Water management options in a globalised world

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Martin Kowarsch (editor)

e-mail: martin.kowarsch@hfph.de

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Institute for Social and Development Studies (IGP) at the Munich School of Philosophy

Kaulbachstr. 31a, 80539 Munich, Germany; www.hfph.de/igp

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Preface

The issue of possible freshwater shortages in the future has secured a dominant position on the agenda of scientists and political decision makers. With good reason: Almost 900 Mio. people lack a safe access to clean water these days. More than a third of the world´s population lives in regions suffering from water stress and trends indicate that water shortage is likely to increase in many regions over the next decades. However, in many cases the reason for water shortage is bad water management, rather than the physical availability of water.

The following collection of scientific and academic papers can serve as an up-to-date overview of current approaches to water management, but also as an introduction to the underlying problems and questions water-related science is facing: They discuss present and future water availability and scarcity as well as crucial economic, technological, political and cultural-ethical issues related to water management in general or related to specific regions.

These articles were written by scientists from different disciplines for the international workshop "Water management options in a globalised world. Promoting a dialogue between economics, ethics and other disciplines" (Lassalle-House, Switzerland, 20-23 June 2011). The contributions initially served as background papers for the respective talks given by the authors, but were then partly revised after the workshop for this publication in order to include some crucial points that arose during the discussion.

The main target of this workshop was – based on a thorough analysis of the underlying problem structure – to identify and to evaluate the most important and most promising freshwater management strategies to tackle drivers of water scarcity and pollution. Furthermore, the workshop aimed at bringing together scientists from various backgrounds in order to promote further dialogue and cooperation. The workshop was organised by the Institute for Social and Development Studies (IGP) Munich together with the Lassalle House in Bad Schönbrunn, where the workshop took place. The IGP is working on, amongst other topics, questions of ethics and philosophy of science related to water management issues.[1] More detailed information about the workshop, its programme and the participants can be found in the Appendix. The following Introduction will provide a summary of what was primarily discussed at the workshop.

We thank the foundation "Forum fuer Verantwortung" (www.forum-fuer-verantwortung.de) and "Wasserwerke Zug" (www.wwz.ch) for their generous financial support for the workshop. Many thanks also to all participants of this workshop for the intelligent, well-informed and lively discussions as well as for their contributions to these workshop proceedings.

For this 2nd edition, chapters 5 and 6 have been revised.

[1] The IGP also conducts the three-year BMBF research project "Sustainable water management in a globalized world" together with PIK (leading the project) and HU Berlin. See http://www.hfph.mwn.de/igp/forschung-und-projekte/globales-wassermanagement.

Introduction

This publication – as did the workshop – primarily deals with (blue and green) water management options (in a very broad, not merely economic sense) with regard to global interrelations, uncertainties and ethical aspects as well as interconnections (or trade-offs) between the different management options. However, decisive for the success of any attempt to identify and evaluate the most promising water management strategies is a thorough and reasonable framing of the problem. The papers in Part I deal with this issue.

Concerning the problem formulation, there was not much disagreement during the workshop about general normative targets of water management. During the final discussion we agreed on the following targets of water management, even though their operationalisation remains unclear and though they are dependent on normative-ethical assumptions:

- Protecting life-sustaining functions of water cycles in ecosystems, also for future generations.
- Ensuring the availability of sufficient water (quantity, quality: health etc) for different present *and* future human purposes, primarily for basic needs and livelihood fulfilment and for basic opportunities in life.
- Managing water and developing infrastructure without endangering other ethically important targets and without creating further problems.

There was less agreement with regard to the framing of the problem on the question of what is actually driving water shortage in many regions, and how these are to be addressed. Roughly summarised, there were two camps: those referring to economic and technological solutions and those stressing the political perspective. The first camp´s view is based on global or micro-economic models and projections of future demand for and supply of water with the target of reducing the gap between demand and supply – particularly for agriculture as the largest user of water (irrigation etc). Such an analysis mostly leads to economic and technological management proposals for a "first best world" without any implementation barriers. If these options were fully implemented and if there were no other obstacles, the water shortage problem could be tackled successfully. In contrast, the second camp regards the water problem as a context-related, political (structures of power, procedures, institutions etc) and socio-cultural problem rather than a problem of economics and technology. From their point of view, in most cases there would be enough water for everyone, but the respective socio-cultural and political structures and contexts lead to adverse effects of the allocation and management of water – and finally to water shortage for some people, mostly the poor. In addition, this camp points out that lifestyles in Western countries as well as the political role played by industrialised countries contribute a lot to the water crisis in many regions all over the world.

In my view, one of the main outcomes of this workshop is a better understanding of these two views, which are not necessarily contradictory, but can complement each other. Although there is high uncertainty – which makes scientific advice for water-related policies even more difficult and calls for much more reflection on this issue – it seems very likely that due to climate change, economic growth, population growth, consumption patterns, mismanagement, environmental degradation and other factors water will become even scarcer in many regions. But on the other hand economic and technological solutions are evidently not sufficient – though necessary – to solve these problems.

From a human rights based perspective it is not decisive whether there is sufficient water for everyone *in principal*, but rather whether everyone actually has safe access to water and sanitation. That is why the scientific community should put more emphasis on integrating socio-cultural-political perspectives. Interdisciplinary or even transdiciplinary research (including also policy makers, professionals and other stakeholders) requires an intensive dialogue between the different disciplines and institutions in order to better understand the differing underlying world views, assumptions and terminology. Our workshop was a further step into this direction. The articles in Part I approach the problem of framing the water problem: chapter 1 presents different concepts and maps of water availability and scarcity, chapter 2 is about the need for water and has a closer look at Central Asia as a regional example. Chapter 3 is about drivers of water scarcity and provides many arguments for the standpoint held by the "first camp". Chapter 4 points out (from an ethical perspective) the need for an adequate problem phrasing as well as for a thorough analysis and evaluation of the consequences and side-effects of the means to the ends of water management: if some means turn out to be too risky, the initial end should be revised.

This discussion between the two different views mentioned above sprang up again when management options were discussed, because their evaluation is closely related to the understanding of the actual problem regarding water. During the three-day workshop the following water management options were discussed:

- Addressing governance, procedures and socio-cultural aspects as drivers for water crisis. Furthermore:
    - Improving scientific advice for water-related policies
    - Improving monitoring of outcomes
- Technological change (productivity increase), particularly in agriculture (technological improvements regarding green water)
- Climate change mitigation, and adaptation
- Pricing water; further market-based and other instruments (water right trading, standards, time-based restrictions)
    - Alternative instruments for (i) exclusion of certain uses of water and (ii) cost recovery
- Virtual water trade (helpful under certain conditions)
- Rising awareness both in businesses and for individuals, e.g. by water footprints
- Changing lifestyles in Western countries and unjust policies and trading patterns
- Harmonizing the management of land and water
- Addressing issues affecting access to water such as poverty, development, empowering people, fairer allocation etc

The articles in Part II of these workshop proceedings discuss some of these options, mainly economic ones.

In order to deepen the understanding of some water managament issues, regional examples are explored. The articles in Part III deal with different aspects of water management in Sudan (governance issues), Nigeria (socio-cultural aspects), Australia (water trade) and Mongolia (a participatory sanitation project). Furthermore, small group discussions were held during the workshop to more thoroughly discuss some water management strategies. These intensive small group discussions reflected lots of the core issues discussed during the whole workshop. Consequently they shall be briefly summarised at this point. The discussions were about (i) governance in Sudan, (ii) water pricing, (iii) the water/food/energy/trade nexus and (iv) socio-cultural aspects in Nigeria. The names in brackets indicate the moderators of these small group discussions and at the same time the authors of the respective sections below:

(i) Governance in Sudan (Julia Ismar)

This workshop discussed the role of the governance of natural resources, especially water. The theoretical considerations touched upon the issue of governance in post-conflict, non-Western societies, and the participants agreed that the concept only has limited analytical leverage, other than commonly advocated by international institutions and the donor community. Without localizing and contextualizing governance, the concept will remain too abstract and fall short of addressing the pressing issues on the ground.

In order to understand governance, it is crucial to understand the societies that have shaped the governance systems currently in place. Consequently, more comparative studies are needed. Applying governance as a comprehensive concept masks the individual complexities of each case that is being analysed, as well as the hegemonic nature that the discourse on (good) governance has taken on over the past decade.

The case of Southern Sudan was used to provide anecdotal evidence for the theoretical discussion: environmental issues are increasingly shifting into the focus of the analysis of the complex conflict setting that has devastated the Sudan over the previous decades. This is not to suggest that water was the trigger for the ongoing violence in Southern Sudan. However, environmental issues have definitely shaped the conflict setting and thus need to be analysed in order to fully grasp the dynamics. Water governance/policy has been instrumentalized for a long time as it followed purely political considerations. Consequently, water governance has also contributed to the ongoing circle of violence as it undermined stability and legitimacy of the state in Southern Sudan and cemented existing conflict lines in the society. The question of the conflict over water and land between farmers and pastoralists remains a pressing issue that needs to be addressed by the new government of South Sudan.

(ii) Water pricing (Wolfgang Bretschneider)

Water has got a value, we all agree on this. And on the other hand, these values are reflected by economic prices. Then the question is: Are these the value we reasonably care about? And: Is an economic price the right instrument with all its implications?

There are two functions a price fulfills potentially. The first one is to manage the problem of usage-conflict in the light of scarcity. Assuming scarcity, people have to be discouraged from using water in certain (normatively: unnecessary) ways. A price as mechanism excludes certain (normatively: inefficient) uses of water. The function of exclusion could be fulfilled by other mechanism. We learned that in Australia or Ghana the problem is solved by time-restrictions for consumption. And there are other mechanisms to protect the resource, which are interesting to explore.

The second function a price fulfills is the financing of water services. “Water as such” is just “there”, however, water services have to be produced, i.e. financed. If they are not, they just do not exist. Basically, the services can be financed also by other financial sources, i.e. taxes or transfers. We heard the argument, that a *user-price*-based financing has the advantage of the “magnetic impact”: If the needy people pay, the service supplier has an incentive to “come there”, i.e. to provide a given service. On the other hand we heard that South Africa has positive experiences with financing through transfers from rich to poor water users.

Unfortunately, we could only *start* to discuss the first question. The second and also big question of the “How to?” remains open.

(iii) The water/food/energy/trade nexus (Martin Keulertz)

The purpose of this session was to highlight the centrality of the water/food/energy/trade nexus at a time of dramatic global changes in the international political economy. It was argued that we are at the beginning of a new economic cycle triggered by resource (and crucially water) scarcity and new actors on the global scene. The new economic era we are approaching will introduce a ‘green economy’ with a greater focus on resource efficiency. This neglect will bring new changes but also opportunities of economic growth. Crucial for this new economic thinking will be the aspect of efficiency gains in the private sector such as in the supply chain. The example for a country that is applying such methods is Qatar, where the leadership is deeply conscious about its water vulnerability. Qatar looks at various options to decrease its water insecurity. First, the state seeks to grow food through desalinated water domestically and land purchases abroad. Second, efficiency is sought to be increased through collaboration between the public and the private sector to decrease waste in the supply chain. This thinking is novel in the global economy but it should be accompanied critically by environmental scientists across the globe. Whether this strategy works will decide upon the success of the new economic cycle and the potential to use resources more wisely at a time of population growth in Asia and Africa. The participants of this session critically reflected upon these strategies but also upon the question to what extent this era will be influenced by what is currently called the Western world. China, India and other actors in the new world order were discussed in a very self-reflexive manner. The main outcome of this session was the need to think ‘bigger’ and to what extent the academe in the West can influence the new discourses around water/food/energy and trade at a time of global change.

(iv) Socio-cultural aspects in Nigeria (Emmanuel M. Akpabio)

Cultural ecological knowledge of resource management tends to be very strong and driven by environmental contexts of livelihoods activities.

The notion of scarce water as an economic good should be balanced by recognition of all the social and human rights dimensions of water.

Constructive dialogue should be used as a tool of engagement with local cultures and stakeholders.

Modern systems of resource management have failed to factor in such contexts to evolve a flexible and contexts sensitive project implementation for socio-economic development.

Some local ideas of water management are useful. However, there is the usual mistake of sidelining such local concepts and knowledge in wholesale preference for the modern. This has always been counter-productive.

Working with local cultures in water resources management and identifying local needs could achieve the twin objectives of education (especially on misplaced beliefs) and learning from their strength-integrated knowledge.

PART I:

GRASPING THE WATER PROBLEM

Chapter 1:
Water availability and scarcity: now and future trends

Dieter Gerten
Potsdam Institute for Climate Impact Research (PIK)
Research Domain II: Climate Impacts & Vulnerabilities
Telegraphenberg A62, 14473 Potsdam, Germany
gerten@pik-potsdam.de

Quantifying water scarcity at large scale, and water-for-food requirements in particular

In the past, numerous indicators have been developed to measure freshwater scarcity at scales from local to global. Already the following, incomplete list (see e.g. Dyck 1999 for a more complete account) demonstrates that the range of such indicators includes more or less simple indices that describe merely the hydroclimatic situation; indices that relate available water resources – typically the water in rivers and sometimes also groundwater aquifers – to the number of people that potentially use this resource; and indices that account more explicitly for socioeconomic conditions and capacities to cope with water scarcity.

- The “aridity index” (Thornthwaite 1948) and other indices (such as the PDSI/Palmer Drought Severity Index; e.g. Dai et al. 2004) that derive water shortage from climatic variables.
- Indices that relate the water resource, e.g. the “water crowding” index or “Falkenmark index” (e.g. Rockström et al. 2009).
- Indices that relate the actual water withdrawal to the water availability (as applied e.g. in Vörösmarty et al. (2000).
- The “Water Poverty Index” (e.g. Lawrence et al. 2002) that incorporates people’s capacity to cope with water scarcity.
- “Water footprints” of countries, individual people, businesses etc. that account for the water used for the production of specific goods, while this water often has its origin abroad (in the case that production of a product happens elsewhere than the consumption of this product) (see explanations and respective publications at http://www.waterfootprint.org/).

Most of these indicators have the advantage that they can be applied at large scales and that they do not require many data, so that they can be relatively easily computed for identifying regional differences and hotspots of water scarcity. As a further advantage, some indicators capture the social conditions (esp. the water demand side, the accessibility of water and the economic situation), which are of at least equal importance for water scarcity than the biophysical conditions (see the concept of “physical” vs. “economic” water scarcity). However, there are some obstacles that make it difficult to identify whether a region or country is water scarce: First, the outcome of a water scarcity analyses will depend on the choice of the indicator or a combination of different indicators (of which there are about 150 presently), and results based on different indicators are hard to compare. Second, the data needed for computing the indicator values are often very uncertain (e.g. groundwater resources) or not available at all, especially in countries of the South (unfortunately including many countries that exhibit pronounced water scarcity); therefore, scarcity analyses often have to rely on model-based analyses.

Third, and perhaps most importantly, many water scarcity analyses are provided at the country scale, which implies assumptions about the distribution and use of the water resources. For instance, Vörösmarty et al. (2005) have shown that the larger the spatial unit for which water availability and demand are averaged, the lower is the estimate of the number of people who experience water scarcity. Indeed, at the largest scale, i.e. globally, there appears to be enough water to meet the demand – also for a growing future population, given that water will be managed well (Molden et al. 2007). Thus, the spatial unit of a water scarcity analysis (usually a grid cell, country or river basin) implicitly makes the assumption that the water is evenly distributed within that unit, or that it can be accessed equally well by all people living in that area. In turn, computing water scarcity at the highest possible resolution (e.g. at a scale of 1 x 1 km) need not be the most realistic approach, since people certainly use not only the water in their immediate surrounding but also from abroad. This is particularly true if there is an import of “virtual water” from other regions, as most products consumed in a given location required the use of water in the very region where they were produced.

