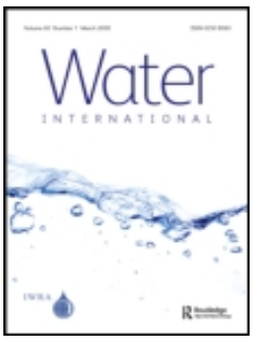

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Connections between poverty, water and agriculture: evidence from 10 river basins

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The authors analysed livelihood conditions in 10 river basins over three continents to identify generalizable links between water, agriculture and poverty. There were significant variations in hydrological conditions, livelihood strategies and institutions across basins, but also systematic patterns across levels of economic development. At all levels, access to water is influenced by local, regional or national institutions, while the importance of national versus local institutions and livelihood strategies vary with economic development. The cross-basin analysis suggests a framework for thinking about water–agriculture–poverty links that can inform future research and policy development.

Keywords: poverty; water poverty; sustainable livelihoods; economic development; agricultural water management; Basin Focal Project

Introduction

The global water and food crisis that led to the Consultative Group on International Agricultural Research (CGIAR) Challenge Program on Water and Food (CPWF), and the Basin Focal Projects (BFPs) within it, can be seen, from a global level, as the result of three colliding factors: an increased demand for food to meet an increase in global population; rising incomes that drive increasing demand for water for food production and other purposes; and a renewable, but finite and already over-committed water resource (Molden 2007). This view motivates pessimistic scenarios that feature closing river basins, the breakdown of environmental security, deprivation of water resources to some groups, and curtailed livelihood options. But these are not the only or inevitable consequences of change, and represent a selection only of the range of possible outcomes as water and food systems develop. At smaller scales, individual case studies have illustrated important

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local variations on, and departures from, the broader global themes and their underlying assumptions.

Case studies, however, while informative and valid within their context, shed little light on the full range of conditions that are observed in river basins around the world. There are situations in which systems adapt to enable continued development, or where people are impacted by important but less noteworthy trends, both of which are less likely to be studied and reported on than those that entail more dramatic and easily recognized problems. Moreover, case studies, in isolation, cannot explain generalizable conditions of global significance. The top-down, global approach and the bottom-up, case study approach can thus lead to two extreme views. At the global level, there is a clear picture of increasing stress on natural resources but unclear impact on communities and households, while detailed case studies present clear local accounts but offer little information about how representative they are of the range of situations that are likely to exist.

This paper provides an intermediate view between these two extremes by presenting evidence from the 10 river basins of the BFPs to describe more fully the link between water, agriculture and poverty. The basin papers in the September 2010 special issue of *Water International*[1] provide evidence about the links between water and poverty from a range of case studies, using a variety of analytical techniques. A specific focus of the research was to determine whether there is a link between agricultural water productivity and poverty. The questions addressed by the Basin Focal Projects were broader than this, however, and revealed an important variation between basins at different levels of development. Accordingly, we ask how agricultural water use may impact development, broadly conceived, within river basins.

Water, poverty and "water poverty"

There are at least two ways to think about water and poverty. First, we can ask, how do water-related constraints and opportunities contribute to poverty and its alleviation? Second, we ask, what are water-specific forms of deprivation? The first framing points to links between water and poverty, where "poverty" is conceived in broad terms. The second framing leads to the concept of "water poverty". An important conclusion from the BFP research is that the first approach is more analytically tractable than the second; moreover, it is arguably more relevant for policy. The dominant approach within the water field, however, has been the second, water poverty, approach. Accordingly, we review those ideas briefly here.

There are multiple definitions for "water poverty" (Sullivan 2002, Black and Hall 2004, Cook and Gichuki 2006). The influential Black and Hall (2004) definition is a functional poverty definition, in that it lists observable deprivations associated with water risks and constraints. It also includes an implicit institutional context, introduced by way of explicit categorical inequalities, that is, inequalities arising from socially recognized categories, such as ethnicity, religion or gender (Tilly 1998), specifically, those affecting slum dwellers, women and girls. Cook and Gikuchi (2006) illustrate the underlying causes of agriculturally based water poverty, highlighting the role of low water productivity in the dynamics of poverty. Their framework encompasses assets and livelihood strategies by discussing the importance of livestock, crops and water infrastructure to the poor. This more expansive view is captured well by the sustainable livelihoods framework (DFID 1999), which is discussed below. Sullivan (Sullivan 2002, Sullivan and Meigh 2003) takes a functional

definition of water poverty and makes it operational by constructing a water poverty index, which is a hierarchical aggregate. The water poverty index is a weighted sum of component indicators that measure water resources, water use, access to water, water-management capacity, and ecosystem needs. The bottom of the hierarchy is a set of specific indicators that are aggregated to form the component indicators.

