Water, food and development: The CGIAR Challenge Program for Water and Food (CPWF).

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Abstract

Evidence is emerging of an impending crisis caused by the demands for water from a food production system striving to meet the future needs of more than 9 billion people. Globally, the problem seems straightforward; agriculture needs to produce more food while consuming less water. The manifestation of this process on the ground is very complex because it involves three problem dimensions: The first is that the food and water crisis involves interlocking systems of water, food production and rural development, each of which contain distinct attributes that do not relate together simply. The second is that the problem interacts between processes at local, basin and global scales. The third is that change processes involve people in highly complex networks of institutions, almost none of which embrace all three.

The Water and Food Challenge Program is the first venture of its kind to bring together specialists in the three domains of agriculture, hydrology and development in a global-to-local program that also focuses on change through institutions. The effort raises major challenges of managing interdisciplinary research effort amongst hundreds of institutes located in Asia, Africa and South America. We believe effort at this scale, complexity and involvement is necessary to deliver plausible change.

This paper describes the background analysis of the global problem, as it plays out in nine major river basins. It proceeds to describe the principal components of the research-for-development program and the pathways necessary to achieve impact.

Keywords: Challenge Program, Water, food, agriculture, Basin Focal Projects.

Water, poverty and inland fisheries: Some lessons from Africa and Asia.

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Abstract

While small-scale inland fisheries are often presented as a ‘backward, informal and marginal’ economic activity (in comparison to the other water-related sectors such as irrigated agriculture or hydro-power generation), we argue in this paper that the reality is much more subtle and complex. Relying on empirical data from West Africa and the Mekong Basin, we show that

fishing is a critical component of the livelihood strategies of a wider part of the local population, far beyond the few professional full-time fishers living in the community. In fact, for a large proportion, if not the great majority, of the rural farming households living in the vicinities of rivers, irrigation reservoirs, permanent and/or seasonal ponds, or even floodplain, fishing is often a critical source of cash, which is used to complement their main farming activity. In the second part of the paper we revisit the question of the relation between poverty and small-scale fisheries. The analysis shows that this relation cannot be easily reduced to a simple correlation between income-poverty and dependence on fisheries. A more thorough analysis is required that can address both the diversity of fishing practices and the diversity of causes and characteristics of poverty. Using a recent framework emphasizing vulnerability and exclusions as two central dimensions of poverty, we show that poverty factors in fishing communities often include a wide range of variables other than income: land ownership, debt, access to health, education and financial capital, and marginalization from political decision making.

Key-words: Small-scale fisheries, poverty, West Africa, Mekong, livelihoods.

Water and agricultural productivity in the lower Mekong Basin: Trends and future prospects.

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Abstract

The population of the lower Mekong Basin is expected to increase from the present 60 million (approximately) to more than 100 million by 2050. Combined with rapid economic growth, increasing energy demands and increasing food demands, this will put great pressure on water resources and food production. Natural resources are already under pressure, with seasonal water shortages in NE Thailand, hydropower development in the Upper Mekong in China and increasing forest clearing in the uplands of Laos. Other concerns are fishery sustainability in the Tonle Sap and elsewhere, water quality deterioration and salt intrusion in the delta.

Agricultural productivity varies markedly across the lower Mekong Basin: it is higher in the Mekong Delta, moderate in Laos and lower in Cambodia and northeast Thailand. There is steady growth of both productivity and overall production in Vietnam and Laos whereas the growth in Cambodia and Northeast Thailand is modest. Overall production of rice, the main staple in the basin, is increasing everywhere, while per capita increases are marked in Vietnam and modest elsewhere. Most agricultural income is from rice cultivation and per capita income appears to be static or falling slightly in many parts of the basin. The income from livestock and other crops is important and growing as a proportion of overall income from agriculture. Fisheries provide a major part of the intake of animal protein in all parts of the basin, but especially in Cambodia and Vietnam. Production of capture fishery is static with some signs of overfishing, while aquaculture production in the delta is increasing rapidly.

To provide for the predicted increased population in 2050, and also to cope with an anticipated shift in some countries to a diet higher in animal protein, considerable increases in production must be made. Some of this may come from expanding the area under production. Expanding the areas of irrigation may be another option, but this will likely also have downstream impacts. Capture fisheries appear not to offer the prospect of increased production whereas aquaculture and mixed use rice-fish systems both appear capable of greatly increased production.

Further threats are expected to arise from climate change. The picture is neither clear nor uniform across the basin, but it is expected that in several regions the dry season may lengthen and intensify, and that the rainy season may shorten and intensify. Thus both seasonal water shortages and floods, which destroy life and property but are vital to many ecosystems and to fish production, may be exacerbated, as may saltwater intrusion into the Delta.