Fourth, the majority of water availability and scarcity assessments are focused solely on the “blue” water available in rivers, reservoirs, lakes and aquifers, which can be withdrawn for different purposes such as irrigation (e.g. Vörösmarty et al. 2000; Arnell 2004). However, the “green” water needs to be acknowledged as well, which is the precipitation water that has entered the soil and sustains the terrestrial ecosystems as well as the growth of rainfed agricultural vegetation (in fact, about two third of global crop production rely on green water; Rost et al. 2008). Integration of green and blue water in water scarcity assessments has been accomplished only recently by use of macro-scale hydrological, ecological and crop models (see Hoff et al. 2010 for overview).

However, it remains challenging to clearly define the green water resource and to represent it consistently with blue water in scarcity indicators. Rockström et al. (2009) approached this problem by defining green water as evapotranspiration from grazing land and cropland in a country and relating it to the country’s population. In the case that the value of this modified “Falkenmark index” (or “water crowding” index) is smaller than 1,300 m^3 cap^{-1} yr^{-1}, green-blue water scarcity was assumed to prevail (1,000 m^3 cap^{-1} yr^{-1} if only blue water is considered). To link more directly water availability to food production—the largest consumer of water globally (after green water consumption in terrestrial ecosystems)—one can further assume that countries having less than 1,300 m^3 cap^{-1} yr^{-1} of green-blue water resources are not able to produce a balanced diet of 3,000 kcal cap^{-1} d^{-1} with shares of, respectively, 80% vegetal and 20% animal products (Rockström et al. 2007). Note, however, that the threshold of 1,300 m^3 cap^{-1} yr^{-1} represents a roughly estimated global average. In reality, significantly more, or less, water may be required in individual regions for producing the given diet. The reason for this is that the crop water productivity, i.e. the ratio between crop yield and evapotranspiration during the growing period, differs among regions due to differences in climatic and management conditions in particular (Fader et al. 2010).

This paper provides an estimation of green and blue water availabilities for countries and compares them to the country-specific water requirements for producing a balanced diet of 3,000 kcal cap^{-1} d^{-1} (with 80% vegetal products) calculated from local crop water productivity. The resulting water scarcity indicator is the most complex up to date applicable for global studies on water-for-food demand, and it is hoped that it overcomes most of the shortcomings mentioned above. It is calculated here for the contemporary situation (1971–2000 average) and additionally for climate change scenarios by 2070–2099 (the “2080s”) taken from 17 General Circulation Models (GCMs), including direct CO_2 effects on plants. All underlying calculations were performed at high spatial resolution (0.5° global grid) and high temporal resolution (daily) but are presented as averages for the two 30-yr time slices (present and future). The material presented in the following is based primarily on the study by Gerten et al. (in press), where further details and more results are documented.

Methods and data used for this analysis

The present analysis of water scarcity using a new indicator that directly relates water resources and water needs for a given diet—compared to the widely used conventional “water crowding index”—is based on simulations runs with the global biosphere model LPJmL (Bondeau et al. 2007; Rost et al. 2008). This model computes the growth, production and phenology of 9 “plant functional types” (representing natural vegetation at the level of biomes), grazing land, and 11 “crop functional types” (CFTs, the world’s major food crops). The fractional coverage of grid cells with CFTs was prescribed using a dataset of present cropland distribution combined with a dataset of maximum monthly irrigated and rainfed harvested areas of individual crops (see Bondeau et al. 2007 as well as Fader et al. 2010 for details).

Water requirements and water consumption—and thus crop water productivity—of irrigated and rainfed CFTs are distinguished in the model, especially since evapotranspiration on irrigated land is constituted by both green and blue water. Seasonal phenology of CFTs was simulated based on 20-yr average climate, allowing for adaptation of varieties and growing periods to climate change (Bondeau et al. 2007). Management/yield was calibrated using statistical data for the period around 2000 by sequentially varying parameters for cropping density and other management features (Fader et al. 2010). We omitted future changes in management and in the extent of agricultural land in this analysis.

The blue and green water resource (both in m^3 yr^{-1}) was computed at the grid cell level and then summed up for the respective country, presuming that the food produced with this water is distributed evenly within a country rather than produced and consumed within individual grid cells or within river basins. The blue water resource is understood here as the runoff generated in a river basin, which we redistributed across all cells within the basin in proportion to their accumulated discharge. Cells with a high share of discharge relative to the basin’s total discharge thus were assigned a relatively high blue water resource. The blue water resource per country was given by the sum of this runoff for all grid cells. We also assumed that only 40% of this resource are actually available for food production, e.g. to account for environmental flow requirements (further details in Gerten et al., in press).

The green water resource was computed as the precipitation water that evapotranspires from crop and pasture areas within a country. The green water contribution from grazing land was constrained here either by total grassland evapotranspiration or by the global average water requirement from grazing land. The total green and blue water resource (m^3 yr^{-1}) was calculated as the sum of the green and blue water resources in a country. Green-blue water availability (in m^3 cap^{-1} yr^{-1}) was then calculated by relating the annual green-blue water resource to the number of people inhabiting a country, assuming that they benefit uniformly across the country from its total water resource. Subsequently, green-blue water scarcity was computed for each country as the ratio between the green-blue water availability and the water requirement for food production.

The water requirements for producing a healthy diet of 3,000 kcal cap^{-1} d^{-1} with 20% calories from animal products were estimated from the water needs for producing vegetal calories on a country’s present cropland and from a hypothetical livestock sector. The former were estimated by relating the total amount of calories produced on cropland to the green-blue water consumed on cropland during the growing period, yielding to a global requirement of 0.409 m^3 1,000 $kcal^{-1}$. Following Rockström et al. (2007), the eightfold amount of water is required to produce an equivalent amount of animal calories. This results in a global average of 1,075 m^3 of water per capita and year required for the above specified diet (358 m^3 cap^{-1} yr^{-1} for the vegetal share plus 716 m^3 cap^{-1} yr^{-1} for the animal share). Water needs to produce the animal share were attributed to cropland and grazing land assuming a mixed livestock system with a non-grazing and a partly grazing sub-system, each consuming 50% of the water (as in Rockström et al. 2007; see also Gerten et al., in press). As a result, 840 m^3 cap^{-1} yr^{-1} are required to produce food and feed on cropland, and, respectively, 251 m^3 cap^{-1} yr^{-1} to produce grazed biomass.

LPJmL was forced for the period 1901–2000 by monthly values of air temperature, precipitation cloud cover from the CRU TS 3.0 climate database (Mitchell & Jones 2005). Climate projections for the simulations up to 2099 were derived from 17 GCMs under forcing from the SRES A2 emissions scenario (see Gerten et al., in press, for details). To quantify effects of atmospheric CO_2 concentration on plants and thus on water scarcity, we ran additional LPJmL simulations in which CO_2 was held constant at the year 2000 level. We then used population projections consistent with the emissions and climate projections to determine future per capita water availabilities (Grübler et al. 2007).

Results and discussion

Current green-blue water availabilities, requirements and scarcities

Blue water availability is presently rather low (e.g. <1,700 m^3 cap^{-1} yr^{-1}) not only in many physically water-poor countries in subtropical regions but also e.g. in Central Europe (data not shown). When the green water resource is added to the blue water resource, water availability appears to be much higher, but nevertheless many countries stay below <1,700 m^3 cap^{-1} yr^{-1} (Fig. 1). Most countries at high latitudes and in the humid tropics, or countries with little resources but low population (e.g. Australia), are characterised by high per capita water availability (>4,000 m^3).

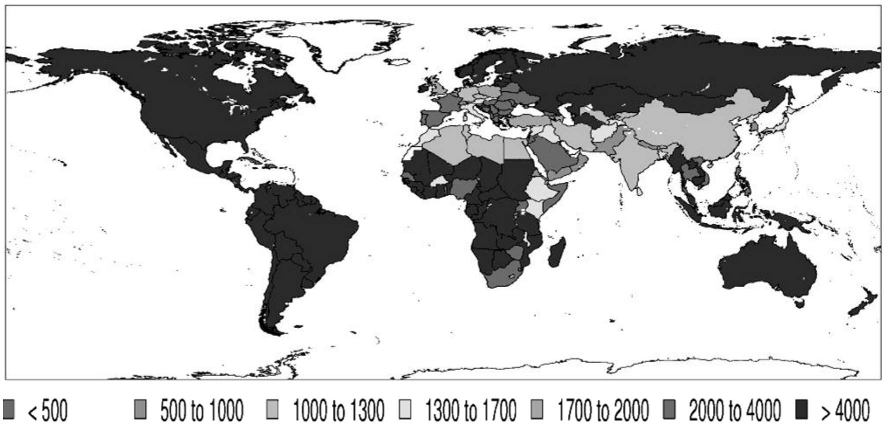

Fig. 1. Present-time availability of green plus blue water, illustrated at the country level (values in m^3 cap^{-1} yr^{-1} and averaged over 1971–2000).

Based on our computations of crop water productivity (and our assumptions for the livestock sector), the water requirements for a balanced diet of 3,000 kcal cap^{-1} d^{-1} vary considerably between countries (Fig. 2a). We find e.g. that in Europe and North America less water is needed to produce this diet than on a global average (1,095 m^3 cap^{-1} yr^{-1}), while elsewhere the respective needs are calculated to be significantly higher (up to >4,000 m^3 cap^{-1} yr^{-1}). This regional pattern results from differences in crop water productivity, which in turn are controlled mainly by differences in climatic conditions, yield levels, and management intensity (see Fader et al. 2010, and Gerten et al., in press, for more detailed analyses).

Relating these water requirements to green-blue water availability gives the degree of water scarcity, and it happens that this varies among countries as well (Fig. 2b). Many European countries classified as chronically water-scarce according to the conventional Falkenmark index (see Fig. 1), however, do no longer appear as being water-scarce when using the new indicator, since comparatively little water is needed there for producing a unit of crop or animal product. Likewise, other countries showing green-blue water scarcity according to conventional analysis (Fig. 1; e.g. South Africa, China, Japan) actually have enough water to meet the need for the specified diet.

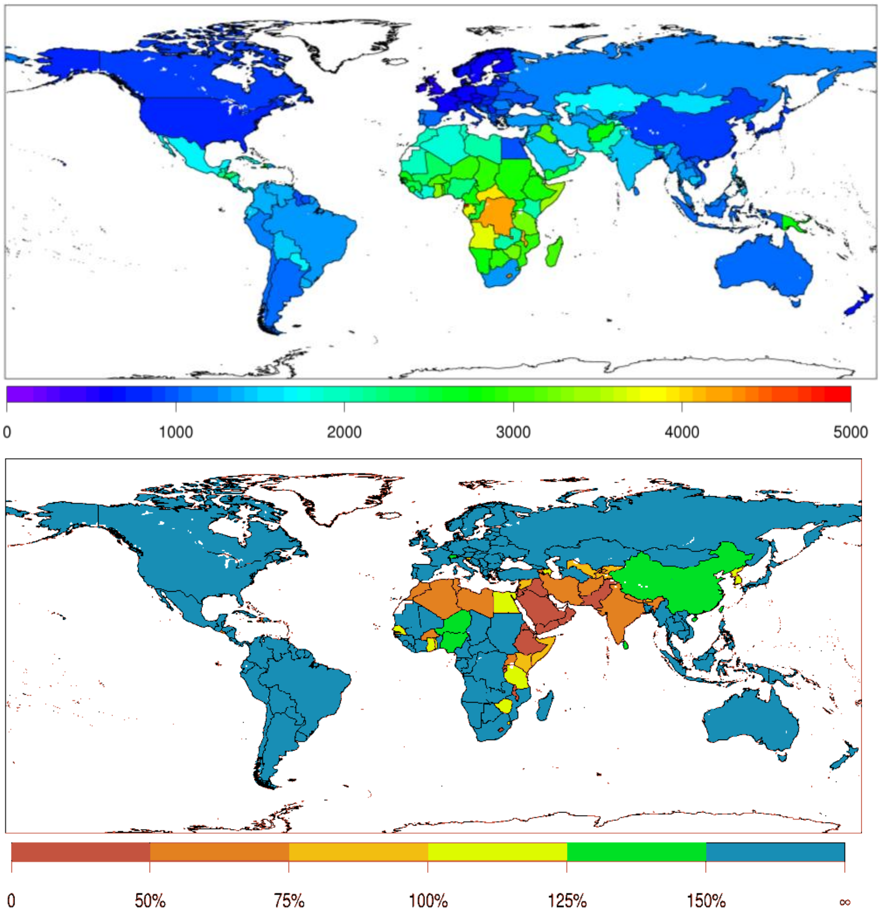

Fig. 2. Top: Countries' water requirements (m^3 cap^{-1} yr^{-1}, 1971–2000 average) for producing 3,000 kcal cap^{-1} d^{-1} with 80% vegetal and 20% animal products. Bottom: Resulting water scarcity expressed as the percentage ratio between green-blue water availability (cf. Fig. 1) and these requirements.

Future changes in green-blue water availability and water-for-food requirements

Green and blue water availability is simulated to change significantly in the future under the suite of climate models considered, even if population changes are not considered (Fig. 3). The change patterns are different for blue water and green water (data not shown), and they result from the complex interplay of impacts of changing precipitation, temperature, CO_2 concentration (all of which affect potential evapotranspiration and soil moisture), and from changes in the CFT's growing periods. Climate change by the 2080s alone (without CO_2 effects) will increase the water requirements for growing food crops in many regions (data not shown, but see Gerten et al., in press). This is attributable chiefly to the higher evaporative demand induced by the warming. In parts of Europe, western Asia and southern Africa, however, water requirements are projected to decrease as a consequence of e.g. prolonged growing seasons enabling higher annual yields while consuming the same amount of water year-round. Water requirements decrease in most regions if the direct CO_2 effects are included (not shown here).

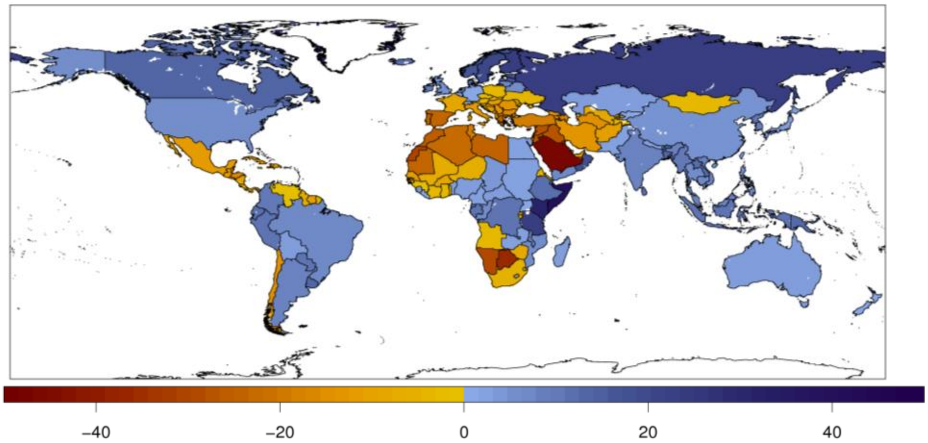

Fig. 3. Relative changes in green-blue water availability by the 2080s. Shown are medians across all 17 climate scenarios, with CO_2 effect, and assuming the SRES A2 emissions scenario. Population numbers held constant at the year 2000 level.