Background: poverty and livelihoods

For a term that has such wide currency, "poverty" is an elusive concept. In its *Handbook on poverty and inequality* the World Bank defines poverty as "a pronounced deprivation in well-being" (Haughton and Khandker 2009), but this is rather vague and does not immediately suggest paths to identify and alleviate poverty. In practice, the World Bank uses the now-dominant approach to measurement, a consumption or income-based poverty line: those below the line are considered to be poor, and those above the line are non-poor. While a poverty line operationally defines who is poor, it is not a definition of poverty in itself. Rather, it derives from an assumption that people would obtain what they need to live if they could, and if they do not, it is a symptom of their poverty. For this reason, as with the original poverty line (Orshansky 1965), many national poverty lines are based on the cost of a minimally nutritious basket of food, on the assumption that food is the most basic necessity and hence an inability to obtain food is a good indicator of overall deprivation.

Metrics tend to create their own reality as policy increasingly seeks to change the value of the metric rather than the underlying reality it is meant to represent (Scott 1998, Molle and Mollinga 2003). This is true also of poverty lines; over time the emerging defects of using them as guides to policy have been addressed by refining the concept (Haughton and Khandker 2009) and by exploring alternative approaches to measuring and defining poverty (Sen 1999, Carter and Barrett 2006). Here we adapt and extend the useful classification scheme of Carter and Barrett (2006), and we discuss the following poverty concepts: definitions based on static and dynamic financial flow; definitions based on static and dynamic assets; functional definitions; and definitions based on capability.

Measures of poverty based on financial flow

Definitions based on financial flow focus on income or expenditure flows. Static measures of financial flow assume that people have relatively stable incomes or expenditures, which largely remain below or above a poverty line. An indicator based on this concept can be calculated using standard household surveys without the need of panel data that track individuals or households over time. But it cannot distinguish between chronic poverty, where people remain poor for many years, and transitory poverty, in which a significant number of people move into and out of poverty (Carter and Barrett 2006). In contrast, dynamic measures of financial flow capture changes in income and expenditure for individuals over time. This requires panel data, which are becoming more widely available, but are still challenging to collect and less readily available than are cross-sectional "snapshots" over time. Within the family of metrics of financial flow, the best option is generally considered to be a dynamic consumption measure. Dynamic measures distinguish between chronic and acute poverty, while metrics of consumption are superior to income as measures of a household's

ability to meet its needs. This is because while income can fluctuate rapidly and widely, through saving, consumption smoothes out these fluctuations (Carter and Barrett 2006).

Measures of poverty based on assets

The argument for measures of poverty based on consumption rather than income points to an important factor, which measures of financial flows miss. People and households accumulate assets when their incomes allow them to do so and make use of those assets to meet their needs in lean times. Sufficient assets also allow them to undertake new initiatives, such as expanding a farm, digging a well, or buying an animal. The advantage of measuring assets rather than consumption is that it can serve to distinguish between structural and random (stochastic) factors (Carter and Barrett 2006). Structural factors are reflected in a steady accumulation or drawdown of assets across many households, while stochastic factors are more acute and less broad-based. As with measures based on financial flows, dynamic measures of assets that make use of panel data are more revealing than static measures, but more challenging to acquire.

Functional poverty definitions

Neither indicators based on financial flows nor on assets are direct measures of the "pronounced deprivation of well-being" that characterizes poverty. An alternative approach is to adopt a functional definition of poverty that identifies specific forms of deprivation and measures them. Most definitions of water poverty (that is, water-specific deprivation) fall into this category by counting, for example, those without access to safe water, at risk of flooding, and other specific hazards and constraints (Sullivan 2002, Black and Hall 2004, Cook and Gichuki 2006). Functional measures are most appropriate for qualified types of poverty, such as water poverty, food poverty and health poverty. They become unwieldy when applied to poverty more broadly, because specific manifestations of poverty can vary widely from one situation to another.

Institutional poverty analysis

One of the most creative thinkers about poverty, inequality and development is the economist Amartya Sen. He has elaborated a capability-based view of poverty, in which poverty is a reflection of the "substantive freedoms [an individual] enjoys to lead the kind of life he or she has reason to value" (Sen 1999). This notion of poverty as freedom emphasizes the impact of the institutions within which individuals and households make their decisions and pursue their livelihoods. It recognizes, for example, that in many societies a woman has fewer chances to live the life that she values than a man with the same assets and for this reason she experiences a deprivation that is not captured either by flow- or asset-based measures. The major role that institutions play in determining livelihoods and poverty outcomes is an important component in the analysis of rural livelihoods.

Livelihoods

Conceptions of poverty have evolved in tandem with concepts of development, and in particular sustainable development, because poverty is expected to decrease with development. In Amartya Sen's framing, the link is explicit: development is the removal of "unfreedoms" that limit people's capabilities (Sen 1999). The asset and capabilities

