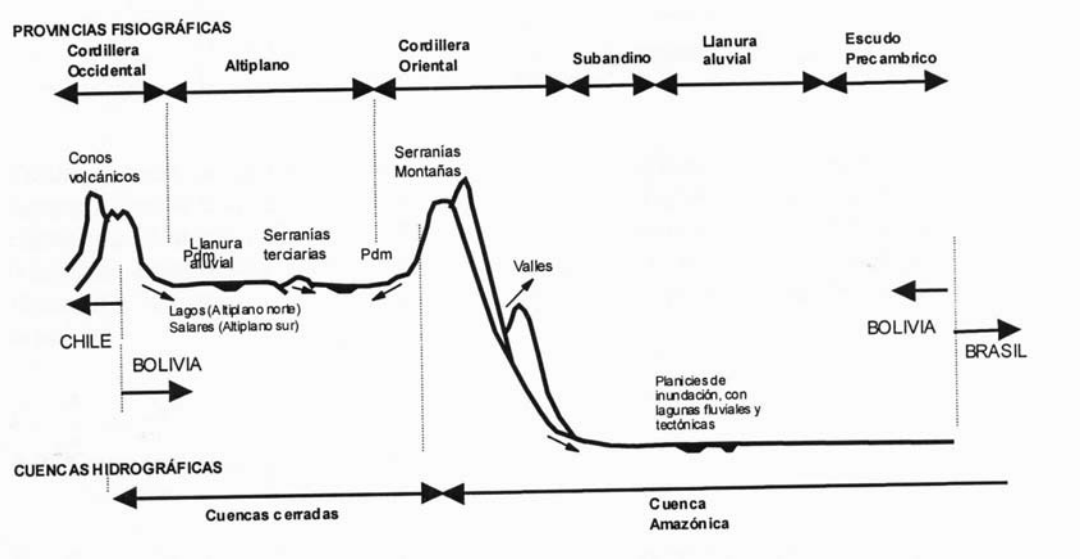
Water Ecosystem Services in Bolivia

In terms of provision of water ecosystem services there is no "one" Bolivia. Rather, the country is split along a series of fault lines, the most important of which are geographical and biophysical. The altiplano highlands (surface area of 246,254 km^2) are a low precipitation desert with most available water coming from summer glacier- and snow- melt. Given that most of the altiplano's water comes from glaciers, land use and land use change can affect such flows only minimally. With the exception of mining-induced pollution and climate change (see below), there is so little water in the altiplano that human activities have little impact on the provision of water ecosystem services. At the other extreme, lowland Bolivia (684,007 km^2), is humid with high year-round rainfall. While there are occasional local water shortages around towns such as Cobija, the human activities that impact water ecosystem services in the Amazon are usually diluted by the metres of rain that fall on the area every year. Thus

[1] This analysis will feed into an initiative steered by the International Institute for the Environment and Development (IIED) to help develop a research programme that has the potential support of the UK Governments Department for International Development. This wider initiative is titled: *Water ecosystem services and poverty reduction under climate change***.** The initiative is asking eight main questions through: (a) widespread consultation; (b) on-line survey; (c) literature review; and, (d) case study policy and practice analyses in Kenya, India, South Africa and Bolivia.

it is only the area between the high Andes and the Amazon—the transitional inter-Andean valleys and slopes (168,320 Km^2)—where human activities can define the scope of water ecosystem services (Figure 1). Notwithstanding this biophysical reality, this report addresses the entire country and collects evidence and undertakes an analysis of all its ecosystems. However, as will be seen, the majority of the policy interventions that affect water ecosystem service provision in Bolivia have their impact in the country's inter-Andean valleys (Navarro and Maldonado 2002).

Figure 1. Bolivia's biophysical reality: desert highlands, transitional valleys, and humid lowlands



Not coincidentally, Bolivia's major economic and political fault-line is also where the highlands meet the valleys. Lowland Bolivia is mercantilist, market-led, relatively prosperous, and increasingly drives the national economy. Upland Bolivia is significantly poorer, and historically has closely guarded its centralized political control. There has been a recent exacerbation of this fault-line, with the 2006 election of President Evo Morales precipitating a profound shift in central government policy. In contrast to all the administrations since 1982 that have leaned towards neo-liberal economic policies, the Morales government (led by the Movement towards Socialism) has two guiding philosophies: 1) nationalization and centralization of all productive industry and; 2) agricultural reform to award poor highland farmers more land, much of which is in the lowlands. Even though these political changes are recent, they will likely have profound impacts on water ecosystem service provision.

1. "Map" of the Bolivian policies that affect the relationship between water ecosystem services and the poor: the policies, laws, institutions, main programmes and initiatives that affect the links between poverty and water ecosystem services

a. Access to water ecosystem services – rights and rules about water services

Principal consumptive water users in Bolivia are irrigation, human consumption, industry, and mining. Bolivia's fundamental **Water Law** was based on an 1879 Decree that was elevated to law in 1906. Numerous attempts have been made to update and adapt this law, including attempts in 1970, 1973, 1975, 1983, 1987, such that there now exist 32 versions of laws generated by the state and civil society. Proposals to change the rules of water access and use are thus in legal gridlock. The Ministry of Water, through its Vice Ministry for Basic Services and the Direction General for Basic Services is responsible for sewage and provision systems for human use (Law 2066 The Drinking Water and Sanitation Law). Other sectoral norms exist that authorize attributes and concede authority

over use and exploitation of water for mining activities, energy, hydrocarbons and within protected areas, many of which are in opposition to other laws. Notwithstanding this legal complexity at the margins, access to water and water ecosystem services is primarily governed by the 1906 water law, the constitution and the environment law, while the norms and general laws that affect water are the Mining Code (Law 1777), the Electricity Law (1604), the Forestry Law (1700), the Land Law (1715) and the Municipalities Law (2028), each of which is discussed below. However, in terms of implementing any of these regulations, central government is usually so short of resources that it has little or no reach into many of Bolivia's more remote watersheds.

Some important features of the water law include a listing of the ways to acquire water rights, which include the free use of rainwater or discontinuous flows, requirement of authorization for other uses of <100 litres/second, and a the requirement of concession from the state, the prefect or the municipality for use of > 100 litres/second. Water property rights come in two forms: 1) the right to use public water, and 2) private ownership, which can be justified through the use of public water for 30 years, or in the case of irrigation for 99 years (in contrast, article 134 of the Constitution asserts that rights cannot be authorized for more than 40 years). Interestingly even the 1906 water law gives owners the right to use, sell or exchange their water right, though it also allows such rights to be expropriated for the public good. Another form of ownership, according to the 1906 laws, is based on tenure of the land where the water originates or through which it passes. Importantly, at least according to the water law, water ownership can be riparian—an integral component of land ownership. This contradicts the constitution, which asserts that all water is the property of the state.

A number of subsequent regulations have adapted the water law. In terms of provision of water ecosystem services, some of the more important are:

The **Regulation of the Institutional Organization of Water Concessions** (Supreme Decree No. 24716 of 22nd July 1997), which established that (notwithstanding any of the above- or below-mentioned laws, or the constitution) the Water Superintendence is vested with maximum authority to guarantee the quality and quantity of water for Bolivians. Article 12 authorizes some level of decentralization of control of water under municipal jurisdiction, subject to approval by the Superintendence. The **Regulation of the Use of Public Goods and the Constitution of Watershed Protection Areas** (Supreme Decree No. 24716 of 22nd July 1997) allows the Superintendence to impose watershed protection areas as long as fair compensation is awarded (Article 3). **The Drinking Water and Sewage Law 2066** (of 11th April 2000) is now the basic law to regulate drinking water provision and sewage, and as such authorizes concessions, licenses and fixes prices, tariffs and quotas (Article 1), while article 23 states that service provides must comply with the Environmental Law 1333 (below). **The Regulation of Irrigation Water Concessions** (Biministerial resolution 001/98 of 25th March 1998) designated similar authorizing control over irrigation water. Interestingly, the recently modified 2004 Irrigation Law prioritizes water use by irrigators—who already use 95% of the country's water—over urban users.