Water scarcity under climate and population change

Fig. 3 implies a high likelihood for many countries that owing to climate change, per person green-blue water availability will decrease by the 2080s (e.g. high likelihood for a decrease by >10% in southern Europe and significant parts of Africa; Gerten et al., in press). However, only a few countries presently not water-scarce are suggested to turn to a water-scarce status by the 2080s due to climate and CO_2 change. Given both climate (incl. CO_2) and population change, however, there is a very high probability that green-blue water availability will decrease in many regions, such that areas in Africa, the Near East and the Middle East that are presently water-scarce will remain so in the future. In addition, a number of countries presently able to produce 3,000 kcal d^{-1} for their inhabitants will probably lose this ability by the 2080s, whereas most countries in the Americas and also Australia will still have enough green-blue water resources for this purpose (Gerten et al., in press). But note, regional differences are masked by the country-scale analyses, such that it may well be that water resources in a number of Australian (and other) river basins may not suffice. If both climate and population change are accounted for, the global number of people living in water-scarce countries will rise to approx. 6 billion, respectively (only 3.4 billion, however, if the B1 scenario was chosen; Gerten et al., in press). The number of people living in water-scarce countries is lower if the new indicator is used instead of the fixed threshold of 1,300 m^3 cap^{-1} yr^{-1}.

In sum, this study shows how existing water scarcity indicators can be developed further in order to compare per person green and blue water availability and requirements for food production, based on grid cell-scale computations of the underlying hydrologic and biogeochemical processes. Application of this new indicator demonstrates that applying a fixed threshold (here, 1,300 m^3 cap^{-1} yr^{-1} for a balanced diet of 3,000 kcal cap^{-1} d^{-1} with 80% vegetal products) often gives a biased view on water constraints to food production, since such an approach tends to overrate water scarcity due to neglect of regional differences in crop water productivity. We also find that water scarcity, even if green water is considered in addition to blue water, will exacerbate in many countries, especially in parts of Africa and Asia. This will be driven primarily by population growth and only secondarily by climate change, which is in accordance with findings from earlier studies based on blue water only (Vörösmarty et al. 2000; Arnell 2004).

Next steps towards a more complete account of water limitations to food security ought to consider the actual diet composition (while here, the focus was on a specified target diet) and also the origin of the consumed products. This will require a more detailed account of the water requirements for livestock products (e.g. by considering livestock feed baskets), and ultimately an integration of “virtual water trade” by accounting for the actual and potential future global pattern of production and consumption of agricultural products and the underlying green and blue freshwater resources.

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Chapter 2:

Human water use, conflicts and sustainability

Karl Tilman Rost (FU Berlin)

Introduction

Freshwater is essential to humans and other life forms on Earth. Its supply has emerged as a major environmental concern for the 21st century. Regional water scarcity is already a significant problem and it is widely suggested that the predicted climatic change as well as demographic changes and food demands will together alter water requirements in many regions. By the end of the 20th century about 436 million people in 31 countries had to live with water shortage and scarcity. According to ENGELMAN *et al.* (2000) their number might increase to 3 billion people in 48 countries by the year 2025. As human and climatic pressure on our freshwater resources will increase worldwide, efforts to manage water resources in a sustainable manner must be integrated into the broader and interlinked contexts of economic and social development as well as of the environment.

The world is not running out of water, but it is not always available where and when people need it. The total amount of water (1,386 million km^3) and the balance of water on Earth remain relatively constant over time. The water cycle describes the continuous movement of water in the atmosphere, on and below the Earth´s surface. It is a complex interdependency of continual water flows among major reservoirs (DINGMAN 1994), where the liquid, solid or gaseous water moves by the physical processes of evaporation, condensation, precipitation, infiltration, runoff and subsurface flow from one reservoir to another (e.g. atmosphere, ocean, lake, river, groundwater).

It is difficult to quantify the global water amount potentially available for human use and management as the data published by various authors differ. About 70 percent of the Earth´s surface is covered by water, but nearly 97 percent of it is in the oceans and too salty for most uses. Of the remainder, 69 percent is locked up in ice sheets, glaciers, ground ice, or permanent snow and 30 percent is in groundwater aquifers. Only 1 percent is in surface-water bodies (e.g. lakes, rivers swamps) and therefore potentially accessible for human use and management (DINGMAN 1994). About 43,600 km^3 of freshwater is available as a renewable resource each year. Despite more than twice of this amount is falling as precipitation, much is naturally lost through discharge to the ocean, evaporation and evapotranspiration and sub-surface seepage.

Water Scarcity and Water Use

At the present time the world´s population is using about 55 percent of the reclaimable freshwater contained in surface water (rivers, lakes) and groundwater aquifers. But the freshwater resources on Earth are unequally relocated mainly because of climatic reasons. Those countries with higher rainfall and lesser evaporation rates often have larger water resources. Climate, seasonal variations, droughts and floods can contribute to local extreme conditions. Local variations within countries can be highly significant. Water stress and scarcity apply, when there is not enough water for all users. Countries begin to experience periodic or regular water stress, when the annual renewable freshwater availability is less than 1,700 m^3 per capita. Below 1,000 m^3, water scarcity prevails (ENGELMANN *et al.* 2000). Water scarcity can be demand-driven, supply-driven or being a result of structural inequalities between different groups of water users.

According to MOLDEN (2007) more than 1.2 billion people live in mostly semi-arid or arid areas of *physical water scarcity*, where not enough water occurs to meet all demands for agriculture, industry and domestic purposes. At times rivers, like the Syr-Darya and the Amu-Darya in the Aral Sea basin, do even not have enough water run-off to reach the sea. Furthermore about 1.6 billion people on earth live in water catchments, where a lack of human capacity, insufficient financial resources or institutional limits cause an *economic water scarcity*, although the natural water resources are abundant.

India (645.84 km^3/per year), China (549.76 km^3/year), and the United States (477 km^3/per year) use most water (PACIFIC INSTITUTE 2009). However these nations are also the territories, where most people live (Tab. 1). But the annual per capita freshwater withdrawal is about three times higher in the United States (1,600 m^3) than it is in India (585 m^3) and China (415 m^3). On the other hand countries with a much smaller population such as Turkmenistan (5.105 m^3), Kazakhstan (2,360 m^3), Uzbekistan (2,194 m^3) in Central Asia, Guyana (2,187 m^3) in South America, or Hungary (2,082 m^3) have the highest annual per capita water withdrawal in the world.

Country	**Total Freshwater Withdrawal (km^3/a)**	**Per Capita Withdrawal (m^3/p/a)**	**Domestic Use (%)**	**Industrial Use (%)**	**Agricultural Use (%)**	**2005 Population (million)**
China	**549.76**	**290**	**7**	**26**	**68**	**1,323.35**
Germany	**38.01**	**460**	**12**	**68**	**20**	**82.69**
Guyana	**1.64**	**2,187**	**2**	**1**	**98**	**0.75**
Hungary	**21.03**	**2,082**	**9**	**59**	**32**	**10.10**
India	**645.84**	**585**	**8**	**5**	**86**	**1,103.37**
Kazakhstan	**35.00**	**2,360**	**2**	**17**	**82**	**14.83**
Kyrgyzstan	**10.08**	**1,916**	**3**	**3**	**94**	**5.26**
Turkmenistan	**24.65**	**5,104**	**2**	**1**	**98**	**4.83**
U.S.A.	**477.00**	**1,600**	**13**	**46**	**41**	**298.21**
Uzbekistan	**58.35**	**2,194**	**5**	**2**	**93**	**26.59**

Tab. 1: *Freshwater Withdrawal by Country and Sector 2006* (PACIFIC INSTITUTE 2009)

Freshwater is mainly consumed for agricultural, industrial, and domestic uses. Besides it is used for non-consumptive usages like the generation of hydropower, for mining, or recreation. The production of food and other agricultural products actually takes about 70 percent of the world´s freshwater withdrawal from rivers and groundwater, whereas the withdrawals of water by industry and municipalities amount to 20 respectively 10 percent, with huge variations across and within countries (MOLDEN 2007). These global averages vary much between regions and countries (see Tab. 1). In Africa, agriculture consumes 88 percent of all freshwater withdrawal, while domestic usages only account for 7 percent and industry for 5 percent. In Europe, most water is used in the industry (54 %), while 33 percent are consumed in agriculture and 13 percent are used for domestic uses (household, drinking water, sanitation).

It takes a huge amount of freshwater to produce crops. To yield one kilogram of rice, one to three cubic meters of water are needed and 1,000 tons of water to harvest a ton of grain. To produce enough food for a growing global population and to meet their altered food demands, it will be necessary to improve the water use and water management in agriculture over the coming decades (MOLDEN 2007).

The most important use of water in the agrarian sector is for irrigation as arid or semi-arid areas like Central Asia, the Near and Middle East, Northern Africa, or the Western United States rely on irrigation farming. Current global freshwater withdrawals for irrigation are estimated to almost 2,500 km^3 per year. Irrigation area world wide has doubled and the water withdrawal tripled between 1950 and 2005 (MOLDEN 2007). In some regions, like in the Aral Sea basin, the renewable freshwater resources are overcommitted due to non-sustainable irrigated cultivation (ROST 2004, 2005; WEINTHAL 2006), while in other areas pumping of groundwater by the farmers exceeds the natural replenishment of the aquifers.

The world´s growing population still is a major factor behind the actual water scarcity in some regions. However, the main reasons for water shortage and scarcity are the non-sustainable water usage and management, a lack of commitment and targeted investment, insufficient human capacity, ineffective institutions and poor governance (MOLDEN 2007).

Increasing Potential for water-related Conflicts

In several regions the overexploitation of water resources is leading to water related conflicts. There is a broad spectrum of water disputes that makes them difficult to address. They might occur of political, military, socio-economic, or environmental reasons (HOFFMANN 1997) and on different spatial levels – local, regional, territorial, cross-national, or global. Most conflicts are related to the control over water resources and grow between water users upstream and those downstream. More than 200 river systems are shared by two or more countries and 60 percent of the world´s population is living in transboundary water catchments (VAN DER MOLEN & HILDERING 2005). Some countries, like Egypt, Syria or Turkmenistan depend for more than 80 percent on upstream countries for their renewable water resources. Overexploitation of water, insufficient water management, the diversion of major rivers, the construction of large dams, or the tap of transboundary groundwater aquifers are certain reasons for international water disputes (BARANDAT 1997; HOFFMANN 1997). One of the regions areas where regional instability is partly related to the control of freshwater resources is former Soviet Central Asia, notably the Aral Sea drainage basin (e.g. ROST 2004, 2005; WEINTHAL 2006).

Transboundary Water Conflicts in Central Asia

Freshwater resources in Central Asia´s terrain of mountains, steppe and deserts are extremely unevenly distributed. Surface water mainly provided by rivers rising from the Tien Shan and Pamir Mountains is the main source for the irrigation areas (e.g. Ferghana Basin) and urban centers like Tashkent, Samarkand, and Bukhara. Since their independence from the Soviet Union in 1991, the former joint use of water resources, mainly generated by the now transboundary rivers Amu-Darya, Syr-Darya, Zerafshan, Talas, and Chu is a major political, economic, and ecological conflict between the upstream republics of Tajikistan and

Kyrgyzstan and their downstream neighbors Kazakhstan, Turkmenistan, and Uzbekistan. In total, 18 transboundary rivers are currently shared by these five countries and its neighbors (WEINTHAL 2006). Most of their catchments contribute to the Aral Sea drainage basin.

In the second half of the 20th century a massive expansion of irrigation mainly for cotton production and the non-sustainable water diversions, mainly in the semi-arid to arid downstream regions resulted in a desiccation of the Aral Sea. Massive irrigation and drainage systems were designed to accommodate the needs of large-scale collective and state farms. The water distribution was mainly demand-based and the non-sustainable water usage resulted in extremely high amounts of water withdrawal.

The dissolution of the Soviet Union dissolved the former highly centralized water management system in this region. The integrated large-scale irrigation systems had to be shared across the newly independent states and water allocation and distribution mechanism became unsuitable (e.g. KLÖTZLI 1997; ROST 2004, WEINTHAL 2006). Each nation redefined its own economic priorities and intended to increase their irrigation areas to meet the food requirements for their fast growing populations. This in turn resulted in increasing withdrawals from the major rivers in the upstream and downstream countries. Furthermore the upstream nations Kyrgyzstan and Tajikistan, which are poor on fossil fuels, expend their hydropower potential (ROST 2004; WEINTHAL 2006). Upstream water development for expanding the irrigation area and the hydropower production in these two countries interferes the agriculture production in the downstream states of Uzbekistan, Turkmenistan, and Kazakhstan.

Notably Turkmenistan and Uzbekistan strongly depend on water allocations provided by the neighboring upstream countries, as their total annual water withdrawal exceeds annual renewable water resources and the attached water allocations (Tab. 2). Both countries have less than 1,000 m^3/yr/person of internal renewable water resources, which involve surface water and groundwater resources generated from the endogenous precipitation.

Country	IRWR (km^3/yr)	ERWR (km^3/yr)	TRWR (km^3/yr)	TWWD (km^3/yr)	TRWR per capita (m^3/a)	TWWD per capita (m^3/a)
Kazakhstan	**75.42**	**34.19**	**109.60**	**33.05**	**7061**	**2214**
Kyrgyzstan	**48.95**	**- 25.87**	**23.08**	**10.08**	**4263**	**1989**
Tajikistan	**66.30**	**- 50.32**	**15.98**	**11.96**	**2338**	**1895**
Turmenistan	**1.36**	**23.36**	**24.72**	**24.91**	**4901**	**5375**
Uzbekistan	**16.34**	**34.07**	**50.41**	**59.61**	**1854**	**2345**
Germany	**107.00**	**47.00**	**154.00**	**32.30**	**1872**	**392**

IRWR (Internal Renewable Water Resources, 2008)
ERWR (External Renewable Water Resource, 2008)
TRWR (Total Renewable Water Resources, 2008)
TWWD (Total Water Withdrawal, 2000)

Tab. 2: *Estimated Data of Renewable Water Resources and Water Withdrawal* (FAO/AQUASTAT 2011)

In Central Asia a sustainable water management is still on a formative level. There is a strong potential for water-related conflicts and disputes at interstate and intrastate levels. Broader reform is needed in the agricultural and energy sector, as well as an improvement in irrigation services. Major pivotal facets of the intergovernmental water disputes are an unavailable or insufficient common water management, inefficient intergovernmental water agencies, the appeal of water quotes or their neglect, and inopportune barter agreements between the neighboring nations (KLÖTZLI 1997, WEINTHAL 2006). International donor funding and capacity building are needed to carry out technical improvements and to build institutional capacity at local as well as at regional levels.

Conclusion

In order to develop our water resources and to avoid water-related disputes and conflicts, a sustainable water management is necessary. Its purpose is simply to manage the water resources while taking into account the needs of the present and future users. Sustainable water management attempts to deal with water in a holistic manner, taking into account the various sectors affecting the usage of water, including the environmental, and technological as well as the political, social and economic considerations. It should also be based on a participatory approach, involving stakeholders, planners and policy makers at all levels. However, there are various requirements, aspects, chances and constraints for a sustainable water management with problems arising from the proper understanding of the subject and from balancing extreme positions and particular aims.