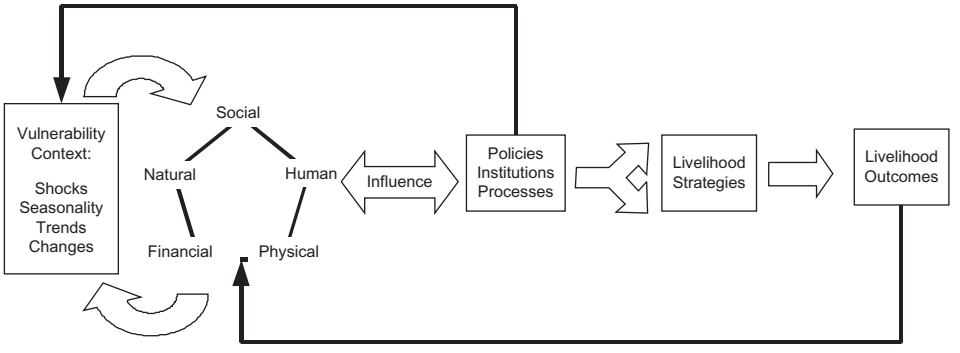

Figure 1. The DFID sustainable livelihoods framework.

approaches to poverty are merged in a view of livelihoods that grew out of dissatisfaction with the views of rural livelihoods prevalent in the 1990s and that are reflected in the UK Department for International Development's (DFID) sustainable livelihoods framework (Scoones 1998, Bebbington 1999, DFID 1999). In this framework (Figure 1), households deploy their financial, physical, human, social and natural assets using livelihood strategies to meet their livelihood goals. They do this within a vulnerability context, characterized by shocks, trends and cyclical changes, and moderated by the formal and informal institutions within which they operate.

The sustainable livelihoods framework is a usable way of thinking about development and poverty, including within the water resources context (Nicol 2000). It encompasses an asset-based approach to analysing livelihoods and embeds them within an institutional context. It also draws upon resilience concepts in its focus on fluctuations in the natural, economic and social environment (Baumgartner and Högger 2004).

Review of evidence from the basins

The basin papers describe basin-specific poverty analyses. They make clear that each of the basin teams of the BFPs followed a unique approach to understanding and analysing water-related poverty. Techniques ranged from scoping methods with low data requirements, to intensive data analysis with significant data requirements. Regardless of the amount of data involved, the general process used in the different basins included:

- choosing indicators of poverty and water poverty;
- identifying candidate causal or correlated variables;
- creating maps of variables and looking for patterns;
- carrying out statistical analysis and modelling, such as systems or hydrological models, Bayesian methods, and spatial statistical techniques, to explore relationships; and,
- using models for hotspot analysis, investigating causality, and scenarios.

We elaborate on these steps in the next section.

Methods

The motivation for carrying out a water and poverty analysis is to identify ways to reduce or eliminate poverty through appropriate interventions. Knowledge of where water-related

poverty exists and why it is there informs the interventions. Therefore, the different BFP basins made use of either general poverty indicators or specific indicators of water and poverty. General measures of poverty included financial flow variables (such as the proportion of the population below an income or expenditure-based poverty line); asset inventories; and functional, outcome-based indicators (such as infant mortality, nutritional status, education, life expectancy, and child mortality and morbidity). Water-related indicators included exposure to hazards (for example, flood risk, drought prevalence, and water-borne or water-related disease), climate data (such as rainfall and remotely sensed normalised difference vegetation index, NDVI), and provision of water infrastructure (such as access to irrigation, access to safe water and sanitation, and water productivity). Some basins also created summary indicators. For example, the São Francisco project constructed a novel index of water availability, while the Mekong project constructed an aggregate index for water-related poverty.

With the chosen indicators, several of the basins mapped poverty, which revealed important large-scale patterns and suggested relationships. At its most basic, poverty mapping is simply the process of putting poverty indicators on a map and looking at them, which was done at an early stage in the Volta and the Mekong to orient the study. Such analyses can reveal compelling large-scale patterns; for example, the Volta and São Francisco basins, which run on a north–south axis, have a strong rainfall gradient, and poverty levels vary, more or less systematically, along that gradient. Similarly, the Yellow River, the Indus, and the Ganges have pronounced upstream–downstream poverty gradients. Complementing this "map and look" approach are semi-formal methods for aggregating poverty indicators into an overall poverty index (as in the Mekong), and formal methods, such as spatial statistical analysis (as in the Niger).

Most of the BFPs carried out non-spatial statistical analyses and modelling that explored the relationships between water and poverty variables. As these constitute the bulk of the poverty discussion within the basin-specific papers, they will not be repeated here. Rather, we focus on the outcome of the analyses, which is to reveal patterns of correlation between water-related explanatory variables and poverty variables.

The "development trajectory"

We take the current development status of the basin as an organizing principle for the framework we develop in this chapter, since it determines the prevailing economic conditions that people are in, whether a basin is dominated by agriculture, by urbanization and industrialization, or is in transition from one to the other (World Bank 2007). The locations of the 10 Basin Focal Project river basins on the development trajectory are shown schematically in Figure 2. The predominantly agricultural basins Limpopo, Niger, Nile, and Volta, are characterized by a high contribution of agriculture to gross domestic product (GDP) and high rural poverty. The basins lying within more heavily industrialized countries, the Andes system of basins and the São Francisco, both have a low contribution of agriculture to GDP and low rural poverty. The transitional basins, Ganges, Indus, Karkeh, Mekong and Yellow, are intermediate between these extremes. As basins move along the trajectory, pervasive poverty gives way to isolated pockets of poverty within communities left behind in the overall economic development.