Finally, as a result of several water-related civil disturbances (see, e.g. Bonnardeaux 2003, Crespo and Orellana 1999) Supreme Decree 26599 of April 20th 2002 called for the **Creation of the Inter-institutional Water Advisory** (CONIAG) to open a space for civil society participation in the making of water policy. Prior administrations have given little authority to CONIAG, and so the advisory has achieved little. In the administration of Evo Morales the advisory has an elevated position in the new Water Ministry, highlighting the current interest in the participation of social movements within government. As could be expected, the new government's focus is on ensuring water for irrigation (which already comprises 94% of water use) and drinking. The secondary priority is on industry and private sector use—which had in the past been the primary focus of policy—while ecological flows and maintenance of ecosystem services are not even mentioned, and appear to be of lowest priority for the Morales administration.

The **Environment Law** (#1333 of April 27th 1992) is of a generic character and does not detail specific activities. One of the primary components of the law that affects the provision of water ecosystem services is the absolute legal necessity for an environmental impact assessment of any work, activity or project that could affect the environment (Article 73). This provision is, at least in theory, a very powerful tool to ensure the provision of water ecosystem services. More specifically the Environment Law states that:

> *Water is originally owned by the state … and its protection and conservation is a fundamental task of the state and society (Article 36)*

Further, the law regulates pollution under the penal code, and calls for prison sentences for acts of water pollution or contamination (Article 105). The law specifically regulates the Mining Sector (though see the section on the Mining Law, below) stating (albeit very vaguely) that mining operations must contemplate restoration in order to reduce and control erosion, stabilize land and protect water supplies (Article 71). Building on this, the **Regulation of Water Pollution** (Supreme Decree 24176 of December 8th 1995) defines systems of control of water pollution and lists acceptable limits for certain pollutants as well as the physical and chemical conditions with which an effluent must comply,

The Environment Law (and indeed the Forestry and other 'conservation' laws discussed below) are actually textbook laws for sustainability, wise management and environmental prudence. However, none of these excellent laws have been well-enforced, for political and financial reasons. Indeed, in some cases laws have mainly been written simply to comply with donor interests/requirements with the relevant authorities knowing full well that the probability of implementing the neatly-crafted regulations is close to zero. Especially true of environmental laws is that they are only enforced when civil society is sufficiently outraged by a particular incident that government is forced to act. Activist civil society organizations therefore sometimes create outcries to force companies (invariably such outcries are against big business) to act to comply with laws.

b. Development of water ecosystem services – policy influences on capabilities and actions that develop water ecosystem services

In addition to the laws and regulations outlined above that affect the human activities that directly impact access to water ecosystem services, policies can affect the ability of ecosystems to maintain and provide such services. By affecting land use and land use change or pollution, a spectrum of policies in a range of other sectors can have profound influence over whether water ecosystem services are maintained or not. Such policies can be grouped into two types:

1. Policies that indirectly may play a role in transforming natural vegetation to other land uses (in general, a change from natural ecosystems to artificial land use will change the provision of ecosystem services, and this change will usually, though not always, be negative, depending on the specific service).
2. Policies that have the effect of changing the frequency and magnitude of pollution events

As noted above, Bolivia is comprised of three fundamentally different biophysical zones. The impact of policies thus varies spatially. Climate change will likely profoundly affect the provision off water in the altiplano as this zone is dependent on annual glacier and snow melt. Melting glaciers may well change hydrological cycles of altiplano rivers fed by glaciers. However, given that climate change is a global phenomenon, there is little that Bolivian policies or practices can to reverse such changes. More locally, water ecosystem service provision in the highlands is affected by Bolivian policies and interventions that either regulate or allow pollution from mining activities, the most severe of which is in

Lake Poopó and the Pilcomayo River[2]. Apart from such pollution issues, most water management activities in the highlands are locally developed and locally managed, often on the tightest of margins between successful water capture and failure.

In contrast, in the Bolivian lowlands, where rain and streamflow is abundant, the primary impact of policy is on sedimentation rates and dry season low flows (affected by vegetation loss close to water courses), and pollution (such as from small scale mining, fertilizers and pesticides). For example, pesticide use is increasing in Bolivia: an average square kilometre under cultivation received 526 Kg of insecticides in 1997/8, with the country spending $ 92 million on synthetic pesticides (Pacett 1999). In the Amazon basin pollution is invariably of contaminants, such as mercury, that are used in gold production, while domestic waste, combined with industrial waste from textile, paper, sugar and factories often threaten the provision of water ecosystem services around urban centres such as Santa Cruz. The dilution effect of metres of annual rainfall means that such impacts are usually important only at the local and not at the landscape scale.

This literal 'dilution of policy impact' is not at all the case in the mid-altitudinal transitional valleys. In the valleys of the Andean foothills, rainfall is very low, often creating desert-like conditions. Further upstream, cloud forest and moist humid rainforest are the sources of water ecosystem services for the downstream dry land production systems. Given that agriculture and livelihoods in the dry valleys are entirely dependent on the provision of water from these upstream areas covered by forests, there is enormous potential for human activities and policies to play a defining role in the provision, or not, of water ecosystem services. It is also important to note that the inter-Andean valleys produce a disproportionate amount of Bolivia's domestic agricultural production. Whereas the lowlands produce soy for export, it is the valleys that produce all of the vegetables for domestic consumption. Although rivers in the tectonically young Andes already have high sediment loads, and the pronounced seasonal climate of the transitional valleys naturally induces January floods and July droughts, human activities can exaggerate or diminish these extremes. The most important human activities that affect provision of water ecosystem services in the Andean foothills are land clearing for agriculture, and road building and other vegetation disturbances that increase sediment load.

The policies that directly or indirectly affect these activities include:

Tenure Laws: As in many South American countries, government approved land tenure, or 'title', is often the exception rather than the rule. The lack of formal government approved property rights is a fact of life in rural Bolivia, and so locally developed institutions have assigned and recognized land rights and related water rights. For example, this was done in Tiquipaya by local farmers unions who designed a system based on how much water had historically been received by each irrigator (Pinto and Duran 2006).

Locally developed *de facto* property rights system are thus often more prevalent, and so are more important as a management tool than the official *de jure* property rights system (Pacheco 2006). This has two important implications. Firstly, land claims often require more than documental proof—and the easiest way to show ownership is to clear the land of its native vegetation. Secondly, it gives the opportunity and responsibility to local institutions—rather than far away government offices—to develop de facto land management policies that can ensure the provision of water ecosystem services (e.g. Crespo 2006). Thus there is simultaneous pressure to change land use (and thus negatively affect water ecosystem service provision) and at the same time an opportunity for local authorities to resolve this problem.

[2] And in some areas the quite heavy altiplano "pollution" is actually "natural". For example, the Oruro Pilot Plan estimates that the naturally occurring sulphates, arsenic and heavy metals transported by rivers such as the Desaguadero and tributaries of the Pilcomayo are in sufficient quantity to restrict the use of the water for irrigation.