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Chapter 3:
Drivers of scarcity and pollution

Joe Hill (ZEFa, University of Bonn)

Overview of paper

Despite extraordinary advances in science and information technology, vast numbers of people across the globe still lack access to water for agriculture, other livelihoods, and domestic uses. This three-part paper begins by introducing the 'global water crisis' and the processes inter-governmental organisations consider to be driving it. It attempts to point out the normative assumptions in this narrative. Part two discusses the 'drivers' seen by the Comprehensive Assessment of Water Management in Agriculture (CA) to have affected the evolution of agricultural systems. A critical view on several of the assumptions made in the CA discourse is taken, by using the example of landholding structure that is intrinsically related to agricultural water management. The purpose of this exercise is to show how alternative views are sidelined from the CA's grand narrative. Part three presents a case study from a rain-fed region of the Indian sub-continent, to tie in some of the highlighted drivers of agricultural system evolution with localised water scarcity in the selected villages. Water scarcity and food insecurity is linked to perpetual under-investment and neglect of agriculture by successive governments. The state has taken away from rural subsistence farming communities their autonomy and control over land and water resources, without providing viable development alternatives. This paper questions the ability of techno-scientific innovation to solve water problems which emerge as market and private property relations enter arenas dispossessing and impoverishing local populations.

The global water crisis and its drivers: An introduction

In recent decades there has been a proliferation of global organisations (e.g. UN agencies, CGIAR institutions)[1] all claiming to represent the views and needs of the world's water users. This paper seeks to highlight the implications of their hegemonic discourses.[2] The argument centres around the two contradictory positions that recur in contemporary neoliberal capitalism: trade-led economic growth, and (attempted) regulation by states and global institutions of the environmental impacts of economic growth (Peet and Watts 2004). There are political and economic tensions between unregulated growth (to fuel ever-increasing consumption, the main marker of happiness and contentment in neoliberal societies) and environmental degradation (ibid.). Power and control over resources is increasingly unequally distributed and clustered at centres. Economic capital is largely put to work for the production of food and goods for urban consumers, side-lining rurally situated subsistence communities. The political and economic tensions between economic growth and environmental degradation are seen to be relieved through conscious and less-conscious 'strategies', which include discourses, employed by global institutions (ibid.).

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[1] United Nations (UN) agencies, and Consultative Group on International Agricultural Research (CGIAR) centres and institutes, are some of the high-profile organisations. This essay does not seek to negate the high quality work these organisations undertake.

[2] Hegemonic is used to describe the way their discourses are presented as common sense and rational; whereas other perspectives are side-lined or marginalised.

The discourse propounded by inter-governmental and international institutions changes subtly over time; however the message remains consistent: that we face a global water crisis, and that poor countries and people will suffer the most and thus must change their ways to adapt to the crisis.

Firstly, the powerful alarmist discourse of a global water crisis is created and maintained by the mixing of abstract notions of water[3], with people in their abstract statistical guise as 'population'. This discourse has been supported by the outputs of global hydrological models run by scientists, some of whom believe their work to be politically-neutral. Population growth and dynamics have been and remain the most oft-stated, hence popular 'driver' to the global water crisis. The UNESCO's International Hydrological Programme quotation, cited below, makes clear this assumption:

"Population density and per capita resource use have increased dramatically over the past century, and watersheds, aquifers and the associated ecosystems have undergone significant modifications that affect the vitality, quality and availability of the resource. Current United Nations predictions estimate that the world population will reach 9 billion people in 2050. ***This exponential growth in population – a major driver of energy consumption and anthropogenic climate change – is also the key driver behind hydrologic change and its impacts.****"* (UNESCO-IHP 2011: 1) [Emphasis added]

Secondly, global institutions repeatedly point their finger at poorer countries, their 'weak' governments, and the pressures their economically poor populations place on natural resources. This conveniently diverts attention from the effects of the global capitalist/neoliberal political economy and the pressures it creates on governments, people and the environment in its production of the affluence that those in power (and living in affluence) have come to consider normal. The UN's World Water Assessment Programme (WWAP) quotation, below, informs us that it is 'our' collective pursuit of higher living standards that drives water crises:

"The amount of freshwater on Earth is finite, but its distribution has varied considerably, driven mainly by natural cycles... That situation has changed, however. Alongside natural causes are new and continuing human activities that have become primary 'drivers' of the pressures affecting our planet's water systems. These pressures are most often related to human development and economic growth... ***Our requirements for water to meet our fundamental needs and our collective pursuit of higher living standards****... Important decisions affecting water management are...driven by external, largely unpredictable drivers – demography, climate change, the global economy, changing societal values and norms, technological innovation, laws and customs, and financial markets."* (WWAP 2009: xix) [Emphasis added]

Nowhere is 'affluence' listed or mentioned as a driver of water scarcity, even though water scarcity is created in 'southern' countries which produce goods for consumers in the 'north', or 'west', or due to the investment of capital in certain pursuits rather than others.[4] The creation of a water crisis, and focussing of attention on poorer countries with 'weak' governments, provides the groundwork for the promotion of market-based solutions to water problems, with profits to be made by powerfully placed actors

[3] What Jamie Linton calls 'modern water'. Until recently, "water has most commonly been thought of as a resource that could be considered and managed in abstraction from the wider environmental, social and cultural context(s) in which it occurred" (2010: 6).

[4] Another example could be carbon emissions produced by China's factories for the benefit of 'western' and urban consumers worldwide – it is China not the foreign consumers who are blamed for the emissions (but do we need all of the goods?).

including governmental, inter-governmental, and corporate actors.[5] This is achieved by framing problems and solutions in technical and hydrological terms. Such a discourse obscures the alternative (unheard) views of local-level diverse water users and civil society groups (located in diverse geographical, political and social contexts), for rights-based initiatives, or devolution of management and control over natural resources to local water users. To Mustafa:

"...to switch focus from the political economic factors that affect access to resources is, in fact, tantamount to turning a blind eye to the injustices at the heart of producing affluence for the few at the expense of scarcity and misery for the many... The sterile per capita freshwater availability numbers may seem alarming...but they really serve to divert attention from water's problematic social geography, from its extremely skewed distribution across sectors and across social groups, and from discursive construction by the power elites as a "resource" to be deployed in isolation from its ecological and social roles toward modernist economic development." (Mustafa 2007: 486-488)

According to the well-known Indian scholar Vaidyanathan (2006), an alternative agenda is being advocated by "a section of opinion in major international lending institutions and some international research organizations…known for their capacity to influence thinking of third world governments and policy makers". This agenda seeks the "[p]rivatisation of water resource development and management on the basis of well-defined property rights in water guaranteed by law, leaving prices and allocations to be decided by the market" (ibid.: 180).

However water's nature, as a common pool resource, (arguably) necessitates that its costs and benefits be shared by water users. Many believe that this requires a socio-political process, not a market-based process. Decentralisation and increased water-user participation, combined with the reduced scope and nature of government's direct involvement in water management could leave a greater role for water-users, NGOs and civil society to address the tasks (Vaidyanathan 2006: 181).

In sum, the global discourse tends to divert attention from the (global, regional and localised) political and social circumstances that produce freshwater problems, such as unequal access to and control over resources. Solutions are framed in predominantly technical and hydrological terms, which serve to veil certain assumptions, i.e. that economic growth for modern development is the pathway ahead for all humankind, to be achieved through privatisation of all resources (and destruction of remnants of collective structures which impede progress).

The United Nations and its discourse

The discourse of the 'global water crisis' emerged only at the end of the 20th century. Linton (2010) critically analyses Gleick's *Water In Crisis: A Guide to the World's Fresh Resources* (1993), and concludes that the constitution of a water crisis is inevitable whenever the quantification of water as an abstract is brought into relation with the quantification of abstract people. By the year 2000 Gleick began to refrain from using the term 'crisis', and admitted that all the projections and estimations of future freshwater demands made over the past 50 years had invariably turned out to be wrong, because in changing historical circumstances people find new ways of relating

[5] To Pierre Bourdieu, neoliberalism proceeds by destroying collective structures which may impede pure market logic. Many water experts hold the view that water management necessitates collective action. Many humans consider collective structures as normal, even natural, and are uncomfortable with the increasing reduction of all human/social interactions to economic, mercantile transactions.

with water, discover new forms of resourcefulness, and apply new techniques to mediate their relations with water (Gleick 2000, in Linton, 2010).

Gleick's sterile per capita freshwater availability statistics continued to alarm him however. Mustafa argues that such modelling serves to divert attention away from water's problematic social geography, from its extremely skewed distribution across sectors and across social groups, and from discursive constructions by power elites as a 'resource' to be deployed in isolation from its ecological and social roles toward the goal of modern economic development (Mustafa 2007).

In 1996 the World Bank, United Nations Development Programme, water services industry representatives and water experts convened the World Water Council, and in 2000 the *World Water Vision,* and its companion document *World Water Security: A Framework for Action,* were presented at the World Water Forum. These documents, drawing heavily on the fourth Dublin Principle (that contradicts the remaining three)[6], framed water as a scarce resource and an economic good that must be managed in an economical and integrated way (Linton, 2010).

Mehta (2000) finds the idea of water as an 'economic good' troubling, because it is a reductionist way to view a multifaceted resource; it ignores localised visions concerning water and water resources management, and market forces do not operate in a vacuum, rather they build on existing social and power relations. Mehta points out that the World Water Council (secretariat in Marseille) and the World Commission on Water (secretariat at UNESCO in Paris) have close partnerships with French-based utilities and water companies such as Vivendi, which could be interpreted as the active promotion of powerful corporations in current water debates. The World Bank and such corporations have argued that the state has hitherto been unable to provide basic infrastructure, so market based solutions may be the answer.

Mehta concludes that narratives of water 'crises', water wars, and water shortages obscure issues concerning unequal access to and control over water, that there needs to be greater pluralism in polarised discourses and debates over 'water as a human right', 'water as commons' and 'water as an economic good'. Rather than draw on vague political, economic or theoretical assumptions, which lead to normative, rhetorical, speculative and apolitical discourses, empirically grounded facts and realities ought to be established by critical research at macro, meso and micro levels (Mehta 2000).

Driver is the key term used by international organisations to explain the natural and social processes affecting our planet's water systems. The latest report of the UN's World Water Assessment Programme, *Water in a Changing World* (WWAP 2009), groups the main drivers that exert pressure on water resources in the following categories; demographic, economic, and social. Population dynamics such as growth, age distribution, migration and urbanisation create pressures on freshwater resources through increased water demands and pollution, and the need for more water-related services. Growing international trade in goods and services aggravates water stress in some countries while relieving it in others (virtual water). Changes in lifestyle reflect human needs, desires and attitudes, and are influenced by culture and education, by economic drivers and technological innovation.

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[6] The 4th principle states that 'water has an economic value in all its competing uses and should be recognised as an economic good'. This can be seen to contradict the previous three, which state that 'fresh water is…essential to sustaining life, development, and the environment', that 'water development and management should be based on a participatory approach…' and that 'women play a central part in the provision, management and safe-guarding of water'.

For example, the section headed 'poverty' states that poor people degrade their environment to survive whatever the consequence, in the process creating scarcity and pollution. The next section is headed 'education', which states that an educated populace has a better understanding of the need for sustainable use of water. The report explicitly states that lifestyles and consumption patterns are the sum of all drivers, and that the production of goods to satisfy growing wants is often not possible without the overuse of natural resources. The section on drivers concludes by saying that 'raising awareness to bring about behavioural change is one approach, but still an elusive goal'.

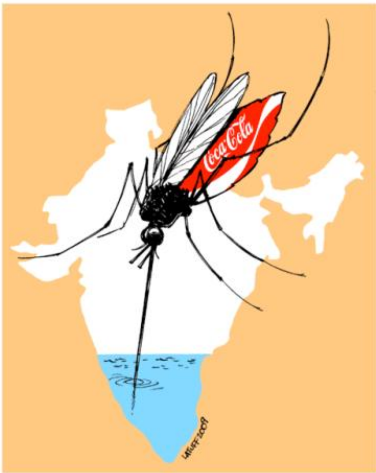
One is left to wonder if the WWAP report is subtly attributing water problems to the less-wealthy segments of society residing in poorer countries. What is strikingly absent from the WWAP report is any mention of over-consumption by wealthy segments of societies worldwide, or the hegemonic consumerist ideology that originated in the north. The behaviour of richer countries, wealthier segments of societies, and multi-national companies that actively destroy environments/ecosystems in their pursuit of material goods and profit, are not mentioned, let alone castigated.

A new UNESCO report, *The Impact of Global Change on Water Resources: The Response of UNESCO's International Hydrological Programme* (UNESCO-IHP 2011), takes a similar stance to the above WWAP report, though is slightly more alarmist, presumably in an attempt to justify its work. The report lists several drivers, though tends to favour the highlighting of population dynamics. The drivers of global change are stated to be: population growth, climate change, urbanisation, expansion of infrastructure, migration, and land conversion and pollution. Aside from climate change in its anthropogenic form, the remaining drivers are processes that have been ongoing for centuries; however this is not made explicit.

Nowhere does the UNESCO-IHP report mention the global political economic system that causes these drivers to have negative affects upon the environment (and people). For example, deforestation, mining or the oil industry, which provide cheap timber, metals and fuel to benefit wealthier countries and segments of society, while creating regional and local instabilities across the globe and in the process destroying local hydrological regimes, get no mention. The report is saturated with images of 'poor' people and degraded environments, but not images of expensive private cars, gadgets and goods in wealthy countries, or luxury tourist hotels in tropical locations (etc), all of which consume vast quantities of freshwater, often in geographical locations where water is scarce and local populations' impoverished. The well known case of Coca cola in India provides an example (figure 1): the company established bottling plants in India's Kerala and Rajasthan states, and drained aquifers causing drinking and agricultural water shortages in villages around the plants. The company did not listen to locals, who were forced to undertake major campaigns, eventually using the country's courts to shut down the company's operations.[7]

[7] Furthermore, the Centre for Science and Environment, based in Delhi, tested Coca cola products sold in India, finding high levels of pesticides. Coca cola disputed this.

Figure 1: 'Coca cola India': Image used by an international campaign to hold Coca cola company accountable in India



Source: Latuff, 2009.

The UNESCO-IHP report seeks to point out that data are sparse in the developing world, and rarely shared across ministries or institutions. Yet is this not understandable in a political economic world order dominated by a few powerful countries and corporations, and where states and their people theoretically have the right to self-determination and independence from hegemonic international organisations? Overall the report presents an alarmist view of freshwater crisis, and from the image thus created states that "since these changes are a global problem, a response to its impacts must also be international" (UNESCO-IHP 2011).

The Comprehensive Assessment of Water Management for Agriculture

The Comprehensive Assessment of Water Management in Agriculture, *Water for Food, Water for Life,* takes a calmer and more optimistic approach than the UN when discussing the challenges that face agriculture and the water resource in the coming decades. To the authors, there is enough land, water and human capacity in the world to produce sufficient food for the growing population over the next 50 years (Molden 2007). Present and pending local water crises are seen to exist not because of shortage of water but because of mismanagement of water resources.