Poverty outcomes in the BFPs were found to depend on where each basin is located on the development trajectory, suggesting that poverty in general is a more useful analytical concept than "water poverty", that is, water-related manifestations of poverty. Moreover, as explained in the Background section above, poverty is best understood within a framework that sees households and communities making use of assets, moderated by the institutions

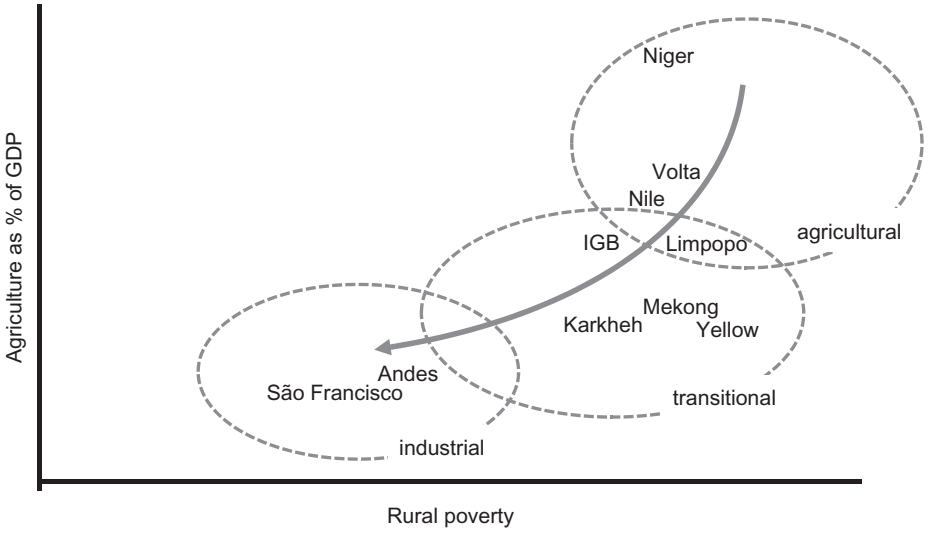

Figure 2. The basins along the development trajectory (World Bank 2007).

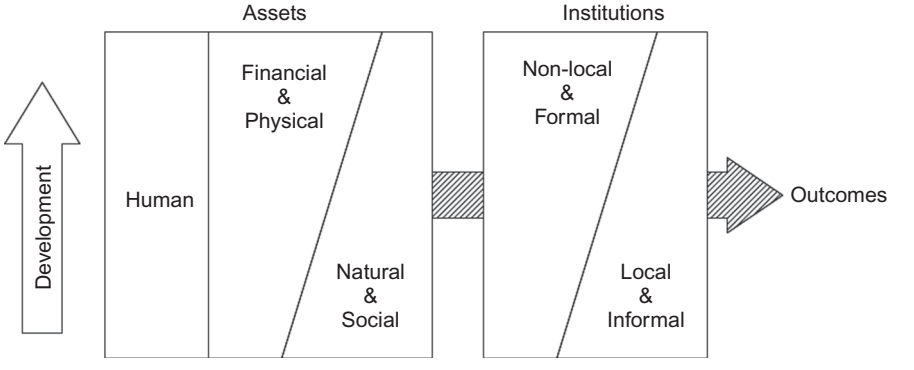

Figure 3. Assets and institutions along the development trajectory.

within which they operate, to achieve livelihood goals. Figure 3 summarizes results from the BFP basin studies. As communities, households, and basins move along the development trajectory in the course of national economic development, the mix of assets shifts from one in which natural and social capital are most important to one in which physical and financial capital play a larger role. At the same time, local and informal institutions decline in importance relative to formal institutions at the provincial, national and basin scale. At all levels of development, human capital is important. The changing role and form of livelihood assets and institutions with development. Figure 3 suggests some characteristic patterns in the 10 BFP basins.

Different aspects of water-related poverty play distinct roles at different levels of development. Table 1 summarizes conditions in basins according to their classification as agricultural, transition or industrial. Some caution is needed with this classification, as within any basin it is usually possible to find mixed classes. The specific, historically contingent, development path within a basin has a very strong influence on the conditions of the water and agricultural systems. It also influences the types of economic opportunities open to people and governments as they produce and consume, while the population and

Table 1. Basins at different development levels.