Land Reform in Bolivia was first driven by the **Agricultural Reform Law 2464** (of August 2nd 1953), and many of its articles are still legal. This law reiterates that all natural resources, including water, are the property of the state. However, it gives that right to all to use water for domestic use and to agriculturalists and raisers of domestic animals the "necessary" water for their production (Article 151). Irrigators are regulated through "turns" in proportion to the area under cultivation (Article 152) while Article 153 states that water that enters a property can be used for agriculture, but that all water excess to what is needed must pass through to benefit others and that water cannot be sold or commercialised (Article 154). However, as with most of the laws discussed in this report, the practical impact of the agricultural reform law on the provision of water ecosystem services is negligible.

The **National Service for Agricultural Reform Law 1715** (the 'Ley INRA' of October 18th 1996) regulates the access and sustainable use of natural resources and guarantees the rights of indigenous groups over their traditional lands. There are several very important articles related to water use and the provision of water ecosystem services. Even if title is clearly held, if the land is not being used for a social or economic function, it may be expropriated. In terms of maintaining ecosystem services, the law itself is unequivocal: conservation and the maintenance of biodiversity or other public goods count as a social or economic function (Article 58 of the law and Article 300 or its regulations). However, judicial interpretation is less certain, and it is certainly popular opinion that leaving forest intact is an act against the poor. This leads to the perverse impact of the widespread clearing of forested land—which may jeopardise the provision of water ecosystem services—simply to give the impression that the land is being used. The need to show "a social and economic function" has thus become a major cause of deforestation.

Following the pro-rural farmer philosophy of the Morales government, redistribution of "under-utilized land" has begun. In the next few years far more land will likely be opened for small-scale agriculture, and awarded communally to indigenous communities. But unjustly taking land from private owners will be political suicide for the government. The state is therefore looking for "underused" public lands to give to farmers for land clearing. This means that parks such Amboró, forest reserves such as the Chore, and forest concessions, are being transformed into agricultural fields, as part of either an explicit government policy or part of an implicit understanding that colonization of such lands will be tolerated. Deforestation is thus increasing, with the potential for a concomitant change in the provision of water ecosystem services, but whether the new colonisations lead to improved livelihoods remains to be seen. In the short term sustainable development seems unlikely, given the rural nature of such clearances, far from towns, schools, healthcare and infrastructure. Further, even when the colonisation policy is explicit, and *de jure* title is actually awarded, there is no incentive for sustainable management of the new lands. Because public lands can only be awarded communally, there is no incentive for long-term private interest, resulting in a potential tragedy of the commons.

Development microfinance: Given that land reform and giving title to colonist farmers is a major focus of the Morales government this process seems likely to continue. There is now an all-powerful Ministry of Planning, which puts in the central government's hands a major role for designing and implementing productive systems (and indeed all other things). As in other socialist systems, the government is now a major player as well as an arbitrator in the rural economy. This is especially true in terms of micro-finance policies, by which the central government is creating new funding mechanisms to give rural landowners better access to credit to aid in their land clearing investments. For example with $100 million from the Government of Venezuela, agricultural producers can now receive 10 year loans for a variety of productive activities. Similarly, a new focus on road building will increase access to marginal rural areas, and increase pressure on watershed.

Bolivia's **Forestry Law 1700** (of July 12th 1996) created one of the most environmentally advanced forest management regimes in the world (Boscolo and Vargas 2001, Contreras and Vargas 2001). A primary objective of the law is protection and restoration of watersheds and erosion prevention (Article 2). A major effort was made to classify the country's forest lands according to most appropriate use.

Those areas that provide important ecosystem services, such as flood prevention are defined as inappropriate for exploitation, but rather they are set aside for non-consumptive use (Article 13). Specifically, all wetlands and an area 50 m around them, and an area between 10 and 100 metres either side of water courses, especially in mountainous areas are declared off limits for any timber production, and must be left as ecological reserves. Landowners may also declare private reserves of other forested areas, which will exempt them from property taxes. The law stipulates the penalties for non compliance with these norms, as noted in Articles 206 and 223 of the penal code. Cutting or clearing of forest in a form that contravenes the regulations is a criminal offence.

The Forestry law has been reasonably successful in improving forest management, but not in reducing deforestation (Boscolo and Vargas 2001). In the lowlands, where timber operations can operate at a large scale, and operators have seen the added value of a 'green image', so that Bolivia has become one of the world's leaders of sustainable management. However, outside well-managed concessions, deforestation has proceeded apace, especially so in the more mountainous watersheds where large-scale timber operations are less economically viable. Most small scale producers do not pay property taxes so the incentive of not paying taxes on conservation land is not particularly useful! Under the new government, the situation is perhaps even worse for the provision of water ecosystem services. The pro-environment, pro sustainability components of the Forestry Law have been emasculated, with preference being given to community based forest management, regardless of its economic efficiency or its environmental impacts. The larger scale vertically integrated businesses, such as La Chonta that produce for the certified wood export market are no longer a priority for the Forestry Superintendence, which is now focusing its efforts on encouraging small scale exploitation. While the environmental impacts of this shift remain to be seen, they are unlikely to be positive as proving technical support, and indeed controlling, hundreds of small operators will less feasible that working with a few major companies.

In terms of ecosystem service provision, the forestry law receives support from other natural resource management legislation. The **Wildlife, National Parks, Hunting and Fishing Law 12301** (of March 14th 1975) declares the public utility of forest maintenance close to rivers, lagoons and lakes, and prohibits deforestation close to, and pollution of, such water courses. The law mandates that all industry, mines, hospitals, health centres and municipalities treat their sewage water before returning it to the river (Articles 123-128, 132 and 133).

While not mentioning water resources specifically, the **Protected Area General Regulations** (Supreme Decree 24781 of July 31st 1997) and the **National Protected Area Service (SERNAP)** (Supreme Decree 25158 of September 4th 1998) determine what activities are allowed and prohibited within Bolivia's protected area system, which currently comprises 17% of the national territory. Both these decrees serve to support legislation that protects watersheds, water courses and wetlands. More specifically, Bolivia is a signatory (in 1990) to the **Ramsar Convention on Wetlands**. This convention obliges Bolivia to identify and protect important wetland areas. To date, eight such areas have been identified in Bolivia, covering more than 6 million hectares, but there is very little, if any, proactive management of these areas in order to ensure the provision of water ecosystem services.

International Cooperation Watershed Projects: Donor-led integrated watershed management (IWM) projects have invested millions of dollars in Bolivia in recent decades. However, in the Pilcamayo and Bermejo watersheds, for example, projects were designed and implemented independently of the local communities, and the problems of erosion, desertification and pollution in the watershed have not been resolved (Pivinskaya 2006). Meanwhile, in the Pirai watershed, flooding risk to the city of Santa Cruz has been reduced but there is no land use change strategy, no watershed management plan and no locally run management institutions (Sauma 2006). The recent ruling paradigm for water management in Bolivia has been donor-led 'integrated' projects. An analysis of 23 such projects (Duran 2006) shows their design and implementation are usually based on three criteria:

1) *Preventing environmental deterioration*: mitigation of erosion, deforestation, loss of vegetation, hydrological extremes, pollution, and impacts of actions such as road and dams;
2) *Reducing poverty*: improving productivity, supporting deprived areas and low human and economic development;
3) *Improving water use* for irrigation, hydroelectricity, mining, tourism, aquaculture etc

Few IWM projects have explicitly focused on water environmental services, but rather it has often been assumed that such projects will establish management systems that ensure sustainability of land and water resources in the medium and long term. Although the need for negotiation, design and collective planning are usually included in project objectives, deliberate attempts to engender sustainability in Bolivian IWM projects have been rare and ineffective.
Financial and economic rates of return are usually expressed through indicators such as cost/benefit analysis, income generation and infrastructure constructed. Economic feasibility analyses have rarely addressed environmental service provision, or undertaken an analysis of the economic requirements to ensure hydrological service provision or future investments.
Most Bolivian IWM projects have focused on the following actions: biophysical and socioeconomic characterization of the watershed, criteria and classification for optimizing landuse, GIS, hydrological studies and mapping, prioritization of intervention zone, projects for production, protection and control, participation, strengthening of farmers groups, training, result dissemination, and leveraging public policy. The principal results of IWM Projects have thus invariably been: documentation, infrastructure construction, increases in vegetative cover, technical and production support and institutional strengthening.