The anticipated changes to climate and hence flow are thus expected to affect agriculture and food production, and may exacerbate the problems of supplying the increased food demand required to feed the growing population.

Keywords: Lower Mekong Basin, water productivity, agricultural productivity, capture fisheries, aquaculture, climate change.

Water, politics, and river basin governance: Repoliticizing approaches to river basin management.

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Abstract

Current mainstream visions of water management tend to promote a view of river basin development as a technical issue where experts and managers endeavour to match supply and demand by the application of technology, sound science, rational and neutral problem-solving approaches, and -whenever deemed necessary- an adequate cocktail of participation from relevant stakeholders. This paper, in contrast, emphasizes that river basin development and management is about shifting patterns of access to a contested and scarce resource and, as such, is inherently a political process.

I argue that an analysis of physical and social characteristics and constraints of river basins must be paralleled by giving attention to ideas, interests and institutions. In particular I focus on two crucial political drivers of river basin development that need to be given more consideration: the converging interests of the main actors involved in capital-intensive water investments and the use of discursive power in the justification of large-scale investments.

This serves as a background to explain why some river basins get overbuilt and how scarcity is generated artificially. With growing competition and pressure over resources, river basin development and management is an arena where actors mobilize discursive, political and other resources to shift benefits, costs and risk, spatially and socially, in a way that favours their interests or world view. Repoliticizing visions of river basin management offers a different and complementary perspective that allows a better understanding of society/environment relationships.

Keywords: Water management, political processes, convergence of interests, discursive power, overbuilt basins, repolitization.

Conflits agriculteurs - éleveurs et gouvernance de l'eau en zone semi-aride africaine

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Abstract

Farmer-herder conflicts and water governance in a semi-arid region of Africa.

Transhumant herding is widely practised in the Sahelian and Sudanian regions of sub-Saharan Africa. Sedentary farmers are displaying new behaviour that endangers this traditional activity, as they try to deny pastoralists access to water as well as the right to graze their herd on crop residues left on fields. Competition for access to water can have harmful effects for herding, which is a leading economic resource in these regions. In this paper T study in detail the case of the Volta Basin. In their nomadic migration between the grazing routes of Burkina Faso and northern Ghana, pastoralists use small volumes of water for their cattle stock (23 million m_3 per year). In the dry season, they draw this water from wells and boreholes unused by non-irrigated crop systems. However, competition between pastoral systems and crop-livestock systems and the conflicts to which it gives rise may change the geographical distribution of pastoral activities, which would increase neither economic output nor water productivity in the Volta Basin. For example, if the herds stay in the lower latitudes, they will sustain losses from animal trypanosomiasis where as the World Bank currently regards pastoral systems as showing a positive balance. In addition, this practice is a particularly efficient use of water, as the herds use a resource that is otherwise hardly exploited. It has been demonstrated that small ruminants and sedentary cattle cannot use the 40% of crop residues consumed by transhumant herds. Moreover, many farmers burn the stalks of cotton, millet and sorghum because they cannot transport them. The cost in water is marginal, which means that the gain in water productivity will be particularly large. The recent behaviour on the part of sedentary farmers is inappropriate at a time when it is being recognised how effectively herding contributes to poverty reduction. Countries should thus be encouraged to adopt legislation to maintain or even promote the mobility of herding activities. Meeting livestock watering requirements is thus a matter of local conflict resolution and good governance.

Cross-basin comparisons of water use, water scarcity and their impact on livelihoods: present and future

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Abstract

We review and compare patterns in water availability, water use and poverty, and explore how these are interrelated, for ten major river basins. Analysis is in part based on results from Basin Focal Projects (BFPs) of the CGIAR Challenge Program on Water and Food (CPWF). There are very substantial differences among basins with respect to size, total population, population density, the proportion of basin area covered with rainfed or irrigated cropping vs. grassland or forest, average rainfall per unit area, and water supply per capita. The extent to which a basin is "wet" vs. "dry" has implications for water availability, degree of basin closure, institutional mindsets (water policies and processes), community water 'norms', seasonal and long-term management planning, and other factors. Within basins there is considerable spatial variability.

There was considerable similarity across basins on how water availability and water productivity were measured. In all cases, water accounting tools were found to be helpful. These show the volume and proportion of water that goes to irrigation, rainfed farming, grasslands, run-off and other uses at different locations in the basin. Water productivity tends to be lower in wetter than in drier areas. Integration of livestock grazing with rainfed crop production resulted in relatively high levels of water productivity. Where water is relatively abundant, a focus on water productivity was in general found less useful than a focus on trade-offs among major water uses.

Although no simple relationship was found between poverty and water scarcity, they were sometimes linked in subtle ways that also take account of other determinants of poverty. It was found that links among water, food security and poverty are best understood within an historical perspective that describes processes of rural transformation and the overall trajectory of development. Even where water scarcity does not cause poverty, opportunities were identified to reduce poverty through water-related interventions.