	Agricultural	Transitional	Industrial
Exemplar basins	Limpopo, Niger, Nile, Volta	Ganges, Indus, Karkheh, Limpopo (South Africa part), Mekong, Yellow	Andes, São Francisco
Role of agriculture in the national economy	Dominant. Agricultural development in many cases a key to broader economic development. Water productivity is very low in most places.	Agriculture a mainstay to rural livelihoods but competing with urban or industrial demands for water. Water productivity is extremely high in some areas.	Agriculture declining in importance as a source of livelihood for most of the population as alternative sources of income develop. Water productivity higher if measured by monetary value (i.e., farmers may grow low-yielding but high-value crops).
Poverty incidence: Indicators of wellbeing.	Widespread. High percentage, even if absolute numbers are low.	General, large numbers but lower percentage. Urban poverty increasing in importance.	Rural poor tend to be "left behind" general economic growth.
Physical infrastructure: road network, energy	Basic infrastructure is limited. A major constraint to agricultural development.	Pressure on pre-existing infrastructure. Substantial investment in infrastructure.	Continued investment.
Water resource development	Very little development of irrigation. Some hydropower. Less than 70% of the rural population has access to clean water supply/sanitation.	Extensive development of irrigation, in some cases to an unsustainable level. Hydropower or industrial users given high priority to meet demands of industrialization. Up to 80% with access to supply and sanitation.	Established. Further development of irrigation difficult due to increasing scarcity, while irrigation development not often targeted to the rural poor. Institutions developing to help share resources and benefits from water resource development.
Environmental security	Ecosystem services very important to specific groups (e.g. fishers and livestock herders) but these are generally informal and not valued in markets.	Major loss of ecosystem function. Ecosystem services not valued in markets. Fishers and smallholder livestock farmers declining. Aquaculture expanding.	Increasing attention to ecosystem function with emerging opportunities for trading of ecosystem services. Aquaculture increases in importance relative to capture fisheries. Livestock dominated by large-scale enterprises.

(*Continued*)

Table 1. (*Continued*)

	Agricultural	Transitional	Industrial
Vulnerability to water-related hazards	Very little protection. Major impact of health on livelihoods through sickness and disease. Livelihood systems rely on risk avoidance.	Moderate protection through engineering.	Engineering and institutional protections developing.
Development of markets and financial institutions	Semi-subsistence farming dominates, although most populations are linked to markets. Local informal institutions.	Active development of markets. Financial services not available to all or for all desired investments. Diminishing importance of local institutions.	Commodity and high-value crops dominate. Widely available financial services. Relatively large role for government institutions.

scale of economic activity within a basin strongly influences the pressures exerted on the natural environment.

Agricultural basins

The predominantly agricultural basins of the BFP basins, the Limpopo, Niger, Nile and Volta are all in Africa. Within these basins, poverty is widespread and heavily concentrated in rural areas. People are largely unprotected from hazards, even recurring, and therefore anticipated, hazards such as seasonal variations in rainfall and endemic water-related diseases.

Crop agriculture is predominantly rainfed, while livestock and fish make important contributions to household incomes and income diversification. Fish and livestock provide essential livelihoods to certain groups, such as pastoralists and freshwater fishers, who are facing increasing pressures on aquatic and land resources. Water productivity is typically very low, in part due to limited markets for outputs and inputs, and in part as a result of risk management strategies that seek to maintain a minimum guaranteed output at the expense of maximizing average output.

Households derive much of their own food from subsistence agriculture and, compared to transitional and industrialized basins, operate relatively independently from state organizations. State-provided infrastructure, such as roads and irrigation, and services, including education, are limited in scope. The dominance of local institutions in agricultural basins often means inconsistencies and conflicts between the plans of the state and their implementation on the ground. At the same time, local institutions ensure a minimal safety net through communal use of resources, although sharing output makes it hard for farmers to invest time and resources into improving their productivity, as the benefits are captured by everyone.

Transitional basins

The transitional basins, the Ganges, Indus, Karkeh, Mekong and Yellow, have developed substantial non-agricultural activities but agriculture remains a mainstay of rural life. These are "patchy" basins containing substantial areas that could be classified as either agricultural or industrial. These basins contain the largest populations of the BFP basins. The numbers of poor are very large, even though the proportion of poor to non-poor is substantially lower than in the agricultural basins. One of the characteristics of transitional basins is that rural development becomes a priority for governments, and in some of these basins, such as the Karkheh and the Ganges, we see considerable political pressure to stabilize the rural economy.

As illustrated in papers on the Yellow (Ringler *et al.* 2010) and Indus-Ganges (Sharma *et al.* 2010), irrigation is highly developed in the transitional basins, and has enabled the populations to expand to levels that now seem, in some parts of the basins, difficult to sustain. Agriculture provides a livelihood for many and in places is at or near to its potential maximum productivity. Partially as a consequence of major expansion of agriculture, ecosystem services have been impacted considerably. Fish and livestock have declined in overall importance, although they are dominant livelihoods for some of the poorest communities, and both livestock and fish continue to play a role in livelihood diversification. In the Mekong and, to a lesser degree, the Ganges Delta, fish remains a major source of livelihood support that is under increasing pressure as development massively increases the demand for hydropower and irrigation water. In the Indus and the Yellow basins, which are drier, conflicts over water use threaten continued development.