- *Documentation:* The principal result is usually a management plan that includes goals, objectives, activities, expected results and future projections etc. In general, information produced is descriptive, explicative and in grand quantity—but rarely deepens the socioeconomic analysis, nor addresses long term sustainability.
- *Infrastructure construction*: such as distribution channels, dams and soil conservation structures. Rarely, however, are maintenance needs analyzed, and such infrastructure works therefore often deteriorate rapidly.
- *Plantations and vegetation restoration:* These sub-projects are designed to improve water production. However, they are usually geared towards providing a long term solution—and hence have little short term impact—and are often based on false assumptions of a forest/water relationship (see Calder 1999, Bruijnzeel 2004).
- *Institutional strengthening:* training and local capacity building often help socialize a project, and while project reports usually assert their success, there are few independent analyses of the sustainability of such efforts. Moreover, after the project cycle is completed, such organizational strengthening rarely continues.

In synthesis, the environmental impacts of Bolivian IWM projects have been limited, especially given the magnitude of the problems. Moreover, perhaps because IWM projects usually emerge from another need or interest, such as forestry or soil conservation projects, they rarely collect sufficient hydrological information to ascertain whether or not interventions have actually had an effect. Thus even though by definition IWM projects are interdisciplinary, in reality they have been bounded by disciplinary thinking. Management is usually far from integrated, and projects have rarely been sustainable, especially in the provision of ecosystem services.

Other key lessons learned include:
- Projects are often manipulated politically—key positions are often political appointees.
- Funding usually tails off in the later stages—just as consolidation needs are increasing.
- Short-term environmental deterioration is occurring much more rapidly than the mid to long-term results that project's are designed to achieve.

- There is rarely local ownership of projects.
- Legal frameworks are rarely in place, and inter-institutional collaboration is weak.
- Frequent changes of already overworked personnel.
- Lack of baseline hydrological and socioeconomic studies and a lack of local knowledge, means that projects are invariably technocratic rather than social in focus.
- There is a perceived inability to measure—and hence unwillingness to focus on—improving intangible social benefits.

One of the more interesting recent initiatives of IWM was headed by the ex-Ministry of Sustainable Development, the "Promotional Project of the National Watersheds Program", supported by four ministries and various international donors, including the Dutch government. The goal of this program was to "strengthen governmental capacity to define and implement watershed management policies", by developing a conceptual management framework and long-term actions, and three years of project implementation. The program implemented 12 projects: 8 oriented towards integrated watershed management, and four towards improving water efficiency. However, after the central government changed, the program has been completely reassessed and the strategies have been painstakingly reset to meet the political interests of the new government.

c. Demand for water ecosystem services – policy influences on markets and non-market demands for (developed) water ecosystem services

A number of Bolivian policy tools create a demand for water, or for water ecosystem services. Demand for water itself and the demand for water ecosystem services are often interconnected so they are treated as such in this section.

The **Electricity Law 1604** (of 21st December 1994) recognises that public utilities, and electricity companies, and hence indirectly the state, require watersheds that have sufficient water, and low enough sediment loads to effectively generate hydroelectricity. A number of provisions in the law prescribe how to ensure that this demand for water ecosystem services must be supplied. The Electricity Superintendence has the authority to authorize concessions and to ensure appropriate environmental protection. In addition to acquiring use rights to a river and building infrastructure, a hydroelectricity concessionaire has the right to request declaration of an upstream protected area, to be managed at the concessionaire's cost (Article 37).

The soon-to-be-decreed **Irrigation Law** will likely give additional rights to downstream irrigators to ensure that water ecosystem services are provided. However, as noted above, it seems unlikely that such national legislation will have an immediate impact at a local level. More likely is that irrigators associations will continue to rely on locally developed institutions to ensure the provision of water and water ecosystem services. For example, already existing in a number of irrigation associations (e.g. in Tiquipaya and Inchuasi) are negotiated agreements in which downstream communities help, through labour, in the protection and care of the upland water sources (Crespo 2006, Pinto and Duran 2006).

Far more common than national policies that affect the demand for water ecosystem services, are local initiatives that recognize the important role that natural vegetation plays in service provision. The demand, and hence ultimately the policies that reflect this demand, will likely continue to come from local sources, such as the city of Tarija, which has the highest rate of water consumption in the country—300 litres/person/day—and a growth rate of 4.8%. The Vitoria watershed is the principal source of water for Tarija, and in the wet season supplies 70% of the demands of Tarija's 135,000 inhabitants. The adjacent Tolomosa watershed is the main water source for rural areas, while the San Jacinto reservoir provides both hydroelectric power and water to supply the rest of Tarija's demands, and that of the vineyards in the Tarija valley.

Notwithstanding the importance of these watersheds, both are under pressure from deforestation, overgrazing and forest fires, all of which threaten the water supplies. Studies and assessments by the NGO PROMETA suggest that if upstream water sources are not protected, dry season flows in the Vitoria River will be reduced by 72% while sediment load will double in the Tolomosa River and the Jacinto reservoir. Contingent valuation analysis estimates that the total economic benefit of the hydrological services provided to the city of Tarija is approximately $0.5 Million per year. In August 2004, a number of local NGOs, Municipal, City and Prefectural government institutions, and private organizations joined to form PRO-AGUA an association dedicated to the protection of Tarija's water sources (Pivinskaya 2006).

Numerous other small scale initiatives attempt to affect the demand for water ecosystem services (as opposed to just water), such as projects by ICO, the Eastern Training Institute (Robertson and Wunder 2005), and Fundación Natura Bolivia (Asquith et al. 2007). These projects are managed at a local level with municipalities, again highlighting the disconnection between national level legislation and policies, and the needs and possibilities at the local level.

d. Macro-policy/ economy – the big policy frameworks that originate at the sub-national or national level and shape all of the above

The basic legislation that governs all others is the **Political Constitution of the State** (including law 2631 of February 20th 2004), although this currently being re-written by a Constitutional Assembly. As mentioned above, the constitution asserts that water is the property of the state, and the state shall authorize its use. Notably, Article 170 notes that the state must ensure the conservation and precautionary use of renewable natural resources.

In defence of water ecosystem, services, the **Penal Code** (approved through Decree 10426 of August 23rd 1972 and modified through law 1768 of March 10th 1997) establishes a penalty of a jail sentence of between 1 and 10 years for poisoning, polluting or adulterating water destined for human consumption, or industrial use, farming or fish cultivation. Excessive water use is also considered a crime (Article 354) (though nowhere is the definition of "excessive" made explicit), as are hunting and fishing on public or private lands without permission (Article 356). Violations of these articles can be punished by a prison sentence of up to three years.

The **Civil Code** (of April 2nd 1976) states that in terms of legal ownership water courses and wells are extensions of land ownership (Articles 75 and 153). A landowner is thus free to use the water that crosses or falls on his land for irrigation as long as he returns (an undefined) "excess" to the water course.