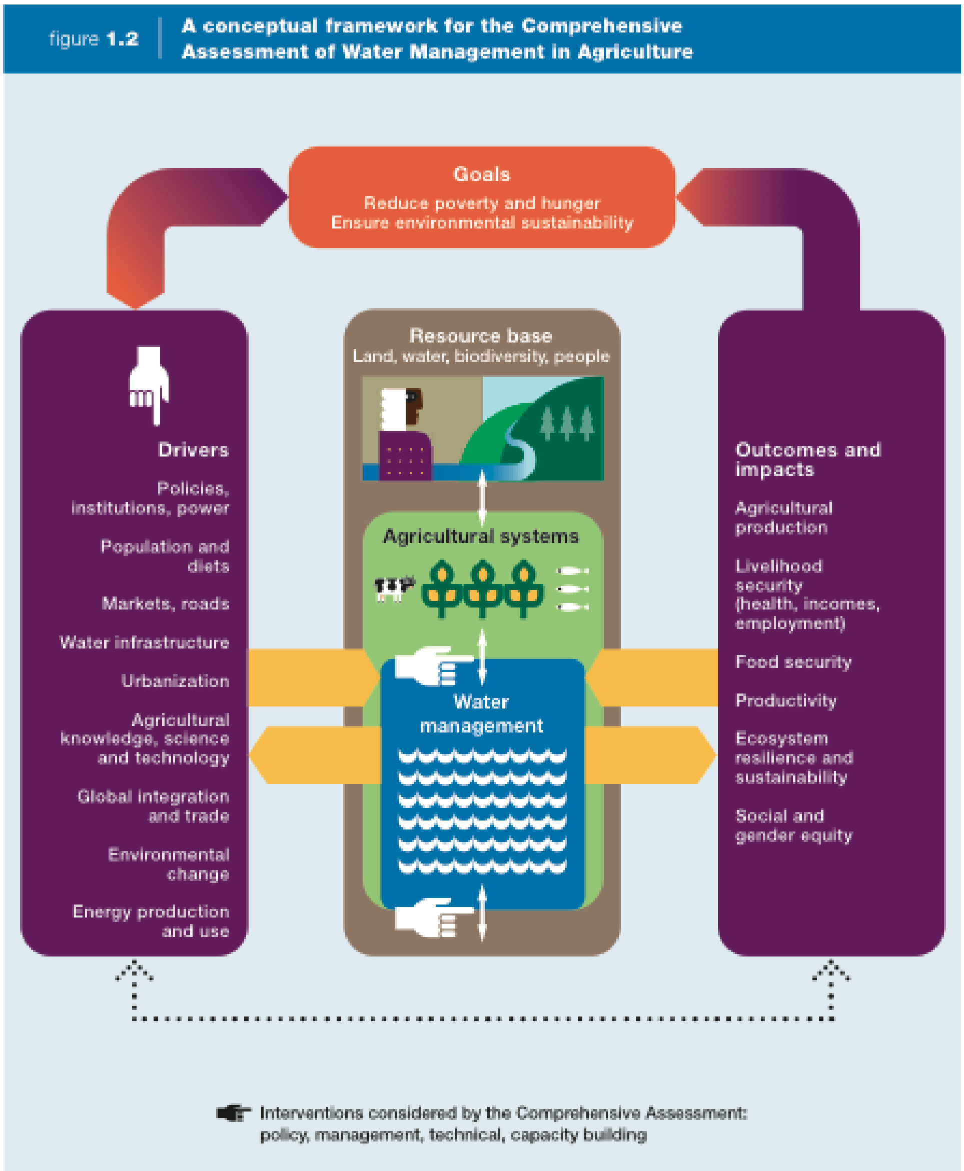
Scarcity is defined from the perspective of individual water users rather than the hydrology of an area. Individual households face water scarcity when they lack secure access to safe and affordable water to consistently satisfy their needs for drinking, washing, food production, and livelihoods. An area is water scarce when a large number of people are water insecure. Water scarcity is defined as physical, or economic. Worldwide, an estimated 1.2 billion people live in river basins characterised by physical scarcity, and another 1.5 billion people live in economically water scarce basins.

Physical scarcity occurs when water resources are insufficient to meet all demands, including minimum environmental flow requirements. Traditionally these were arid regions, but in recent decades artificially created physical water scarcity has emerged, even where water is seemingly abundant. This is due to over-allocation of water and the emergence of new demands. Environmental flow needs are not being met. Symptoms of physical scarcity include severe environmental degradation, declining water tables, water allocation disputes, and the failure to meet the needs of some groups.

Economic water scarcity occurs when investments needed to keep up with growing demand are constrained by financial, human or, in particular, institutional capacity. Symptoms include inadequate infrastructural development, high vulnerability to seasonal water fluctuations, and inequitable distribution of water even though infrastructure exists. Thus the authors take on board and make explicit issues concerning unequal access to and control over water (Molden 2007).

The Comprehensive Assessment's (CA's) conceptual framework relates drivers of change to the evolution of agricultural systems, and these agricultural systems to outcomes and impacts (see figure 2 [figure 1.2 in the original text]). 'Drivers' are defined as the processes that have affected the evolution of agricultural systems, their water management, and their ability to produce. These are recognised to be changing over the order of decades, which means they are difficult to change, and influenced strongly by processes such as global political developments. Nine complex and interlinked drivers are identified: 1) policies, institutions and power, 2) population and diets, 3) availability and access to markets (roads), 4) water storage, delivery and drainage infrastructure, 5) urbanisation, 6) agricultural knowledge, science and technology, 7) global integration and trade, 8) environmental change, 9) energy production and use.

Figure 2: Conceptual framework for the Comprehensive Assessment of Water Management in Agriculture



Source: Molden, 2007: 49.

The Comprehensive Assessment (CA) lays out several Policy Actions as ways to satisfy future food demands with the world's available land and water resources as they stand. The contents of these Policy Actions indicate the limitations to the way water and agriculture have been managed in the past, and up to the present-day (also a driver of water scarcity). 1) Change the way we think about water and agriculture: more strategic rural development-centric investments, abandon the obsolete divide between irrigated and rain-fed agriculture, explore both green (rainfall) and blue (surface) water resources for livelihood options at the appropriate scale for local communities, invest to build knowledge and reform and develop institutions. 2) Fight poverty by improving access to water and its use: take bold action to empower people to use water better, to ensure the right to secure access, to improve governance of water resources, and to support the diversification of livelihoods. 3) Manage agriculture to enhance ecosystem services. 4) Increase the productivity of water. 5) Upgrade rainfed systems: about 70% of the world's poor live in such areas, better management of rainwater, soil moisture, and supplemental irrigation is key to a) cut yield losses from dry spells, b) give farmers the security to invest in improved agricultural technologies e.g. fertiliser, high-yielding seeds, c) allow farmers to grow higher value market crops. 6) Adapt yesterday's irrigation to tomorrow's needs: times have changed, the era of funding large irrigation projects is over, manage groundwater sustainably, above all change the governance of irrigation. 7) Reform the reform process – targeting state institutions: the state, which retains its role as the main driver of reform, is the institution most in need of reform. 8) Deal with trade-offs and make difficult choices: water storage for agriculture vs. for the environment, reallocation vs. over-allocation, upstream vs. downstream, equity vs. productivity, this generation vs. the next generation.

From a critical perspective, the CA can be seen to contain traces of neoliberal bias, such as those contained in other international organisation's global reports. For example, the second from last of the above-mentioned 'policy actions' states that the reform of state institutions is required, with the implicit assumption being that poorer/southern countries need to reform their state apparatus, whereas wealthier countries do not. This is problematic due to the influence wealthier countries have on global agriculture; for example, through the use of trade barriers and subsidies to protect their domestic farmers, or through their control of inter-governmental institutions such as the World Bank, IMF, or UN.

Nonetheless, (most of) the main points raised in the CA regarding reforms needed in state institutions cannot be dismissed: 1) Technical water bureaucracies need to see water management not just as technical but also as a social and political issue, 2) More integrated approaches to agricultural water management are required, 3) Create incentives for water users and government agency staff to improve equity, efficiency and sustainability of water use, 4) Improve the regulatory role of the state, and the achieve the right balance between action by the state and other institutional actors, 5) Develop effective coordination and negotiation mechanisms among the state, civil society, and private organisations, 6) Empower marginalised people (including women) who currently have a stake but not a voice in water management, 7) Build coalitions among government, civil society, and private and community users – and harness market forces for effective reform.

The process through which such reforms will be achieved is not discussed, though the last comment 'harness market forces for effective reform' is suggestive of the route the scientists believe should be taken. Let us consider the term 'reform'. Michael Lipton in his book *Land Reform in Developing Countries: Property Rights and Property Wrongs* (2009), explains how between 1830-1975 'reform' denoted major legislative change that increased efficiency of outcomes and made outcomes or opportunities more equal between the rich and the poor. However, since the mid-1970s the term 'reform' has largely been appropriated by advocates of liberalisation to denote market-freeing, deregulating, de-subsidising, de-protecting and privatising legislative changes that have reduced equality of outcomes.

Ziai (2011) shows how in the United Nation's Declaration (2626) of 1970, which spearheaded the Second Development Decade, there is explicit mention that reform of land tenure systems should be undertaken for the promotion of 'social justice and farm efficiency'. However land reform receives no mention in the UN's Millennium Declaration of 2000 (and in the Millennium Development Goals). Ziai shows how this omission by the UN relates to a shift in the perception and representation of 'poverty' by powerful players in the international arena, from a theorisation pre-liberalisation of poverty as a relative phenomenon (the poor as compared to the affluent) to its modern-day abstraction (depoliticised, amenable to market-based solutions).

Lipton, an expert on land reform and economic development, believes that due to water stress, land reforms must be integrated with water reforms, to entail fair and sustainable access to farm water (Lipton, 2009). Although the CA shares the objective of creating equitable access to agricultural water, it seldom refers to landholding structures or ownership patterns, leave alone land reform in any of its possible forms. This is a curious omission when one considers that landholding patterns – which shape agricultural water use and management practices – continue in many parts of the world to derive from land revenue settlements imposed by European colonial regimes (for example, in South Asia).

However, the omission is less odd when one considers that classic land reform involves state intervention to redistribute land, a process that does not entertain interest in neoliberal government and inter-governmental agency circles (property rights being sacrosanct). The CA uses the term 'reform' only in the following context, "a major policy shift is required [of state water institutions] for water management investments important to irrigated and rainfed agriculture" (Molden, 2007). In other words, the CA delinks the term 'reform' from questions of 'equity' or 'equality', thus decontextualising and rendering abstract notions of poverty, while at the same time linking reform to investment.

Poverty, equity and agricultural efficiency are all terms used liberally in the CA. The goals of land reform are increased output, efficiency and growth (Lipton, 2009). Lipton informs us that though GDP growth has helped to reduce the number of people in the world that were 'dollar-poor', and the green revolution made poverty far less than it would otherwise have been, a large part of the sharp acceleration of global poverty reduction has been due to land reform. Land reform by detour, as Lipton terms the often disastrous collectivisation of landholdings in the period 1910-80 in Mexico, the USSR, Eastern Europe, China and other countries followed by decollectivisation mostly since 1977, has in many cases led to small, not-very-unequal farms, and has affected over a billion people dependent on agriculture. Land reforms that distributed private rights from large landowners to small and landless agriculturalists, in Japan, East Asia, much of South Asia, Latin America and some of Africa, helped another half-billion obtain farmland or work post-1945 (Lipton 2009).

Through increasing poor people's share of land rights (especially via land reform), the poor's income can be raised in five ways; firstly, poor people depend on labour for most of their income, and small farms use more labour per hectare than large ones; secondly, when lower-income people own a farm, they also enjoy income from land; thirdly, by controlling farmland, the poor enjoy income from farm enterprise; fourthly, small farms are more likely than large farms to use local labour and labour-intensive sources of supply for their inputs, farm processing and extra consumption, raising the poor's non-farm income; and fifthly, the poor gain from the economy-wide effects of land reforms (ibid.). These points (with or without consideration of land reform) serve to reaffirm why it is important for rural households to own and control farmland.

While in industrialised countries there is a direct relationship (DR) between farm size and land productivity, in labour-abundant predominantly agrarian countries there is an inverse relationship (IR), because small farms produce more, per hectare per year, than large farms (Lipton, 2009). Chand, Prasanna and Singh confirm this for the Indian context in a recent study, their analysis suggesting the reasons for this (2011). Carefully reviewing the evidence, Lipton concludes that redistributive land reform is good for output and growth in many regions, especially those where land is very unequally distributed at the outset (2009). However without mention of any such research, the CA maintains that "investment that promotes productive and efficient agriculture tend to favour the wealthy, while investments and policies that promote more equitable agriculture are not necessarily productive" (Fraiture, Molden, and Wichelns 2010: 500).

Case study from rainfed India

Field research was conducted for one year in 2004-05 in two case study villages in East Singhbhum district of Jharkhand state, eastern India (figure 3).[8] Ethnographic field research combined quantitative and qualitative methods, and inductive analysis allowed theory to emerge from the data in which it was grounded. The case study villages are inhabited by indigenous people, known as adivasis in India. Adivasis have a history of subordination in mainstream Indian society, politically, economically and culturally. In the villages agricultural production is hampered by a lack of accessible water sources, and in particular the staple paddy crop suffers due to a lack of supplemental irrigation to see it through dry spells. The research aimed to explore the evolution of the agricultural system, especially with regards to irrigation or water harvesting infrastructure, and access to water by farming households.

Figure 3: East Singhbhum's location in Jharkhand (inset: Jharkhand within India)

Source: Bhattacharya, 2009.

Introduction to field research villages

In the case study villages, groundwater is scarce and fairly inaccessible, and the development of wells for agriculture has been limited in the region. Rivers and streams are deep bedded and seasonal. In the past farmer collectives, often families, laid claim to stretches of rivers, and created impermanent check dams made of earth and rock across the breadth of the rivers, to capture and store monsoon flows. The water stored is manually lifted to irrigate vegetables, and used for other purposes, such as bathing and maintaining livestock. Working in collectives, villagers repair these dams each year.

Due to the depth of riverbeds, river water cannot be diverted by gravity to irrigate the surrounding farmland. Therefore farmer collectives (either village communities, or individual joint-families) created small-scale, multi-purpose storage works to capture rainfall runoff from the catchment area, to irrigate their principal paddy crop during dry spells. In the present-day some of these storage works are well maintained, however the majority are in various states of disrepair due to conflicts among command area farmers, most often related to the status of the storage works' ownership rights. Government schemes to develop irrigation infrastructure in the research locale have failed due to use of inappropriate technologies (villagers were not consulted), and local contractors undertaking shoddy work (contracts are given to locally powerful persons).

[8] Financial support from the Economic and Social Research Council (ESRC) and Natural Environment Research Council (NERC), UK is gratefully acknowledged

Introduction to the wider region and problem statement

Jharkhand state received independence in 2000, after experiencing over five decades of poor governance having been appended to Bihar state on India's independence in 1947. The farming population of the research villages effectively received little or no support by successive governments through the colonial period and since Indian independence. In addition, since 1978 local-level democratic checks and balances have been absent due to the unwillingness and inability of successive governments to hold panchayat elections (local-level governance institutions). This allowed unfettered corruption and a lack of development. Further details are provided in, for example, Sengupta (1982), and Corbridge (2003).

In 2008 Jharkhand was ranked the most food insecure state in India (MSSRF and WFP 2008), which relates not only to limited or lack of access to nutritious food, but also to clean water and sanitation. Jharkhand's ranking reflects its history of neglect and under-development, which extends to the agricultural domain where the majority of cultivation remains rainfed. Its irrigated area remained at just 8% through 2002 to 2008 (GOJ 2002; NABCOMS 2008). Jharkhand and other less-favoured rainfed areas were bypassed by the Green Revolution, and only in 2006 has the Government of India constituted an authority to implement a comprehensive programme for the development of rainfed areas (Sharma et al. 2008).