Industrialized basins

The Andes collection of basins and the São Francisco, both in Latin America are classified as industrialized. While neither of them is dominated by industrial production, they are within countries that have significant industrial production, and this affects the employment opportunities, level of infrastructure, and government services available to rural populations. In both of them, agriculture accounts for less than 10% of the annual increase in gross domestic product (GDP), although in Brazil, agriculture is actually increasing in importance as a result of strong growth of commercial agriculture amongst which there remain large pockets of poor small-scale farmers. Rural poverty persists in these areas, but it tends to be more localized, and is characterized as areas that have been "left behind" by the surrounding economic development. In the São Francisco, resource-poor smallholders do not generally benefit from the economic industrialization. They find it hard to gain entry into larger-scale farming and processing operations, and increasingly sophisticated agricultural markets. Moreover, they often do not have access to the resources to adapt to the major changes in the agricultural landscape.

While the poorer areas of these basins have better access to state-controlled services compared to agricultural and transitional basins, they are still marginalized in comparison to other parts of the basin. Access to water has greatly shaped agricultural development in the São Francisco Basin but concern over access to water in these basins is shared with concerns regarding access to education, markets and finance. Water-related hazards, such as flooding and drought, continue to be a problem, but institutions, financial assets, and infrastructure are sufficiently well developed that communities are able to recover from most events.

Results: a poverty and water framework

Earlier in this paper we argued that poverty is a multi-faceted phenomenon, and traced a history of thinking about poverty. In reviewing evidence from the basins we also identified the critical importance of a basin's stage of development to an analysis of water and poverty links. So that we can capture the various aspects of poverty revealed in the basin studies, we combine elements of functional, asset-based, and capability-based definitions of poverty to construct a poverty and water framework. We identify the following aspects of water-related poverty:

- *Scarcity:* where people are challenged to meet their livelihood goals as a result of water scarcity;
- *Access:* where people lack equitable access to water;
- *Low productivity:* where people acquire insufficient benefit from water use;
- *Chronic vulnerability:* where people are vulnerable to relatively predictable and repeated water-related hazards such as seasonal floods and droughts, or endemic disease; and
- *Acute vulnerability:* where people suffer an impaired ability to achieve livelihood goals as a consequence of large, irregular and episodic water-related hazards.

While there are dependencies between these aspects, for example, productivity and vulnerability are both dependent to some extent on scarcity and access, to an important degree they act independently. In particular, institutions mediate the link between scarcity and vulnerability and between scarcity and access, while high productivity can lessen vulnerability in water-scarce areas. Thus, the five aspects of water-related poverty are related to the institutional, variability, and asset components of the sustainable livelihoods framework (Figure 4). Deprivation as a result of water scarcity reflects a lack of natural assets; equitable access is determined largely by institutions; vulnerability to water-related hazards is largely (although not entirely) due to variability in the natural environment; low water productivity is affected by household and community assets, such as access to markets or knowledge; and loss of livelihood due to change is a consequence of variability in the external natural, economic, and social environment.

The poverty and water framework along the development trajectory

Of the different aspects of water-related poverty (Figure 4), inequitable access emerges at all levels of development. Local institutions, basin-scale institutions, geography and hydrology appear to determine whether development and poverty reduction will be broadly or narrowly based. In case studies carried out in northeast Thailand, which suffers from an extended dry season, poor groundwater quality, and floods in the rainy season, local norms favour a broad distribution of benefits from improved production. Perhaps for this reason, small-scale, local initiatives have performed better than large-scale, state-sponsored irrigation projects. In contrast, in the Niger Basin, diverse and fragmented local institutions lead to inconsistent implementation of large-scale projects. Benefits are shared inequitably, which explains the weak (or negative) relationship between water productivity and poverty that was highlighted in the Niger paper (Ogilvie *et al.* 2010). The effects of geography and hydrology can be seen in several basins: in the Andes, where water access aligns with the north–south rainfall gradient and vertical climatic gradients; in the