The **Mining Code 1777** (of March 17th 1997) is explicit in its environmental requirements. Article 36 states that all water used by concessions must be protected and returned to its course or natural basin, while Articles 37, 56 and 58 assert that deviations of water are not allowed if they would interrupt or otherwise prejudice potable water provision for nearby populations. Further, mining activities are explicitly prohibited in canals, lakes or other water courses (Article 44). Other environmental safeguards are also in place, for example that concessionaires are obliged to protect the environment avoiding and/or remediating damages to soil (Articles 45 and 84), and must control all effluents to within the boundaries of the concession (Article 85). While an environmental license is required for operation, unless the operation is within a protected area no environmental impact assessment is required of prospection or exploration (Article 89).

Similarly, the **Hydrocarbon Law 3058** (of 17th May 2005) is explicit in its environmental provisions. The entire chain of hydrocarbon activities must comply with the Environmental Law, and prior to operations 0.5% of the investment must be deposited to pay for monitoring and enforcement (Article 130).

Hydrocarbon activities are also expressly prohibited in protected areas and Ramsar sites (Article 132). However, activities can be permitted in exceptional circumstances when a Strategic Environmental Impact Evaluation establishes the viability of the activity within the national sustainable development strategy. The definition of what would constitute such an exception is left unspecified. Moreover, confusingly, article 133 states that activities *can* be undertaken in protected areas, subject to strict zoning and implementation of a management plan, public consultations and an environmental impact assessment if such activities do not put at risk conservation of the area.

As can be seen in the confusing and exception-laden wording of the hydrocarbon and mining laws, given the importance of these sectors for the national economy, in practice the need for exploitation trumps all other sectors and laws, not least the environment. It is probably fair to say that mines and the oil sector can use as much water as they want, and cause as much damage as they want with relative impunity. The exception is if the operator is an international company that can be closed down or forced to pay compensation for environmental damage. Given their economic importance, local mining and hydrocarbon companies act with impunity.

In the near future, under the Morales government, mining and hydrocarbon sectors will likely continue to trump all other sectors. The partial "nationalization" of the oil and gas sector has increased royalty and tax payments to the government from $360 million a year to $1600 million, increasing the sectors' economic importance for Bolivia's development. Not least, national coffers are now swelling, and there is additional money available for infrastructure development. This process seems likely to continue, with increasing revenues for the national government in the next five years. However, there are already signs that this policy might lead to reduced investment in the hydrocarbon sector, which would have a negative effect on revenues in the medium and long term.

Upland-lowland migration: A major trend in the last decades in Bolivia has been increasing migration from the poor uplands to the richer lowlands. This has not been government policy, but rather a natural response to the growing importance of Santa Cruz in the national economy. Migration is often stepwise, from rural highlands to rural lowlands, often with a stop in the transitional valleys, and then ultimately to an urban centre. Primary participants are the poorest farmers from the altiplano (Osinaga 2006). Given the poverty of the migrants, the state's macroeconomic policies have essentially bypassed this process. The new immigrants produce primarily for the growing domestic markets, especially so from farmers in the mid-altitude highlands, such as the Santa Cruz valleys. Exchange rates and trade policies have had little effect on migration-driven land use change patterns, while billions of dollars worth of poverty reduction policies implemented by the government and outsiders have had little impact on these small-scale agriculturalists[3]. Deforestation in the mid-level highlands of Chuquisca, Cochabamba and Tarija and Santa Cruz has thus not been caused by macroeconomic policies. Rather, deforestation has been caused by expansion of urban markets (Cochabamba and Santa Cruz) for agricultural produce and small-scale migrations from the altiplano. Such migrations have until now only indirectly been influenced by government policies, though this seems likely to change (del Rio 2006, Pacheco 2006).

Preferential high soy prices: Lowland deforestation has been exacerbated by global soy prices, especially prices in the countries such as Colombia and Venezuela that as part of the Andean Community of Nations Treaty have had privileged trading relationships with Bolivia (and have thus essentially paid artificially high prices) (Killeen 2007). These preferences have been strengthened through a recent agreement with Venezuela that promises to pay small and medium sized (though not large-scale) Bolivian soy producers above-world market prices. Crops for export have also received tax privileges from the Bolivian state. On the other hand, cattle and beef production has been

[3] Annually, an average of about $700 million flow into Bolivia in the form of grants or concessional loans (near 10% of GDP, UNDP 1998). A large percentage of such funds are invested in environmental projects (Bojanic 2001).

artificially restricted in lowland Bolivia, with some export markets closed due to the presence of foot and mouth disease.

Bolivia's decentralization law (the **Popular Participation Law 1551** of April 20th 1993) was part of a packet of reforms designed to make public investment more efficient. Critically important was the goal of including actors who had traditionally been marginalised by the neo liberal economic model, including indigenous peoples, subsistence farmers and urban neighbourhood groups, and making the state and government closer the citizens it serves. Responding to the need to decentralise the administration of health, education and road services, the government opted for "municipalising" the country" making municipalities governing entities autonomous from central government, with their own budgets, power to elect their own authorities, and power to take decisions within the municipality, with an emphasis on citizen participation and the development of demand for public works and social oversight of government (Pacheco 2004). More specifically, the decentralization process had the following goals:

- Development of new political-administrative divisions: throughout the country municipal sections were expanded, from 24, almost all of which were urban, to the conformation of 327 autonomous municipalities, both urban and rural.
- Devolution of central government's power and the transfer of 20% of tax revenues to the municipalities, based on municipal population (Popular Participation Law Article 20). This changed the concept of tax revenue being expended where it had been collected, which previously had favoured the three largest cities in the country (La Paz, Santa Cruz and Cochabamba) with 86% of tax expenditures.
- Promotion of participation and social democracy, through the conformation of local organizations such as Territorial Base Organizations (OTBs) that can form Vigilance Committees to oversee and monitor resource use under the Popular Participation Law. This new role given to local actors has changed the concept of public management. In the first year of the Popular Participation Law 14, 500 community, neighbourhood, and indigenous peoples groups and many Vigilance Committees were awarded legal status and recognition.
- Investment and promotion of social and economic development are now municipal responsibilities. The responsibility for transferring property, administration, maintenance and investments in infrastructure such as for irrigation are now with municipal budgets.

Bolivia's municipalities thus now have partial authority and some of the funds needed to manage natural resources, such as forests water and wildlife that lie within their borders. While difficult, there is thus an institutional structure in Bolivia that facilitates direct negotiations between project designers and local government. The decentralization process would appear to be irreversible. Over 45% of the population believe that the municipalities respond better to solving local problems than the central government (26%) and the prefectures (14%). More than half (52%) of the population believe that municipalities should receive more funding to carry on local activities. However, municipal provision of social infrastructure, such as schools, health, roads, irrigation, and increased participation of civil society, has not been enough to reduce poverty. Indeed, the incidence of poverty has grown from 62% to 64% between 1999 and 2002, and migration from rural areas to cities has increased. The challenge for municipalities is to create jobs and promote local development (Vargas 2006, Molina 2006).

Decentralization and autonomy processes started more than a decade ago. This process will not change much under the current administration, and if anything will go deeper and broader. Indeed, the government of Evo Morales actually wants to bypass both regional governments, and even the municipalities that have been designated as the institutional structures for decentralization, with the logic of giving resources directly to communities and local groups. Given the common lack of capacity of such organizations, this may well rebound and increase dependence on an even more centralized government structure. As can be seen from the above description, while there is little specific to

watershed environmental services in decentralization legislation, the new laws provide ample opportunity for local actors to take responsibility for the provision of such services.