East Singhbhum district, in which the research villages lay (figure 1), falls within the 'South Eastern Plateau' sub-zone of India's 'Eastern Plateau and Hills Region' agro-climatic zone. At about 100 metres above sea level, the climate in this sub-zone is humid to sub-tropical, and characterised by plentiful but uneven distribution of rainfall. Average annual rainfall is between 1300 and 1350 mm, with roughly 80% falling within the south-west monsoon period June to September. The IPCC and CA has highlighted the likelihood of considerably reduced water availability for agriculture in such rainfed regions due to changes in average temperatures, shifting patterns of precipitation, and changes in the frequency and intensity of extreme weather events.

The CA advocates policies and investments to improve farm-level access to irrigation water and crop water productivity and thus to enhance overall agricultural productivity as important components of rural development strategies. Past production increases are recognised to have mainly originated from land expansion rather than increasing yields, and severe land degradation due to poor land use is a major concern. A distinction is made by the CA between human- and climate-induced water stress: rainfall variability generates dry spells almost every rainy season, which are manageable by investments in water management, such as supplemental irrigation (human-induced scarcity); whereas meteorological droughts (deficient rainfall occurs once in 5 years in Jharkhand (Sharma et al, 2008)) which result in complete crop failure, require social coping strategies, e.g. social welfare measures, such as public food distribution system (climate-induced scarcity).

Soil and water conservation or in-situ water harvesting is recommended for rainfed agriculture, combined with supplemental irrigation systems based on rainwater harvesting, river-flow diversions or groundwater sources for dry spell mitigation (Wani et al. 2009). An important regional study (Phansalkar and Verma 2004, 2005) highlights the need in rainfed eastern India for the extensive development of decentralised water harvesting structures, one for every two hectares, yet does not question the barrier that landholding structure may present in doing so, nor does it acknowledge the management of pre-existing works.

Management of irrigation infrastructure in the research villages

In the research villages just a quarter or so of agricultural farmland is in the command area of storage works, so the creation of further storage works would benefit those having farmland outside of pre-existing works' command areas. However the research suggests that the landholding structure imposed upon the villagers by colonial and post-independence governments has impeded the creation of new storage works by villagers themselves. The British colonial government for the purposes of revenue collection created a rigid landholding structure and a series of intermediaries (including village headmen and estate managers) between the state and farming households. Previous to this intervention, adivasis communities through traditional leadership had controlled the land within their village boundary. Land reforms were conducted by the Indian government on independence in the early 1950s. Village headmen and other intermediaries' roles were abolished, leaving farmers in direct contact with the state. Control of 40% of the district's land (in East Singhbhum district), previously 'village land', was transferred away from village communities and to the state. Coupled with the dependency upon the state that was nurtured by its proclaimed monopoly over development activities post-independence, this research posits that the landholding structure (owned/controlled by the state or privately) has impeded the creation by farmer collectives of new storage works in appropriate topographical locations.

In addition to the lack of creation of new irrigation facilities, the management of many pre-existing works is sub-optimal, due to the effects of demographic and livelihood changes, and the limited land reforms that took place post-independence, all of which have restricted many command area farmers' access to water. Several types of storage work exist; those owned by individual families, and those created by village headmen along with community members. The ownership and management of the storage works created by village headman was altered drastically when following independence the state undertook land tenure reforms that left the headmen on a par with other farmers, and took away control of village land from the headmen and communities. The erstwhile headmen claimed full ownership to once-communally owned storage works, and began to deny irrigation water to other command area farmers. This, over time, led to the deterioration of these storage works, because villagers became unwilling to contribute their labour for maintenance in return for water, as they has done in the past. This has negatively affected paddy production and yields, due to reduced access to water for many farmers. It has also affected village-level social relations.

Having had control over their collective land, forest and water resources taken away by the state (in the colonial and post-colonial periods), and with little or no development activities being undertaken by the state[9], the rural population have been forced to degrade their own environment to survive, i.e. deforesting the locale for fuel-wood to cook with, mining away rocky outcrops for sale to middle-men, and farming even the most marginal lands to feed themselves. Paddy yields have changed little in 100 years.[10] The result is a degraded environment and a largely food-insecure, resource-poor, agrarian population that faces both economic and physical water scarcity.

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[9] Of India's 281 districts, the research district is one of just 17 that maintained the lowest agricultural growth (<1.5%) in India in the period 1962 to 1993 (Bhalla and Singh, 2001).

[10] In 1910 the average paddy yield in the district was estimated at 1432 kg/ha (Reid, 1912). In 2005, calculations from field data show that the average paddy yield differs little, at 1444 kg/ha (field research data, see Hill, 2008).

The 'drivers' of water scarcity in the research villages

The above briefly-outlined case study provides an example of localised water scarcity which is both human and climate-induced. Abstract modelling of the villages or region would obscure the history of the evolution of irrigation infrastructure in the villages, and the fact that some villagers have access to water whereas others do not. It is no coincidence that in such villages and regions, relatively wealthier farmers have access to water (for example, via diesel-powered pump-sets), and politically active persons (often the same relatively wealthy farmers) may access government funds and schemes to improve their personal wealth and/or water and agro-infrastructure. The 'drivers' of scarcity cannot be poverty or lack of education in a context of the adivasi-worldview of being at one with nature, and of living and working at subsistence level and for the collective good. Rather, the 'driver' of scarcity has been the imposition of essentially capitalist political economic institutions upon these indigenous people, such as rigid individualised property rights systems for farmland, and alien administrative systems.[11]

Firstly, the British imposed a rigid private property regime in land rights for their collection of revenue. Secondly, the independent Indian state confiscated all village land, and failed to recognise the remnants of communal rights over land held by adivasis. Thirdly, the officers and elected representatives of modern state institutions such as the development block and panchayati raj hold value systems fundamentally at odds with those of adivasis (Mahapatra 1986). Take notions of leadership for example, adivasi leaders act as mediators in village relations, seeking to maintain ecological balance in the process, whereas Indian government officers are concerned with modern economic development, at any cost. Control of land, it is apparent, is central to irrigation, agricultural and ecological systems in the villages, as well as the social systems that sustain them. The crises faced by farming households are the result of the perennial mismanagement of natural resources, not by the farming households, but by the state.

How can this be remedied? The CA's identified driver, 'policies, institutions and power', has clearly affected the evolution of agricultural systems in Jharkhand. The CA recommends that reform of state institutions is needed. Since its formation the new state of Jharkhand has been outsourcing agricultural planning to parastatal agencies, and examination of these documents (e.g. AFC 2004; NABCOMS 2008) shows that they contain mistakes, utilise old and unreferenced data, and fail to consider social and political issues in their conceptualisation and representation of water, land and the communities with which they will supposedly work. The prevailing political economy of water and land resources management is not conducive to progress as it stands.

The case study has attempted to demonstrate how control over land and other resources falling within village boundaries has been determined by successive governments largely through the effects of land revenue settlements and land reforms. This has impeded the development of the required water infrastructure, e.g. storage works, by farming households and communities themselves. With the absence of local democratic forms of governance, the nexus of local contractors, bureaucrats and elected officials have unaccountably misspent public funds. State and non-government agencies' sparse attempts to develop irrigation have largely failed due to the use of inappropriate (energy-intensive) technologies, inadequate attention paid to landholding patterns and pre-existing water-community relationships during design and construction processes,

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[11] Brown's analysis of collective rights over land suggests quite rightly that the complexities of demographic changes and shifting valorisation frontiers means that 'common property' cannot be assumed to be inherently 'good' or 'just' (Brown, 2007). The very limited case study material from Jharkhand presented in this paper serves only as an example of how localised water scarcity is created. This work in process needs substantial elaboration.

or their targeting of individuals rather than collectives. The result has been the continuing impoverishment of Jharkhand's population, the unbridled exploitation of Jharkhand's rich mineral resources by large Indian and multinational companies, and migration of Jharkhandi villagers across India to work as cheap labour. In the process wealthier segments of Indian society have benefitted.

Conclusion

The 'global water crisis' is a discourse created by powerful actors that serves to divert attention from the (global, regional and localised) political and social circumstances that produce freshwater problems. The discourse arguably serves to justify market-based solutions at the expense of alternative views such as rights-based and community-led initiatives.[12] Therefore healthy scepticism is required when reading international and inter-governmental agencies' documents (especially when one considers that many of their scientists claim to have no agenda, a claim that can hardly be sustained given the gravity of the social and environmental challenges faced by humankind).

The Comprehensive Assessment of Water Management in Agriculture brings a calm and optimistic view to agriculture in the next 50 years. However some of its normative assumptions (e.g. relating to its conceptualisation of poverty, equity, efficiency, and reform) are troubling, as is the complete absence of mention of land reform. To Lipton the 'war' between land reform and liberalisation is bogus, because land distribution usually helps and is sometimes essential to make liberalisation pro-poor, growth-inducing, or even politically sustainable or feasible (2009: 4-5).

A case study from two rain-fed villages located in the Indian sub-continent seeks to tie in some of the highlighted drivers (in particular 'policies, institutions and power') of agricultural system evolution with water scarcity. The research argues that one cannot consider scarcity to be the result of poverty, over-population, or lack of education. These phenomena are actually symptoms of the larger, over-arching 'driver' of water scarcity, and water pollution, which is that of the capitalist global political economy, with its institutions of privatised, individualised wealth and property, and value systems alien to a vast majority of indigenous/subsistence farmers. Mehta's (2000) views hold for the Indian case study: the idea of considering water as an economic good is troubling, because it ignores localised visions concerning water, and because market forces do not operate in a vacuum rather they build on pre-existing relationships. Mehta's conclusion resonates with Mustafa's (2007), that narratives of water 'crises', water wars, and water shortages, obscure issues concerning unequal access to and control over water, and that greater pluralism is needed in polarised debates over 'water as a human right', 'water as commons' and 'water as an economic good'.

This paper concludes with a call for more contextualised regional and local studies of freshwater scarcity and problems surrounding distribution of resources. Modelling of freshwater availability and scarcity at continental and global scales, even national scales, seems to fuel neoliberal arguments for the use of tools such as privatisation of resources, enforcement of individualised property rights, etc. It is difficult to see how the poor and dispossessed, or ecological systems, will benefit from more of the same.

[12] Baker (2005, 2007), analyses the commodification of nature, and recommends greater conceptual precision in our analyses of neoliberalisation. Neoliberalism is not monolithic, and it creates political opportunities that may be progressive (2007).

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Chapter 4: Ethical targets and questions of water management

Martin Kowarsch

Institute for Social and Development Studies (IGP)
Kaulbachstr. 31a, 80539 Munich, Germany
e-mail: martin.kowarsch@hfph.de

1) Introduction: the pragmatist way of applying ethics

How to allocate water equitably between, say, the current generation and remote future people, or between upstream/downstream riparians? Does nature have a right to water, too? Which use of water should have priority, e.g. between communal, spiritual or industrial uses of water? Should water be priced and should water supply be privatized? Although meanwhile a "human right to water" seems widely accepted as the core normative guideline for water management, it is not so clear what such a right means for the above – as mere examples – mentioned ethical questions of water management. It is not even clear what the crucial questions of "water ethics" [1] should be. Therefore, this paper first develops a framework for identifying and answering crucial ethical questions of fresh water management (ch. 1-3), before it sketches answers to some selected controversial issues in water ethics (ch. 4-6). Ch. 7 concludes and provides an outlook on further tasks of water ethics.

Ethics ("moral philosophy") philosophically reflects mores and their implications. Mores, or moral beliefs, can be regarded as convictions of *ends in themselves* (e.g. in terms of "well-being" of the primary ethical objects, be it humans only or also other entities) which *guide human action* explicitly or implicitly. Reflecting actions ethically does not mean to simply introduce an additional and competitive aspect beside economic reasons etc when assessing a situation, but rather it means to weigh up all these economic, socio-cultural, environmental and other aspects by means of ethical criteria. Thus, water ethics – as applied ethics – reflects end-in-themselves guidelines for managing fresh water resources (as a human action). Water management has an impact on the well-being of ethical objects by affecting the availability and the quality of water resources and natural water cycles (which are already influenced a lot by humans).

It is, however, controversial, how one can "apply" ethics. Already the formulation of a problem (including the definition and operationalisation of "well-being" etc), i.e. the crucial questions of water

[1] "Water ethics", as it is understood here, means ethics of fresh water management, whereas "management" is used in a very broad and non-technocratic sense throughout this paper. Conceptions of "justice" usually are discussed within political philosophy, but basically are ethical issues, too.

ethics, is difficult as it is determined by the respective moral point of view (Putnam 2004, Grimm 2010). Based on pragmatist philosophy (see, e.g., Dewey 1988 and Putnam 2004), applied ethics necessarily has to be a highly interdisciplinary undertaking based on *empirical* scrutiny, in contrast to approaches assuming that abstract and general ethical norms can be directly applied to specific situations, simply as rules. From a pragmatist point of view, general normative guidelines are merely an assistence to ethically analyse a specific situation (e.g., to point out issues of intergenerational justice: future people cannot make themselves heard) – they provide orientation rather than rules (Grimm 2010). This is not only due to the need for operationalisation and its interpretation in specific situations, but also due to the pragmatist conviction that new and ethically problematic situations can require new, or slightly revised, ethical guidelines. Otherwise, there is a danger that one simply attempts to apply given general normative principles to specific situations without noticing what is *actually* the ethical problem in a given situation. This is called the "sticky finger problem" (Grimm 2010).

The real water ethical problems from a pragmatist perspective, thus, can only be identified by thoroughly looking at specific situations (and their constituents and context) that became somehow problematic. Proposed *solutions* to the so determined problems of water ethics – that is: proposed means for the related general targets of water management (water policy) – ought to be related to the constituents of the specific situation in question. Then, the consequences (side-effects) of the proposed means have to be scrutinized (relatively adverse side-effects of means should lead to a revision of ends), and finally, the solutions should be tested in practice (Grimm 2010). While these steps (based on John Dewey) may sound somewhat trivial, it is rarely followed by water ethics, as far as I can see. The result of employing the above mentioned steps would be a water ethic which really addresses the crucial questions (rather than problems that primarily are of interest within given academic discourses) and in addition provides solutions that are related to the specific practical context of the problem in question, that is: they are more practically based and better contextualised.

2) Preliminary moral standpoint: triangle of justice

A problematic situation cannot be analysed ethically without implying value judgments. The ethical stance here taken analysing the water problem and for suggesting solutions to itis the triangle conception of justice. As a tool for orientation and analysis, this triangle of justice allows to identify the crucial water ethical questions (ch. 3) and helps answering them (ch. 4-6). For this reason, the conception is briefly sketched below, based on the more detailed version in Kowarsch/Gösele, forthcoming.

The triangle of justice is based on the following core moral implications of human rights: universality, equality, freedom and solidarity (Reder, forthcoming). The core demand of the triangle of justice is: Everyone should equally have the inviolable freedom to live a flourishing life (that is: to choose from a sufficient range of life conceptions), connected with – but not dependent on – the duty for everyone to grant the same for other people and to actively support them concerning the realisation of their rights, as far as possible without violating one's own rights. More specifically, the "freedom to live a flourishing life" is interpreted along three (*tri*-angle) dimensions of being a human. First: physical-psychological; second: talents, interests, capabilities and actions; third: being involved in processes and decisions. The numbers of the dimensions have nothing to do with priority of any dimension.