Several trends were identified that will affect water and poverty and likely payoffs from water-related investments. These include demographic change, climate change, and the continued transformation of rural society. In most basins, these trends will involve trade-offs – between upstream and downstream communities, energy and food production, agriculture and fisheries, and economic development and environment. Getting the balance right in these trade-offs will require good governance at local, regional, and basin scales.

Keywords: Water availability, water productivity, water accounting, poverty measures, diversification, intensification, rural transformation, demographic change, climate change.

Mapping basin level water productivity using remote sensing and secondary data in the Karkheh River basin, Iran.

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Abstract

Water productivity (WP) mapping is essential to evaluate the performance of current water use at the river basin scale. WP mapping is also essential to identify opportunities to improve the net gain from water by either increasing the productivity for a given consumption of water or reducing consumption without decreasing production. This requires the computation of all benefits and overall water use at a similar spatial domain. Generally the secondary data related to agricultural, livestock and poultry production are managed at administrative district level, whereas hydrological data are collected at sub-watershed scale. This scale difference, hinders estimation at hydrological scales such as sub-catchment to river basin. Due to these limitations, estimates of WP beyond field and farm scale usually do not exist, as is the case of the Karkheh River basin of Iran. To address these issues, in this paper we demonstrate an approach to estimate WP at different scales using a range of datasets. To understand the productivity gaps within and between sub-basins of the Karkheh Basin, we assessed land and water productivity for major crops using a questionnaire survey of 298 farmers. The farm-level land and water productivity in irrigated areas was considerably higher than in rainfed areas. The yield of irrigated wheat and its WP, in terms of yield per unit of gross inflow, averaged 3320±1510 kg/ha and 0.55±0.20 kg/m^3, whereas the corresponding values for rainfed wheat were 1460±580 kg/ha and 0.46±0.22 kg/m^3.

For analysis from sub-catchment to basin scale, we assessed economic WP, in terms of gross value of production per unit of actual evapotranspiration, for all agricultural enterprises including rainfed and irrigated agriculture, livestock production and overall vegetation production using remote sensing data and routine secondary data/agricultural statistics. The sub-catchment estimates show that the water productivity variability is quite high: 0.027-0.071 \$/m^3 and 0.120-0.524 \$/m^3 for rainfed and irrigated systems respectively. Inclusion of livestock changes both the magnitude and patterns of overall water productivity and in doing so highlights the importance of fully accounting for all components in agricultural production systems. The WP mapping exercise presented in this paper identified both bright- and hot-spots for helping policy makers and managers to target better resource (re)allocation and measures to enhance productivity in the Karkheh Basin. The approach is applicable to other river basins.

Keywords: Water productivity; variability; agricultural production; gross value of production, evapotranspiration; mapping; Karkheh

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Poverty, agriculture and water.

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Abstract

We are told the world faces a crisis in which conflicting demands for food and water will cause important increases in the risks of food insecurity, poverty and environmental damage to major river systems. Population increase clearly reduces the per capita availability of freshwater resources, and agriculture remains the predominant water user. Nevertheless, more detailed

analysis of the linkage between water, agriculture and livelihoods presents a more complex picture than one paraphrased by “water scarcity leads to increased poverty”.

We propose a more dynamic view to help our understanding, from which solutions can also be understood. Agriculture is being called on to meet the food demands of an expanding population. But the livelihood effects of increased pressure on the agricultural system must be considered in conjunction with those of both agricultural and non-agricultural responses.

Using analyses of poverty measures, agriculture and water from several regions as illustrations, we propose four scenarios in which an agricultural system under pressure can constrain development. The first two describe situations in closed or closing basins:

- First, when increased demand for irrigation sucks in water from other users;
- Second, when expansion of non-agricultural activities is constrained by existing agricultural demands;
- Third, when a stagnant agricultural water productivity fails to satisfy the food demand of an expanding or changing population; and
- Fourth, when pressure on the river system leads to loss of capacity due to degradation or over-exploitation.

Keywords: Poverty, agriculture, water poverty, water scarcity, livelihoods, closed basins, stagnant agricultural production, degradation, over-exploitation.

Assessing agriculture-water links at basin scale: A hydro-economic model of the São Francisco River basin, Brazil.

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Abstract

The São Francisco River provides about 70% of the surface water in Northeast Brazil, and like much of Brazil the basin includes communities characterized by a broad range of incomes, including persistent poverty. The basin’s agricultural systems cover a wide range between capitalized export-focused enterprises and subsistence farms, and the basin also hosts several important water-dependent ecological zones. Increasingly, the complex web linking water availability, water quality, water productivity, economic growth, poverty alleviation and community and ecosystem health is coming into focus. Brazilian federal law requires that public policymakers promote and guide water management so as to improve overall social welfare. However, knowledge gaps hamper implementation:

- We do not know how decisions on water use are taken by important water-use groups, and once taken, how these decisions affect the water-use options available in other parts of the basin, now and in the future; and

• We lack information for assessing scale-dependent, freshwater dynamics and using these dynamics to predict the effects of alternative water policies designed to promote increased water productivity, and enhancement of livelihoods and the environment.