Conclusion: the impact of current policies on the provision of water ecosystem services

The underlying water law is supposed to govern the provision of water and water ecosystem services in Bolivia, but this 1906 law is outdated and disarticulated from Bolivia's reality. Many policy makers have tried and failed to update and modify this law. Faced with legal gridlock in the water legislation itself, various sectors, upon observing the insufficiencies of the law, have developed new sectoral laws and policies. Many of these laws affect water service provision, but contradict, strengthen, oppose or ignore the articles of the water law itself. Fundamental legal contradictions and super impositions of jurisdiction and rights characterise the different sectoral laws, the constitution and the water law. For example the Civil Code and the INRA Land Law recognize geographic jurisdiction over water conflict resolution, while sectoral laws, such as the Electricity Law, recognize authority of the relevant Superintendent. The net result is a confused, unmanageable system of contradictory laws. Added to this is the general inability of the Bolivian state to reach into its more remote areas, which leaves a jurisdictional vacuum that at least in the short term will most likely be filled by locally developed activities and policies.

Analysis

In Table 1 the above-described policies have been assigned scores based on the intensity of their effect on the provision of water ecosystem services. This ranking is by definition arbitrary, but it provides a first guide as to the importance of the policies. Each policy was given a 1 to 5 scoring of intensity of impact, including negative impacts/influences.

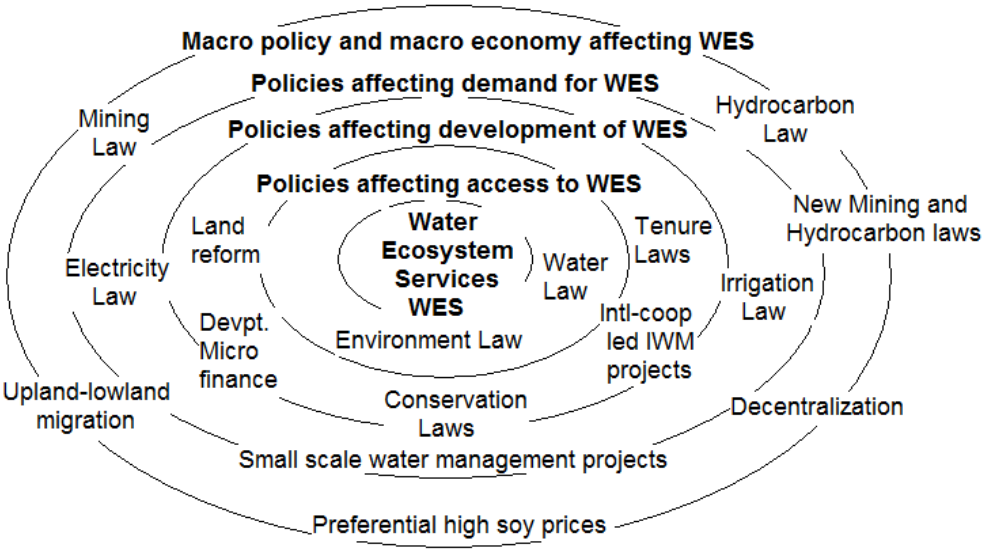
Table 1. Policies and their impacts

	Flood prevention	Low flow maintenance	Clean water provision	Aquatic biodiversity
Access to water ecosystem services				
Water Law*	3	3	3	3
Environment Law*	5	5	5	5
Service development				
Tenure Laws*	3	3	3	3
Land Reform*	-3	-3	-5	-5
Development microfinance	-5	-5	-5	-5
Forestry and other conservation laws*	4	4	4	4
International Coop. watershed projects	5	3	0	0
Demand for services				
Electricity Law*	3	3	0	-1
Irrigation Law*	0	0	0	-4
Small–scale water management projects	2	4	5	3
Macro policy and macro economy				
Mining Law	0	0	-5	-5
Hydrocarbon Law	0	0	-5	-5
Upland-lowland migration	-5	-5	-5	-5
Preferential high soy prices	-5	0	-2	-2
Decentralization	5	5	5	5

While there are a number of polices that appear to have strong impacts, it is important to note that numbers assigned to policies with an asterisk (*) are the 'hypothetical impact' of the policy were it to be implemented. However, it is a fact of life in Bolivia that the majority of laws are legal artefacts that have little relationship to the real world. Thus notwithstanding the high numbers ascribed to these laws-as-written, the real impact of these policies on water ecosystem service provision is close to negligible.

In Figure 2, we have attempted to show graphically the inter-relationships between the different policies. Policies closer to the centre of the circles have a more direct impact on the provision of water ecosystem services than those policies further away.

Figure 2. Inter-relationships between the different policies



2. How will the policy and practice map differ under climate change scenarios?

Given upland Bolivia's large food dependence on rain fed agriculture, the melting of the mountain glaciers and its susceptibility to drought or floods, the country is extremely vulnerable to climate change (Bojanic 2001). With increasing global temperatures, glaciers in Latin America have receded dramatically in the past decades, and many of them have disappeared completely (Campos and Mata 2001). Climate change will thus likely profoundly affect water cycles in the Bolivian highlands. Spring and summer glacier- and snow melt drive the altiplano water cycle, so the likely impact of climate change will be to increase extreme flows. There will likely be higher spring and summer flows and floods in the short term, while long term increased temperatures may serve to reduce summer base flow.

The likely impact of climate change in the mid altitude valleys is an increase in extremes. For example, in early 2007 the worst floods in 25 years hit Amazonian Bolivia. Unusually strong El Nino rains in the Andean foothills decimated the agricultural sector in Santa Cruz, which lost at least $90 million in one month. Hundreds of thousands of cattle drowned and the Department of Beni (annual budget $30 million) lost $200 million. El Niño/Southern Oscillation (ENSO) seems to be a driver of much of the climatic variability in Latin America (IPCC 2001). Under the scenario of 'permanent' El

Niño-like conditions caused by climate change, rainfall and flooding extremes will likely increase (Campos and Mata 2001, Killeen 2007).

While detailed modelling exercises that show this for mid and high altitude Bolivia are lacking, a number of General Circulation Models (GCM's) suggest that climate change will lead to an increase in temperature of 2–3°C in the Amazon basin by the year 2050. This will decrease precipitation in the Amazon during dry months, leading to widespread drying (Kattenberg et al. 1996, Betts et al. 2004). However, most authors stress the uncertainty of their Amazon models. A recent comparative analysis of different GCM models found that five models predicted an increase in precipitation in the non-Bolivian eastern Amazon, two a decrease, and four no change in rainfall regimes (Li et al. 2006).

Empirical and modeled data thus suggest that the Amazon basin is at particular risk to climate change effects. Warmer temperatures and decreased precipitation during already dry months could manifest in more severe droughts. Coupled with land use changes, these changes could lead to increased erosion, degradation of freshwater systems, loss of ecologically and agriculturally valuable soils, loss of biodiversity, decreased agricultural yields, increased insect infestation, and spread of infectious diseases (WWF 2007). Amazon forests are also threatened by secondary effects of climate change, such as a potential increase in the frequency and intensity of fires. There is a well established link between forest fires, climate change, and extreme El Niño events in the Amazon (Nepstad et al., 2001).

As noted above, many of the legal policy interventions that currently affect the provision of water ecosystem services are more 'paper laws' than effective policing instruments. Despite the apparent importance of these laws-as-written, the real impact of these policies on water ecosystem service provision is close to negligible. Given the minimal impact that such laws actually have on the provision of water ecosystem services, the above table will differ little under climate change scenarios. As mentioned earlier, even if central government laws and policies were actually implemented, such policies could affect water ecosystem service provision only in the mid altitude valleys. Elsewhere, policies can have minimal effect on the hydrological cycle.