The first dimension of justice is basic needs fulfilment (as a threshold) for everyone on a physical and psychological level. The concept of "basic needs" used here identifies goods and circumstances that are directly and minimally necessary for long-term physical and psychological well-being. Basic needs primarily include: enough food and drinking water, clean air, warm and dry shelter, physical and psychological inviolacy (including, e.g., sanitation), sufficient health care and relaxation, a basic level of social recognition, the minimal capability to self-determination and cultural identity as well as minimal self-confidence concerning one's own capabilities.

The second dimension of justice demands sufficient opportunities for everyone to realise one's interests, talents and skills. Although different people require different *specific* opportunities for their flourishing life, one can identify some key general requirements and preconditions for realising most of these opportunities: (1) equal access to socio-economic, political and cultural processes and institutional positions, (2) equal access to a good educational system and other forms of capacity building, (3) equal access to crucial economic goods and natural resources and services. However, allowing some inequality provides an important incentive for economic activity. The task is to find a balance between this incentive and the negative consequences of unequal distribution of wealth. Redistribution of property can be demanded, if some persons (e.g. in regard to their basic needs fulfilment) need support.

The third dimension of justice demands (i) that persons should also have the right to be collectively self-determined (this means that on a meta-level all members of a community should have the possibility to shape the structures and processes, which shall lead to basic needs fulfilment and shall provide opportunities), as well as (ii) that everyone should have the right to fully participate in every process, which concerns oneself, *and* that those processes have to be fair. Fair procedures require transparency concerning important information, comprehensibility of this information, a certain balance of power, clear and effective rules as well as fair treaties and contracts (e.g., without misuse of power or enforcement). They demand *equal* rights (e.g., equal political voting rights or equal right to fair trials) and the exclusion of arbitrary discrimination, paternalism (even if it is benevolent), interference with one's privacy, attacks upon one's reputation, etc. (iii) Subsidiarity is another demand of this third dimension of justice.

All of these three dimensions of justice are irreducible to each other, but also highly interrelated: Economic opportunities, e.g., can help to fulfil one's own basic needs. Basic needs fulfilment in general is necessary for most of the opportunities, and having effective access to basic goods highly depends on fair procedural conditions. Priority should always be given to those who are far away from fulfilment of their rights. Taking *human* rights seriously, they have to be extended not only globally, but also through time. Hence, in principle, the rights and duties concerning the three dimensions of justice also apply to future persons. Although e.g. the prevalent liberal equality approaches have some difficulties with justifying rights of future people, one can clearly affect the lives of future people enormously given the direction of causality, e.g. by destroying the natural conditions of human survival. Even though rights presuppose existence, future persons can bear rights, because if they exist in the future, they will bear these rights then (Meyer 2008). Future generations should have the freedom to live a flourishing life, too, and present generations have the duty to care for its groundwork (without abandoning their own rights).

The triangle of justice is a consistent and comprehensive ethical conception of justice – unlike the Universal Declaration of Human Rights. That is why conflicting targets (when managing water) can be disclosed more easily than with a list of human rights, or even only the right to water, for instance. This conception of justice claims to be "universal", but in a pragmatist sense: normative ethical guidelines can only be developed from experiences in specific situations, pragmatism asserts. They are solutions to specific problems in their respective empirical context. This does not mean, however, that there cannot be objective and universal general ethical norms (though always fallible!), when they have “proven” themselves sufficiently in practice. As Habermas (2010) and others point out, ethicists – independent from their ethical background – more and more refer to human rights as the standard ethical point of view. That is why human rights serve as the basis for this conception of justice. Yet, it still leaves large space for a broad (fair and rational) discourse within and between communities about some important aspects of justice (what exactly are basic needs? What are opportunities more concretely, or what are requirements for them? What can count as a fair procedure?), that can only be determined more precisely within a (sub-)culture. As was said above, such a conception of justice serves as an orientation rather than a set of rules.

Some prevalent *alternative* ethical points of view are summarised in table 1:

Table 1: Different conceptions of justice in water ethics

Water ethic standpoint	**Core ethical aspects of water issue**
Utilitarianism	How is water management affecting aggregated utility in terms of economic welfare (consumption, now and in future)?
Libertarian freedom	How does water management affect liberal rights of people, and their freedoms (now and in future)?
Liberal equality	How does water management affect equality (now and in future) and human rights?
Social contract and discourse	Under which procedural conditions are decisions made?
Priority, threshold, feminist	How does water management affect the poor and oppressed / How is power used in water management, particularly by men?
Socialist, Marxist	How does water management affect the working class, distributional and property rights issues (now and in future)?
Physiocentric, biocentric	How does human use of water influence non-human living beings and ecosystems (now and in future)?
Communitarian, religious	How are local traditions and cultural-religious values affected?
Triangle of justice	How does water management affect basic needs fulfilment, opportunities and procedures (now and in future)?

3) Identifying crucial issues of water ethics

In order to identify the crucial issues of water ethics based on empirical knowledge and, with it, to identify the general normative targets of and conditions for water management, *(1)* the functions of and the need for blue and green water as well as for a certain condition of the water cycles have to be taken into account and have to be evaluated from the perspective of the triangle of justice, which leads to water ethical demands “on the first level”, that is: a general level answering the question who or what has which moral rights and duties in general, presupposed these rights and duties can be realised. These preliminary 1st level demands may also answer the question what should be the targets of water management at all. *(2)* Then, water shortage [2] and the possible endangerings of the condition of water cycles, now and in the future, are to be explored, since they cause the ethically problematic situation regarding the “1st level” ethical demands, *(3)* before those drivers, context and constituents of adverse or positive water situations and related conflicts are analysed, which can be influenced by human actions.[3] From each of these drivers possible management strategies can be derived. *(4)* Based on this assessment of the ethically problematic situation and the preliminary management options, the crucial

[2] Concepts like water shortage, scarcity etc already imply normative judgements – which furthermore indicates that water ethics is not only about distributional conflicts.
[3] These drivers can themselves be highly related to the “needs” for water in the first step (1) of the analysis.

water ethical issues can be identified and "2nd level water ethical demands", that is: more specific demands, no longer preliminary or prima facie, can be formulated. – While such an extensive enquiry cannot be conducted here (see more detailed in Kowarsch/Schröer, forthcoming, and Anisfeld 2010), at least some core points of it can be roughly summarised in order to demonstrate the above mentioned procedure and core general results:

(1) *Why water is essential for all living beings (directly and indirectly) and for ecosystems:*

- *Ecosystems*: they need water and water cycles in a certain condition and quality for many life sustaining functions, such as, e.g., for transporting nutrients and minerals or watering plants. Water cycles are decisive for weather and climate (e.g., climatisation of the atmosphere through evapotranspiration);
- *Domestic water use and sanitation*: drinking, cooking, cleaning, sanitation, etc;
- *Industry and hydro power*: industry needs water as an ingredient, for cooling, cleaning, etc. Water is extensively used to produce energy (hydro power);
- *Agriculture, inland fishery, forestry*: water availability is crucial for irrigating croplands, etc. Due to population growth and changing consumption patterns (especially meat consumption), more and more food production and water is needed;
- *Transport, recreational and spiritual uses*: requires a certain condition of water resources.

Which of these diverse needs for water are really important from the perspective of the triangle of justice? All life-sustaining uses of water are absolutely important ethically (basic needs fulfilment, both intra- and inter-generationally). This includes water for ecosystems (see ch. 4). Yet, economic, spiritual and recreational uses of water are important, too, since they are required to a certain extent for having sufficient opportunities for everyone now and in the future (second dimension of the triangle of justice). To sum up, the core *prima facie* [4] (preliminary, "first level") water ethical demands are:

1. Protecting water cycles in their crucial and life-sustaining role for ecosystems and human life.
2. Providing sufficient water in quantity and quality for every person, now and in the future, in order to ensure basic needs fulfilment and sufficient opportunities.
3. Manage water and develop infrastructure without endangering other demands of justice or without creating further problems

These 1st level and preliminary normative-ethical demands cannot be separated from the 2nd level of water ethics, since "ought" implies "can", and the latter is analysed on the 2nd level of water ethics. The other way round, 2nd level water ethics presupposes the 1st level demands as orientation and a means to evaluate different water management options. Thus, both the 1st and the 2nd level water ethical questions are important.

(2) *Water availability and threats:*

In some regions, water availability presumably decreases in the future (see D. Gerten´s contribution in this workshop proceedings). Although water is renewable on a global scale, water can be limited on a watershed scale (Sarni 2011, p. 34). In addition, ecosystems loose their resilience due to direct or indirect human interventions (Falkenmark/Folke 2002). Floods and droughts pose further threats.

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[4] Note that they are merely "prima facie" because they do not explore whether these ends are achievable at all or what the consequences of possible means to these ends are (side-effects, trade-offs with other targets, etc).

(3) Major drivers for fresh water-related threats or their reduction:

- *Climate change and variability*: global warming does not only significantly reduce water availability in some regions, but also disturbs water cycles and ecosystems, leads to increasing demand for water (cooling, agriculture, drinking) and reduces water quality (increase of bacteria, etc); natural variability is decisive, too;
- *Land use changes and hydraulic engineering*: e.g., deforestation, surface sealing, dewatering of moors; dams, canals, wells;
- *Demographic factors*: population growth, migration, urbanisation, more senior citizens
- *Technology, innovation*: desalination, higher efficiency in agriculture (vapour shift);
- *Economic development and lifestyle changes*: e.g., increased meat consumption, more intensive agriculture, higher demand for energy (e.g. hydro power or biomass), increased industrial use and pollution of water;
- *Income distribution and allocation*: e.g., access to water resources for the poor;
- *Quality of governance and management*, for instance: corruption, (lack of) control of obedience to water law, (lack of) maintenance of human water systems, (lack of) information and education, (lack of) participation or free trade (virtual water trade), (lack of) incentives to use water more efficiently (e.g., water pricing).

Related to these drivers are loads of theoretical management options such as, for example, climate change mitigation and adaptation, laws to avoid land use changes, increased participation of affected people, governmental investment in technology (R&D), forced migration, reducing population growth, building higher dams or denying access to water for some poeple or corporations.

(4) Crucial water ethical issues on the second level, based on the triangle of justice: [5]

It is not only obvious that a few of these possible management strategies are ethically dubious and many options have adverse side-effects, but also that there are some trade-offs among the water management strategies themselves, e.g. between climate change mitigation (more hydro power and biomass needed) and protecting water cycles (less hydro power and biomass production). (a) The thorough and critical evaluation of means in the light of their consequences (side-effects and trade-offs with other targets [6]) and the possible revision of the preliminary ends therefore appears as a crucial water ethical issue. However, these very complex questions can only be addressed appropriately in close collaboration with empirical disciplines and the people involved in the respective problematic situation. (b) In addition, typical questions of distributional justice arise in water ethics, too: e.g., conflicts between upstream and downstream riparians, between different lifestyles and water uses (communal versus industrial), or between the current generation and remote future people (sustainability). These issues are related to many procedural questions (e.g., questions of participation, public debate, or the question of duty-bearers: the state or the individual? Etc). (c) In the complex field of water ethics, many more ethical questions arise *indirectly* or on a *meta-level*, such as for instance guidelines for water-related scientific policy advice, for dealing with risks and uncertainties, or for implementing water ethical demands in a morally often reluctant "second best world".

[5] *Precedent* water ethical issue (see above) are an adequate meta-ethical standpoint (a theory of applied ethics and of problem formulation, etc) and a general conception of justice. The latter comprises also the question of water as a moral end in itself (see ch. 4) and the question of pluralism/ universalism (see ch. 2). Note that among the ethical standpoints in table 1 (see above) there seems to be a kind of consensus at least about the (only preliminary) human right to water as a prima facie water ethical claim on the very abstract "first level".

[6] Among other ethical targets, which have to be harmonized with preliminary water ethical demands, are targets of ethics of democracy, gender ethics, environmental and animal ethics, ethics of economics, property rights and business ethics, or population ethics. Hundreds of questions emerge from that for water ethics.

4) Intergenerational justice and sustainability

Having sketched a method of identifying crucial water ethical issues and core general results, in the following chapters (4-6) some *answers* to water ethical questions shall be sketched – again based on the ethical stance of the triangle of justice. This might also make the practical implications of the assumptions and results from ch. 1-3 clearer. – The focus in this chapter 4 is on intergenerational justice in water ethics, actually a topic on the "first level" (preliminary, prima facie) of water ethics.

(a) It is ethically crucial not to endanger the resilience of ecosystems – even if it is a complex task of sustainability and related to considerable uncertainties. As already indicated above and as explained by natural scientists in more detail (e.g., Falkenmark/Folke 2002, Gunderson/Holling 2001, Anisfeld 2010, ch. 8), the various functions (physical, biological, chemical) of water cycles in the ecosystems are essential for all life on earth. And their functions for living creatures presumably become even more important considering population growth, increasing meat consumption, global warming etc. Climate change is one of the biggest threats to many ecosystems (IPCC 2007).

One task of ethics concerning this issue is to point out this ecological threat, which had been neglected for a long time (Falkenmark/Folke 2002), because it cannot be seen and felt as easily as physical water scarcity. What does such an ethical claim mean more specifically? Again it has to be referred to natural sciences: Ecosystems are not static, but rather dynamic systems, which adapt to changing environmental conditions and disturbances (Falkenmark/Folke 2002). Thus, the goal is not to keep a status quo, but rather to keep or increase resilience of these systems. This danger of catastrophic events – breakdown of major life-sustaining ecosystems – is, however, associated with high uncertainties. To answer the question how to deal ethically with uncertainties (e.g. as Weitzman 2009 does) is a big challenge for ethics. But why should we care at all about possible catastrophes in the remote future?

(b) Some ethicists (see, e.g., Armstrong 2006, Brown/Schmidt 2010) and even some important political documents (EU 2000) [7] attempt to motivate the protection of ecosystems by stating an intrinsic value of water, that is: by regarding water as an ethical end in itself. This is astonishing, because in other ethical debates such a point of view usually would be regarded as rather exotic. Although I sympathize with the "precautionary" idea that it is better to draw the circle of ethical objects rather too far than too narrow, in my view such a moral belief cannot really have practical consequences for our actions in water management, because there is no reasonable way to determine the ethically legitimate needs and interests of water (cycles). I even wonder whether this debate about an intrinsic value of water (cycles) is an example of a "sticky finger problem" (see ch. 1) in water ethics. Maybe the original ethically problematic situation was precisely the threat of a collapse of ecosystems, and, with it, a hazard for human beings. But instead of more thoroughly analysing the specific empirical situation and this threat for all life on earth, the typical debates in environmental ethics (who or what is a moral rights bearer?) were continued. Based on this presumption, the question whether water has an intrinsic moral value does not seem crucial to me for water ethics.

(c) However, intergenerational justice based on the triangle of justice (ch. 2) can provide sufficient reasons for the same ethical demands: Since a collapse of ecosystems represents a substantial threat to

[7] "Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such" (EU 2000).

humanity and since there are good reasons to take persons in the remote future into account (see ch. 2 and Meyer 2008), the protection of the resilience of ecosystem is clearly demanded ethically.[8]

5) Conflicts, procedures and the right to water

Conflicts between upstream and downstream riparians or between different possibilities to use water (cycles) presumably are as old as human civilization. While in economics and other social or natural sciences many ethical value judgements are made regarding water management issues without noticing it (see, e.g., Putnam 2004) – neglecting quite a few of the crucial questions of water ethics (see ch. 3) as a task for *ethics*, at least distributional conflicts had always been regarded as *ethical* questions. Different theories of justice (see table 1 in ch. 2) gave different answers to this question. How can the triangle of justice help to solve conflicts about water resources?