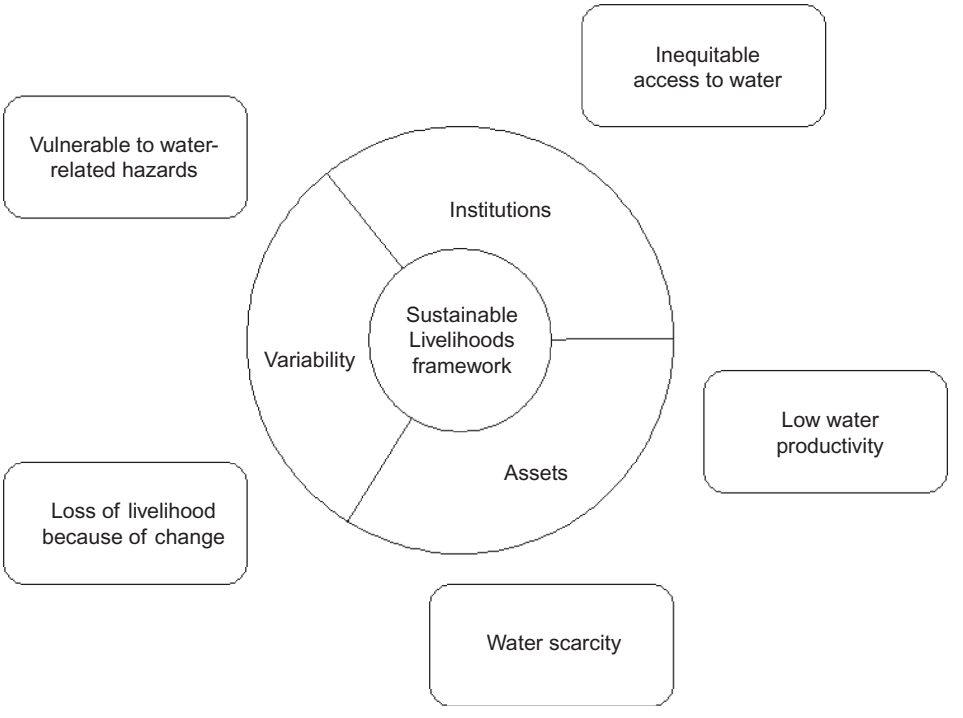

Figure 4. The poverty and water framework and its connection to the sustainable livelihoods framework.

Volta and São Francisco, where poverty follows the rainfall gradient; and in the distinct poverty trajectories of the upper and lower parts of the Ganges, Indus, Limpopo, Nile and Yellow.

Unlike access to water resources, other aspects of water-related poverty play different roles at different stages of the development trajectory. For agriculturally dominant basins, water scarcity is common, exacerbated by a lack of storage, and water productivity is an effective lever for development, if the benefits are broadly shared, and households suffer from chronic water-related hazards. As basins become more industrialized, water scarcity becomes less common or less severe, and water productivity becomes one of many inter-related factors that impact upon poverty levels. Households and communities are more vulnerable to acute water-related hazards, that is, hazards that happen rarely but have a large impact.

Water-related interventions along the development trajectory

As shown in Figure 2, agriculture plays a smaller role in the economies of basins that are closer to the industrial end of the development trajectory, and they have a lower incidence of rural poverty. Poverty reduction means, in practice, movement along the trajectory from the upper right of the figure towards the lower left. A consequence of this, as we argue below, is that water-related interventions are more or less effective depending on where a basin lies on the trajectory. These differences can be understood from the changing mix of livelihood assets shown in Figure 3.

Within agricultural basins, development of agriculture is often a pre-requisite to other forms of development. Until recently, standard agricultural development theory argued that rising agricultural productivity was essential to raising rural incomes, as it enabled rural populations to diversify into non-agricultural activities (Timmer 1998). Following recent extensive research into rural livelihoods, the current understanding is more nuanced (FAO 1998, World Bank 2007), but rising agricultural productivity has been identified as a key factor in the transition out of rural poverty in several countries (World Bank 2007). Local activities and innovation are essential, and a primary goal is to reduce barriers to effective and equitable institutions. These activities often require the development of infrastructure and services around rural populations. However, as at any stage of development, institutions are important, and these interventions may be ineffective if the benefits are captured by elites.

Irrigation may have substantial impacts, but only if other contributing factors are also improved, including markets and financial institutions, and if local institutions are supportive. As described in the papers on the agricultural basins (the Limpopo, Sullivan and Sibanda 2010; the Niger, Ogilvie *et al.* 2010; the Nile, Awulachew *et al.* 2010; and the Volta, Lemoalle and de Condappa 2010), there is very little irrigation at present, and only limited water is available to expand irrigation coverage. As smallholder production is dominated by rainfed agriculture, marginal improvements in rainfed agriculture, if they are widely shared, are likely to have a larger impact than irrigation expansion. Moreover, field-scale innovations can be carried at relatively low collective risk, and can support the development of human and social capital that make larger-scale improvements more successful.

In transitional basins (the Ganges and the Indus, Sharma *et al.* 2010, Karkeh, Ahmad and Giordano 2010, the Mekong, Kirby *et al.* 2010, and the Yellow, Ringler *et al.* 2010), access to water resources or to the benefits they generate are of greater importance to the poor than water scarcity or basic provision of infrastructure. In each of these basins, except the Mekong, the poorest areas are those without irrigation. At the same time, extensive irrigation has provided water to farmers at the cost of increasing pressure on scarce water resources. The Mekong is a wet basin, and large-scale irrigation dominates only in the delta; in other parts of the basin, farmers use small-scale irrigation systems. Consequently, investments in infrastructure and development of institutional capacity to manage water resources are needed, as with the agricultural basins, but under conditions of increasing pressure. Infrastructure and institutional capacity, in turn, can help to manage chronic hazards as substantial improvements are made in water supplies and sanitation, together with flood control. Given the large numbers of people in these basins, secure provision of basic services has a significant impact on wellbeing and national development goals. Within existing transitional basins, there is limited scope for further development of large-scale irrigation and there is already a high level of productivity in some irrigation areas (for example, in the Yellow and Ganges), suggesting that improvement of rainfed agriculture in the poorest parts of these basins may be overlooked as a source of change, while diversification through aquaculture and livestock can help to smooth variations in income.