3. The interests and effectiveness of the state in water ecosystem services

As can be seen from the above discussion of state promoted laws and policies, the effectiveness of the state in the provision of watershed services is very low indeed. The role and effectiveness of municipal governments will likely increase in the future, but these young institutions struggle with very low human capacity.

Bolivia's municipalities thus now have some degree of the authority, and some of the funds to manage the natural resources, such as water, that lie within their borders. While difficult, there is thus an institutional structure in Bolivia that facilitates direct negotiations between project designers and local government. However, technicians are often poorly trained and even senior municipal decision makers lack capacity for natural resource management. Moreover, staff turnover is high, meaning that trained technicians often leave before their training is complete.

Politically, the only messages that are currently acceptable relate to poverty reduction and economic development. The Morales government is pro-poor farmer, which means pro-land reform, pro-irrigation, anti-private sector, and anti-markets. Such political discourse will likely continue in the next few years. How this will translate into practice is as yet unknown, but a number of important trends can be identified.

- The state is committed to giving free or low cost water to the poor, including poor irrigators, despite not having the resources to subsidise infrastructure development.

- Water ecosystem services are not valued as such. Forested land is seen as a dormant resource that should be cleared for agriculture or at the very least logged.
- There are few environmental champions in government. Any environmentalists that are in government are keeping very quiet at the moment.

4. The role and effectiveness of other parties in influencing policy that affects water ecosystem services

Projects promoted by outsiders to "help" communities have invariably failed in Bolivia. One of the major reasons for these failures is a lack of trained local human resources. This has necessitated that projects be designed and implemented by outsiders, who have often lacked knowledge of the cultural, socioeconomic and biophysical context. Lack of local involvement has meant that project uptake is rare, and failure has often been inevitable. For example, the FAO-SEARPI planted extensive eucalyptus and pine plantations that are now ignored by communities in the Pirai watershed as they play no role in water provision, and communities receive no incentive to manage them. National and international consultants hired to manage such projects have simply failed to do so, occupying their time writing never-to-be-seen-again reports. Currently, the greatest bottleneck in ensuring the provision of water ecosystem services is the lack of human capacity, both inside and outside Bolivia, for designing appropriate mechanisms for the provision of water ecosystem services.

In Bolivia's current political climate social organizations trump all other forms of decision-making. Institutionally, the Morales administration grew out of, and still resembles, a farmers union. Social movements are thus critical to ensure water ecosystem service provision, but many of the movements closest to the government are most socialist and hence often the most radically anti-environment. For example, in May 2007 government sponsored-colonists pushed their way into Madidi National Park, not only disturbing wildlife, but also displacing the indigenous groups who already inhabited the area. The Morales government's lack of interest in environmental protection is also exhibited by its choice of new National Park directors—sometimes the very people who have spent their lives opposing such protected areas.

The role of NGOs in influencing policy has been relatively small. From 2004-2006 Natura Bolivia coordinated a (DFID-funded and IIED facilitated) collaborative research project that identified and worked with almost all the 60-plus NGOs and academic institutions interested in implementing or researching water ecosystem services initiatives. Such institutions included FAN (the Friends of Natura Foundation) ICO (the Eastern Training Institute, PROMETA (Protection of Tarija's Environment), CIAT (the Tropical Agriculture Research Centre), all of which have been involved in small scale initiatives. The role of NGOs at a policy level has been minimal, especially so given the recent profound changes in national governance structure.

Researchers have played a major role in providing information about the likely impact of different land use interventions. As noted above, a significant proportion of aid to Bolivia has been for environmental projects, which have invariably involved production of studies and/or environmental impact assessments. Duran (2006) observes that one of the major products of most integrated watershed management projects has been extensive research and documentation. Biophysical research is thus rarely a limiting factor in development of policy interventions to ensure the provision of water ecosystem services. Indeed such research is often repeated, again and again, with neither links to policy, nor even with links to research into how to turn these biophysical studies into policy tools. A case in point is the Rio Grande. The 1995 Santa Cruz Land Use Plan (PLUS by its Spanish acronym) mainly funded by the German Government (KfW), required extensive research, which was systematically documented (Cordecruz et al. 1995). Downstream Rio Grande was zoned as requiring a protection forest in the river's floodplain. After more catastrophic floods the German government (GTZ this time) supported another biophysical study (Wachholtz and Herold Mergl 2003) that

concluded that a protection forest was required for the river's floodplain. After further floods, in 2006 a Departmental Government-commissioned study (Pivinskaya pers. comm.), concluded the river's floodplain needed to be reforested and protected. While there is now a Departmental Policy promoting such a flood plain forest, the actual impact of this policy has yet to show itself, more than 10 years after the solution to the problem was first identified. Sorely lacking in the entire process has been 1) analyses of how to use such biophysical facts to spur political action, 2) actual reforestation/protection actions, and 3) research to see if and how such different actions have succeeded or failed.

5. Other likely changes

There are a number of changes occurring in Bolivian society that are unrelated to ecosystem services, but will likely have an important indirect impact on their provision. The most important of these are: rural-urban migration, highland-lowland migration, and increases in regional autonomy. Each of these changes has already been discussed, and each is interrelated, so we here consider the synergistic effect of them. The likely short-term result of these processes is increased pressure on the water ecosystem services provided by the mid altitude valleys. This will exacerbate, and be exacerbated by climate change. Over the next 10-20 years flooding events and dry season droughts will likely increase in severity and frequency, and the negative impact on the poor will get worse. In the medium term though, the valleys will probably depopulate: many young men and women are already leaving the valleys to be educated, and few are likely to return. Pressure on upstream forests may then diminish and it may be possible to restore some level of ecological equilibrium. This is a natural process that requires no explicit policy, though interventions that encouraged rural-urban migrations could enhance it.

Farming in the altiplano will likely slowly disappear. In this already hostile environment, climate change may be the final straw that breaks the rural economy's back. This will cause short term trauma in the economy and fabric of society, but this will simply speed up a process that is already in motion. In the lowlands, deforestation will continue apace. The Bolivian Amazon likely will be transformed, as has been the Brazilian Amazon, into cattle pasture and then mechanized agriculture.

Climate change effects on agricultural yields will vary by region and by crop. Under certain conditions, the positive physiological effects of CO_2 enrichment could be countered by temperature increases—leading to shortening of the growth season and changes in precipitation, with consequent reductions in crop yields (IPCC 2001). However, it should be noted that there are relatively few agricultural climate change impact studies have been done in South America, especially the Amazon. What does appear clear though, is that subsistence farming in the Amazon is particularly threatened by potential consequences of climate change with northeastern Brazil likely to suffer yield impacts that are among the most severe in the world (WWF 2007).
The challenge, in the lowlands, the altiplano and the mid altitude valleys is to develop policy interventions that can cushion individual and communities from the more abrupt effects that these changes will likely bring.

6. Research priorities

In order to most effectively guide research in order to obtain results that can develop and implement improved policies, three important country-specific questions need to be addressed:

1) What hydrological and biophysical science is needed?
2) What economics and social science is needed?
3) What institutional and policy analysis is needed?

How much of the science behind water ecosystem service provision is still unknown?
At a broad scale the science of ecosystem dynamics and their subsequent degradation in tropical forests is actually very well known (Asquith 2002). For most ecosystem services, the rule is clear: if we can maintain natural vegetation, then the environmental services will (in general) look after themselves. However, water ecosystem services are a little more complex.