This paper describes a basin-wide hydrologic model and a basin-wide economic model of agriculture. When the models are linked, they are used to assess the effects of access to and the cost of irrigation water on agricultural change, and the effects of agricultural change (perhaps promoted using water policies) on water resources. Two separate basin-wide models are developed. The first is MIKE Basin, a model used to calculate water budgets for large watersheds. Data are aggregated to the level of user-defined sub-basins within the main watershed. MIKE Basin uses a conceptual rainfall-runoff model (NAM model) based on a multiple-tanks concept that simulates the release of water from the different storage units in each sub-basin. Runoff from each user-defined sub-basin is accumulated or routed down the river network; stage-discharge and rule curves are used to operate the reservoirs. The second is a positive mathematical programming model developed at município (county) level. The model uses observed farmer behavior to identify factors influencing the extent of agriculture, crop mix and production technology, and then uses these relationships to predict the effects of changes in economic, policy or hydrologic circumstances. These two models are then 'linked' to assess the effects of agricultural change in water use (and hence on water resources), and the effects of water and other economic policies on agriculture.

Preliminary results suggest that although the water resources of the SFRB are generally under-utilized, substantially expanding agriculture in the basin could put major pressure on some of the river's environmental flows, even at the river's mouth. Increases in cultivated area would, however, increase agricultural GDP and rural employment, both of which would help reduce rural poverty. Results also demonstate the potentially uneven economic effects of water-use regulations across farmer types; poor farmers are less affected than non-poor farmers under some circumstances.

Given the array of hydrologically inter-related water-scarce and water-surplus areas within the SFRB, a basin-wide approach to water management is clearly called for. In some areas water is scarce (or will become scarce very soon) and policy action to identify water rights and manage water resources should be put into place. In other areas, water use in agriculture can be greatly expanded; in these areas, market access and capital constraints are the factors limiting agricultural expansion and modernization.

Keywords: Hydrologic modeling, economic model of agriculture, water policy, Brazil, basin-wide water management.

Yields and water productivity of rainfed grain crops in the Volta basin (West Africa).

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Abstract

The transboundary basin of the Volta River is shared by six countries in West Africa, with Ghana and Burkina Faso occupying the larger part. The gradient of precipitation patterns divides the basin into agro-ecological zones corresponding to cropping systems based on cereals (maize, sorghum and millet) when progressing further north from central Ghana. This paper aims at analyzing the links between rainfall distribution in time and space, agricultural vulnerability and the farmers' strategies.

We computed water productivity (WP, kilograms of crop per cubic meter of rain) using time series of field estimates of agricultural production in Burkina Faso and Ghana gathered from the national statistics. The values are very low in the Volta basin: mean WP barely reaches 0.15 kg/m^3 for maize (± 0.05), with a mean yield of 1.25 t/ha (± 0.58).

Spatial distributions of yield and WP showed some similarities, with relatively higher values in the south of Burkina Faso. Differences in the spatial distributions appeared when water becomes the main limiting factor (in Northern Burkina Faso, with low yields but high WP), or on the contrary in regions where there is a large excess of rainfall (south-west of the basin, with high yields but low WP).Yearly rainfall explained only a small proportion of the variation in yields for WP for maize, millet and sorghum.

We sought to explain these observations by using simulation modelling (DSSAT) to develop a frequency analysis. We generated ninety-nine years of simulated weather for sites separated by 1.5° latitude over a 9° degree transect on the meridian of Ouagadougou. We estimated the agricultural risk as a result of rainfall temporal distribution at the plot scale. We then focussed on case studies taken from different cropping systems to understand strategies to cope with risk such as dispersion of fields to mitigate spatial rainfall variability (plots at some distance apart from one another), or the influence of the onset of the rains on the choice of crop varieties.

Yields were very partially linked to the annual amount of rainfall. The important factor, especially in the sudano-sahelian region of the basin, was the interaction between dry spells during the rainy season and soil water-holding capacity. The agricultural choices of the farmers could be explained by risk aversion strategies: they prefer to cultivate crops with lower mean yields but with a lower susceptibility to rainfall amount and distribution, and thus lower the risks of failure. At both plot and basin scale, the model indicated that fertilizers would allow much higher yields and thus a better water productivity.

Keywords: Volta basin, Ghana, Burkina Faso, water productivity, rainfed agriculture.