Within industrialized basins, represented here by the Andes (Mulligan *et al.* 2010), and the São Francisco (Vosti *et al.* unpublished data), the opportunities for improvement in rural livelihoods arise less from improvements in the traditional agricultural sector than from salaried employment in the rapidly growing commercial sector, or from specialization within smallholder farming to capitalize on the development of new urban markets. In these basins, except in the poorest areas, which are pockets resembling agricultural or transitional basins, increasing water productivity is less a policy lever for poverty reduction than it is

a strategy for the agricultural sector to meet its own goals. These goals themselves can help reduce poverty, via employment generation within and outside of agriculture. Water-related poverty persists, but strategies to reduce poverty, including water-related poverty, focus more on employment and market access than on water as such. In the São Francisco Basin, improved access to water may be necessary for reducing poverty in some parts of the basin, but will not be necessary in all areas, and is unlikely to be sufficient in any of them.

Conclusions

Poverty is a multi-dimensional phenomenon, and thinking about poverty has evolved over time as an appreciation of its complexities has grown. The links between water and poverty are also not simple and resist prescription. However, work in the BFPs revealed some common patterns and conclusions that can help to guide future policy and research. That work leads to the following conclusions concerning the nature of the relationship between water and poverty.

(1) From both an analytical and policy standpoint, it is more relevant to policy makers to understand the influence of water-related variables on general poverty and livelihood measures rather than to seek the meaning of indicators of "water poverty".
(2) There is no simple link between water scarcity and poverty because the nature of this relationship is strongly influenced by position along a "development trajectory". Although the development trajectory does not predict the character of water-poverty links, this condition is such a powerful factor that a first step in analysing the water–food–poverty links within a basin should be to determine where it lies along that trajectory.
(3) At any level of development, analysis of the links between water and poverty should take into account the livelihood strategies and institutional environment of the households at whom those interventions are targeted. The character of the relevant institutions and the mix of assets varies systematically with the households' and basin's development status.

Concerning interventions, we determined four different types of interventions from evidence within basins, each related to a different kind of livelihood capital.

First, interventions that seek to increase human capital are likely to be effective at any level of development, as long as they are matched to the needs and capacity of the community. Examples included improvements in human capital to support fisheries in the Volta; health and education in the upper Niger; education of farmers in the Indo-Gangetic basins in crop-specific practices; and education in the industrial Andean basins, since this was found to correlate strongly, and inversely, with poverty. Interventions such as the introduction of new management techniques, sharing knowledge about alternative crops, and individual and community capacity building can improve livelihoods and reduce poverty throughout the development trajectory.

Second, investments in natural capital are likely to be more effective at the agricultural stage of the development trajectory since people in these conditions rely most strongly on natural capital for their livelihoods. Nevertheless, realizing the benefits of investment in natural capital is also contingent on institutional support. Interventions such as rainwater harvesting, the development and support of water-user associations and other local water institutions, and techniques to improve green water use are likely to have a significant

impact in agricultural basins. Analysis from the Niger, Nile and Volta emphasized the continued role of traditional institutions and the potential gains to rural livelihoods through improvements at the field scale.

Third, investments in water-related physical capital are likely to have a greater marginal impact on poverty at the agricultural and transitional levels of development, although individual improvements are unlikely to be successful without concurrent attention to surrounding infrastructure. Small reservoirs, small-scale multiple-use water systems, local road building, tube wells, small and large-scale irrigation, and similar interventions are more likely to reduce poverty levels where physical and financial infrastructure is not already well developed. While they are also important at the industrial level of development, in these situations they are best seen as strategic investments for regional development, rather than as mechanisms for poverty alleviation. Analysis from the Andean system of basins and the São Francisco, showed that poverty in these basins is strongly affected by national and regional institutions and by access to labour and agricultural markets, as well as to markets for non-agricultural goods produced in rural areas.

Fourth, at any level of development, the institutional context in which interventions are introduced is a strong influence on their success. The nature of dominant institutions varies as the basin passes through the agricultural, transitional and industrial stages of development. At the agricultural stage, the role of basin-wide institutions is less important to poverty reduction than are small-scale institutions. However, at the transitional and industrial stages, such large-scale institutions can be crucial for assisting those left in pockets of poverty as the basin experiences strong growth in population and economic activity. This was particularly apparent in the Indus, Ganges and Yellow River basins, where irrigation, which is more highly developed in some parts of the basin than others, is strongly correlated with lower levels of poverty. In the course of development the shift from local and informal institutions to non-local and formal ones can favour some groups and individuals at the expense of others or at the expense of the natural environment; as basins become more strongly industrialized, the economic capacity grows to invest in institutional processes to address any distortions.

Note

1. Andes (Mulligan *et al.* 2010), Indus-Ganges (Sharma *et al.* 2010), Karkheh (Ahmad and Giordano 2010), Limpopo (Sullivan and Sibanda 2010), Mekong (Kirby *et al.* 2010), Niger (Ogilvie *et al.* 2010), Nile (Awulachew *et al.* 2010), Volta (Lemoalle *et al.* 2010), and Yellow (Ringler *et al.* 2010). The report on the São Francisco is an internal BFP document, which will be published on the Internet in due course.

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