A common perception is that protection of forests in the upper sections of watersheds can help maintain water flows and quality and reduce erosion. The prevailing perception is that deforestation leads to reduced dry season water flows, lower water quality and increased levels of erosion. However, such generalizations about forest-water linkages are risky. The impacts of forests for water flows, quality erosion, sedimentation, water table levels and productivity depend on a number of site specific features including terrain, soil composition, tree species, vegetation mix, climate and management regimes.

Indeed, myths and misunderstandings underlie much of the discussion about how forest cover relates to sedimentation, rainfall, and water flows. Deforestation probably has only a slight effect on large-scale flooding and regional rainfall. Sedimentation poses little medium-term threat to hydroelectric plants. And although sediment does constitute a problem, in many places road construction, urbanization, and other non-agricultural activities generate as much or more sediment as do agricultural activities. Forest clearing, if followed by land uses that prevent rainfall from percolating into the ground, increases run-off. That, in turn, may reduce dry-season water flows. But deforestation is at least as likely to have the opposite effect, since forests generally lose more water from evapo-transpiration than does shorter vegetation (Calder 1999, Bruinjzeel 2004).

Tropical montane cloud forests such as those at the headwaters of Bolivia's inter Andean valleys constitute the exception. These forests are known to intercept clouds or fog and channel some of the water to the forest floor as canopy drip. Thus, even though strictly speaking they may not affect rainfall, they do influence the amount of water that moves from clouds to the forest floor. As a result, removing cloud forests may well reduce the amount of water available for different purposes. Deforestation of cloud forest is likely not only to decrease water yield, but also to greatly decrease dry season flow (Calder 1999, Bruinjzeel 2004).

Given that there are few hard and fast rules about how land use change will affect water ecosystem service provision in a given watershed, a clear research need is watershed specific analyses of streamflow, baseflow, and peakflow, and their relationship to precipitation, evapo-transpiration and land use and land use change. In short, there is a fundamental need for basic hydrological data. Most Bolivian watersheds, even those with multi million pound management plans being implemented, have little basic data available for more than a few years. Basic data collection is a necessary prerequisite for other research, and more importantly, for any interventions or policies that will be implemented in a given watershed.

Notwithstanding the value of such watershed specific research, the general principle—"*if we maintain natural vegetation cover, we will maintain a watershed's environmental services*"—can usually be relied upon. There are thus likely diminishing returns to further investigations to find out exactly why this general principle is invariably true, and such resources might be better spent on other research themes.

How much more economic analysis is needed?
The socio economic research community has extensive experience in environmental services assessment and valuation. Such studies suggest that further economic valuation is not the most cost effective research program. In many cases, we actually already know within an order of magnitude the value of ecosystem services. For example, Costanza et al. (1998) calculate that global

environmental services have a value of $33 trillion a year. At the local level, the most widely used economic tools are contingent valuation (CV) methodologies. For example, CV tools have demonstrated a willingness to pay for a connection to potable water is ~$2 per month in Haiti, ~$3 in Brazil, ~$1.50 in Nigeria, ~$4 in Kenya and ~$1.20 in the Philippines (Bohm et al. 1987, Briscoe et al. 1990, Whittington et al. 1990).

But are such numbers the actual "value" of the environmental service of potable water? And, given that any research has an opportunity cost—research funds used to investigate one issue means that another will not be researched—are they particularly useful numbers to have? A lack of such economic numbers is usually not the most pressing bottleneck for reducing poverty. Detailed basic research is not always necessary for ensuring the provision of water ecosystem services. Indeed, in the Bolivian context, **we already know enough economics and science** to design interventions that will most likely support the provision of water ecosystem services.

Rather, the bottleneck for reducing poverty and protecting environmental services in Bolivia is political and institutional. The most important research intervention that could be supported in Bolivia would be to explore how to develop institutions and interventions that are actually effective in reducing poverty and protecting environmental services in the country's socio political context. In recent years an average of about $700 million a year has flowed into Bolivia in the form of grants or concessional loans, and a large percentage of these funds have been invested in environmental projects. It is thus a sobering fact that there is a dearth of information about which interventions actually work to protect water ecosystem services and improve rural livelihoods. What is the most politically and economically effective way to reforest a high-value river floodplain like the Rio Grande? Can education lead to real changes in behaviour that better protect ecosystem services? What form of in kind or cash direct payments can best persuade upland farmers to conserve their water producing cloud forests? If we are brutally honest—which very few of us actually are—we have very little idea what the answers are to these questions.

What institutional and policy analysis is needed?

There is thus a clear need for research that can help Bolivian policymakers to develop appropriate institutions, policies and laws that to ensure the provision of water ecosystem services. However, a traditional research program is unlikely to succeed. For example it is clear that Bolivia needs a new water law, and any research analysis will likely propose just that. However, the 32 attempts since 1906 to pass such a law suggest that such a policy solution is not feasible. Another likely policy proposal would be the development of mechanisms for full water pricing and the possibility of water trades or payments for environmental services (PES) mechanisms. But would such research results be particularly useful? Is there any clear cut evidence to suggest that, apart from theoretically, PES schemes actually work?

A research paradigm for water ecosystem services and poverty alleviation in Bolivia[4]

On the contrary, conservation scientists and practitioners have depended on intuition and anecdote to guide the design of investments. If we want to ensure that limited research resources make a difference, we must accept that testing hypotheses about what policies and interventions protect environmental services requires the same scientific rigor and state-of-the-art methods that we invest in testing ecological hypotheses. Our understanding of the ecological aspects of ecosystem conservation rests, in part, on well-designed empirical studies. In contrast, our understanding of the way in which policies can prevent ecosystem decay rests primarily on case-study narratives from field initiatives that are not designed to answer the question "Does the intervention work better than no intervention at all?" Sadly, we actually have no idea if the billions of pounds invested in Bolivia in the last decades have achieved anything.

[4] Some of the text in this section is from Ferraro, P.J., and S. K. Pattanayak. 2006. Money for Nothing? A Call for Empirical Evaluation of Biodiversity Conservation Investments *PLOS Biology* **4(4): e105 (0482-0488)**

When it comes to evaluating the success of its interventions, the field of ecosystem protection and biodiversity conservation lags behind most other policy fields (e.g. criminal rehabilitation, and disease control). The immature state of conservation policy research is most clearly observed in the recent publication of the *Millennium Ecosystem Assessment*. While the biological chapters are rife with empirical studies, the *Policy Responses* volume lists as one of its "Main Messages" the following: "Few well-designed empirical analyses assess even the most common biodiversity conservation measures." There is thus a fundamental need to design a regional research initiative that purports to evaluate a series of conservation/development interventions at a more fundamental level. The goal of such an initiative would be to find out whether, for example, conservation education workshops change behaviours that affect environmental service provision more effectively than direct payments for protection (PES). A fundamental shift in focus is needed, away from measuring and monitoring "inputs" (e.g. investment pounds) and "outputs" (e.g. reports, articles) to a quantified and replicated measurement of "outcomes" produced directly because of investments (e.g. environmental service provision). The field of program evaluation provides the tools for such a focus on outcomes: randomized experimental policy trials and, when interventions are not randomly assigned, appropriate statistical tools to evaluate the effects of an intervention.

How should research be done?

Research needs to be led by local institutions if socially and politically important lessons are to be learned. However, as noted, one of the greatest bottlenecks in Bolivia is the lack of human capacity. The most cost-effective donor research investments will be to build local capacity to undertake effective, analytical studies, rather than simply recompiling existing information as is currently the norm.

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