The triangle of justice does not offer a *final* answer, but it provides some basic conditions for a solution of these intra-generational water conflicts: *First*, access to water resources ought to be managed in a way that enables everyone to fulfil his or her basic needs, if this is possible at all. *Second*, allocation has to ensure that everyone has sufficient economic, cultural and other opportunities, which depend on water availability.

Third, the decision about the allocation of water resources (including the process that led to the formulation of the decision problem and including the monitoring of the realization of the decision at stake) has to be made in fair procedures. To repeat some aspects of fair procedures (see ch. 2), participation of all the people who are affected by the decision is required (according to the principle of subsidiarity), as well as high transparency of information and of procedures, and equal political rights for everyone rather than paternalism or arbitrary discrimination. Different cultural or religious beliefs have to be taken into account, because the interpretation of the three dimensions of justice is highly dependent on cultural contexts (see ch. 2). Procedures about such complex issues like water management with all its trade-offs and interdependencies with other policy fields are neither fair nor effective, if people are not well informed and skilled. Therefore, an extensive public debate (as fair and rational as possible) and better education, particularly for poor people, seem decisive.

A *fourth* basic condition has to do with property rights, which are a core aspect of these conflicts. While for libertarians property rights play a central role in their conception of justice, for the triangle of justice property rights are less important. They can be justified ethically, because they can serve as an adequate *instrument* to provide a minimum of planning reliability concerning one's own life plans (especially economic plans) and serve as an economic incentive. However, property rights are not moral rights on the same level as, e.g., the right to have the opportunities mentioned above, but are merely derived from those moral rights and are entirely dependent on them. Ethically, this allows some kind of redistribution, if necessary. Thus, property ethically is always connected with a strong social obligation in regard to common welfare.

How useful is the "right to water" *ethically* for these questions? In my view, the right to water – which is difficult to operationalise – stresses the need for sufficient water supply (in quantity and quality), but it neglects the need for a certain condition of water flows (e.g. for hydro power or cooling water) and, even more important, the need for protecting water cycles in their ecological functions (ch. 4). It

[8] There are reasonable biocentric arguments (taking into account also non-human living beings as moral objects), e.g., which strengthen the need for the protection of water cycles even more. But the demands are not very different to what is demanded by the triangle of justice in this context.

might even somewhat neglect some important human uses of water, such as water for irrigating croplands, although the need for water in agriculture is presumably the biggest challenge in the future from the perspective of basic needs fulfilment. Another disadvantage of the concept of a human right to water is, as was said in ch. 2, that it is not part of a consistent, comprehensive and coherent conception of justice and, therefore, it might have difficulties with identifying and solving moral trade-offs. The abstract right to water, which can be interpreted as a prima facie right "on the first level" (see above) without really telling us who has related duties or who pays for its realisation, does not seem to be the result of a method as described in ch. 1. But nonetheless I assume that the human right to water is of utmost *political* importance and therefore should be supported.

6) Consequences of water "economisation"

After the discussion of a prima facie water ethical claim (1st level water ethical demand) in ch. 4 and a 2nd level water ethical problem in ch. 5, this chapter briefly discusses, as an example, the consequences (side-effects) of an important water management option: economic incentives to use water more efficiently. Giving water services a price is the most obvious way of creating such an economic incentive. Meanwhile there is a relatively enhanced (and, fortunately, more rational) discussion of water as an economic good (up to date overviews of some basic points of the discussion can be found, for example, in Priscoli/Wolf 2009, Appendix D, or in Sarni 2011, ch. 3).

The advantage of water pricing (via taxes, tariffs or permits) is evident: If water is too cheap, or even gratis, households, farmers, industry and others are tempted to use water in abundance and very inefficiently – presumably even if they are informed quite well about the threat of water scarcity in the respective watershed. Prices and markets have sufficiently proven in economics to be a very effective and helpful instrument for dealing with scarce goods, because they provide an incentive to save scarce resources, to use them more efficiently or to possibly substitute them, and an incentive for technological innovation. Not only can prices provide these incentives, but also they can be used to internalize social and ecological externalities *comprehensively*. This is necessary to determine and to reach [9] a social optimum or a reasonable standard for the use of water, e.g. to stay below a maximum of groundwater withdrawal per annum in order not to endanger a sustainable use of these resources.

However, the practical (social and ecological) success of adequate water pricing depends on a large number of conditions. Some examples: (i) Prices for water services are often much lower than the total social and ecological costs of water services would be. The major reasons for this are non-internalized ecological and social externalities, which is called a "market failure", and in addition also local, regional or national governmental subsidies, which distort market prices and which shall keep the prices for water services low for social reasons. While it seems relatively easy to abolish subsidies, a much bigger problem is to determine the social and ecological externalities *in terms of money* in order to determine the total social and ecological costs of water. What – from the perspective of the society as a whole – is the monetary value of an ecosystem compared with the use of water for inland fishery, for instance? These are obviously ethical problems. They get even more complicated when considering substantial uncertainties regarding ecological and long-term consequences of water use: how to value an uncertain damage or benefit? (ii) As was already mentioned above and also argued in

[9] A classic is the so called "Pigovian tax" (explained in every introductory textbook to environmental economics): Such a tax – in theory – helps to reach the social optimum efficiently by internalizing external costs (environmental and social damage). Decisive are not only the social and ecological *costs*, but also the demand curve expressing also the *benefits* of water use for society. A cap and trade system, as considered for greenhouse gas emissions, would be another instrument for reaching standards efficiently.

W. Bretschneider´s and K. Bernsen´s papers in this workshop proceedings, not only one target (more efficient use of water, e.g.), but several ethical targets have to be addressed at the same time. For instance, distributional aspects and affordability have to be taken into account.

A famous quotation by Oscar Wilde provocatively expresses the widespread concerns regarding water pricing: "A cynic is a man who knows the price of everything but the value of nothing."[10] The quotation from the EU document above (see footnote 8) indicated such a deep concern, too. From an ethical perspective this debate is sometimes misleading, because it seems as if abstract normative ideals – such as "economisation is bad" – are employed (which themselves might be driven by a legitimate moral concern), rather than addressing the more specific and more crucial water ethical problems (see ch. 3) and rather than offering a solution to water ethical problems which is really based on the constituents and context of the specific problematic situation itself (see ch. 1). The decisive water ethical question does not seem to be: Is water pricing ethically good or bad? Is water a public or a private good? But rather: Under which more specific conditions is water pricing, privatization, etc desirable? From the perspective of the triangle of justice, property rights and economic incentives are mere *instruments* for the realization of justice, and should be evaluated as such.

The crucial ethical aspect is to more precisely analyse and evaluate the actual consequences of such an instrument in specific situations – rather than *abstractly* discussing about "economisation" of water –, and to identify conflicting ethical targets related to this specific situation. In the light of the three dimensions of the triangle of justice (see ch. 2) the primary ethical targets are marked out. From this perspective, pricing is neither intrinsically good or bad ethically, but this instrument has to serve the ethical demands of the triangle of justice. The same holds for the question whether water supply should be privatized in order to make it economically more efficient. Since, as was said above, many factors and conditions determine the success of these economic instruments, it seems necessary to *continually learn* from practical experiences: "experiments" with different management options seem indispensable (see, e.g., the disappointing results regarding privatization of water supply reported in Franke/Lorenz 2010 for the case of France and Germany).

On the other hand, it might be helpful for the ethical discussion to disclose the deep concerns underlying the critique on economic approaches to water management. For example, the deep concern that economic approaches (already indicated by the term "water *management*") imply a technocratic world view rather than taking governance and other political, social and cultural aspects of water management (and its failure) into account. Or the deep concern that water is merely seen as an *economic* good by economists, rather than regarding water *also* as a socially, culturally, ecologically, spiritually etc important good. Or, as was mentioned above, the fear that economic approaches neglect distributional issues.

The very popular "integrated water resources management" (IWRM) approach is an attempt to combine the strength of economic approaches with ecological and other aspects. IWRM can be explained as follows: It is "a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership´s Technical Advisory Committee 2000, quoted in Brown/Schmidt 2010, p. 7). IWRM is an utilitarian approach. However, utilitarianism – which is still very popular in economics – only looks at preexisting preferences and not at an "unexpressed need for an enlightened existence" (Feldman 1991, p. 5). More importantly, IWRM seeks for aggregated net benefit instead, e.g., for increasing

[10] Mainstream economists, however, would respond to Wilde, that prices actually do express the value of goods on a perfect market.

individual freedoms.[11] Therefore, IWRM neglects some distributional and other important ethical issues.

7) Conclusion and outlook

It was argued that the crucial questions of water ethics – the ethics of fresh water management (in a broad sense) – can only be identified if a general moral standpoint (here: the triangle conception of justice) is applied not in terms of rules for action, but rather as a mere tool to analyse a specific situation based on empirical scrutiny. The need for thoroughly looking at the actual problems and their constituents and specific context was pointed out in order to avoid the "sticky finger problem". An old saying rightly asserts that a problem well put is half solved. One of the most important water ethical questions (2nd level) is the analysis of consequences of water management options; there should be no sacred cows among the ends and possible means. Decisive in each case is to analyse the ends-means connection and to revise the ends, if the means turn out to be too risky. Formulating the water management problem, for instance, simply as the problem of closing the gap between future human demand for water and water supply (primarily by more efficient use of water) seems too myopic: it neither really reflects 1st level water ethical issues (which demand for water should be fulfilled?) nor 2nd level issues (what about the side-effects of the means applied to reach this target?).

The brief discussion of some preliminary and of some more specific issues of water ethics in chapters 4-6 was somewhat superficial. This is to some extent due to the fact that more specific water ethical demands can only be justified by analysing a very specific situation in time and space. Therefore, a more specific case study is of utmost importance for water ethics, if it does not only want to provide *prima facie* ethical demands on the 1st level.[12]

There are lots of further questions that a water ethic has to answer (see, e.g., the various issues discussed in Llamas et al 2009 and Brown/Schmidt 2010).

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[11] Furthermore, IWRM needs high agreement (quite rarely!) between, e.g., all the upstream and downstream riparians (compare the critique on IWRM in Anand 2007, p. 238). Another problem with IWRM is that it pretends to be objective and value-neutral (Brown/Schmidt 2010, p. 8), which quite obviously is not true.

[12] In 2012, a case study will be carried out in South Sudan by the Institute for Social and Development Studies (IGP) for precisely this purpose.

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PART II:

WATER MANAGEMENT OPTIONS

POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Chapter 5:
Irrigation Water Scarcity and the Effectiveness of different Policy Options

- Preliminary Results -

Christoph Schmitz[1], Hermann Lotze-Campen and Dieter Gerten

Potsdam Institute for Climate Impact Research (PIK)
Telegraphenberg A31, 14473 Potsdam, Germany

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[1] corresponding author: schmitz@pik-potsdam.de

Abstract

Climate change and an increasing demand for food, feed, and bioenergy will lead to a rising pressure on global water resources over the coming decades. Regional water scarcity can be mitigated by increasing water supply and/or reducing water demand from various sectors. But regional impacts and measures are also connected through global trade flows, especially trade in water-intensive agricultural products. Hence, regional water scarcity has to be assessed in a global context.

We have coupled a global vegetation-hydrology model with a global land-use optimization model to assess the impacts of changing water availability on the agricultural sector. The special features of our coupled hydro-economic modeling approach are a spatial resolution of 50x50km with global coverage, and an endogenous implementation of technological change in agriculture. A fine spatial resolution is necessary in the context of water, since the spatial distribution of water supply and demand is very heterogeneous. This allows for the identification of regional hot spots of water scarcity and regionally specific shadow prices for water. Endogenous technological change is an important feature especially for long-term assessments, where technology becomes one of the major drivers of change.

We generate scenarios on future trade liberalization and changing meat consumption. The impacts on regional water scarcity and the implicit value of water resources are assessed. Implications for policy formulation with regard to water management on a national and international scale are discussed in a concluding section.

Keywords: Water scarcity, agricultural trade, technological change, demand patterns

1. Introduction

1.1. Food production and water use

The world's population will reach 9-10 billion by the middle of the 21st century and stabilize at this level (Lutz et al. 2001). Due to further economic development and growth, in many regions people will on average have higher disposable incomes than today. This will lead to higher consumption of goods and services. With rising income, changing living conditions and lifestyles, e.g. through increased urbanization, dietary habits will also change. Total food consumption, measured in energy units, will increase. Moreover, the relative share of animal products in total food consumption will rise. It can be expected that food and dietary trends, which have been observed in rich countries over the last decades, will be taken up by most developing societies in the future. About 70 percent of total human freshwater withdrawals are used in agriculture, mainly for irrigation in regions with insufficient precipitation. Irrigation agriculture contributes about two thirds of the world production of rice and wheat (Rosegrant et al. 2002). Human consumption of meat and milk increases the demand for land and water required for the production of animal feed. Agriculture has to compete with other sectors for the available renewable water resources. In the course of economic development the water demand for private households and industry will also rise. While it was possible to reduce some types of industrial water use considerably in rich countries, industrial water use in developing countries is expected to rise strongly in the future. The same holds for private households. In addition, water requirements for environmental purposes, e.g. maintaining the functionalities of wetlands and rivers, will be articulated more strongly in the future and will have to be taken into account in water allocation plans, not least in order to protect and maintain biodiversity. This will exacerbate the water conditions in many regions.

Water availability for agricultural production is mainly determined by local precipitation. Not only the total amount of rainfall per year or within the growing period is important, but also to a large extent the temporal distribution and variability within the growing period and at critical stages of crop development. Even though groundwater, reservoirs and fossil water resources are increasingly exploited as sources for irrigation water, agricultural production in many regions depends strongly on natural precipitation and soil moisture. Climate change will lead to changing precipitation patterns, the extent of which is still uncertain for some parts of the world (Menzel et al. 2003). In Europe, on average, more precipitation can be expected in winter months. More droughts in the summer months are to be expected in Southern Europe, but slightly wetter conditions in Northern Europe. Some important agricultural production areas, like North America or Australia, may become considerably dryer by the end of the 21st century (IPCC Data Distribution Centre 2004). This could have severe impacts on world agricultural markets.

1.2. Options to avoid water scarcity

Efficiency gains

Over the last four decades, agricultural yields for many crops have been steadily increased by 1-2 percent per year, mainly due to technological advances in plant breeding and mechanisation. Global agricultural production was, on average, able to keep pace with population growth. However, the goals of plant breeding research were mainly focussed on increased yields per area, but less so on increased water use efficiency. For the future, the big question remains, to what extent productivity growth rates of the past can be maintained in the future, and at what level resource constraints become binding. With a strong focus on the optimisation of water use in crop production and irrigation, it is likely that substantial progress can be achieved. For example, yield potentials of new rice varieties are up to four times higher than traditional varieties, but with the same level of water use through evapo-transpiration (Smil 2000). Furthermore, irrigation efficiency is a main trigger for less water demand. Over 50% of the water which is intended for irrigation is lost due to bad management, losses in the conveyance system and inefficient application to the plant (Rohwer et al. 2007).

Infrastructure improvements

In the past there have been many attempts to alleviate local water scarcity with improved water supply. Large-scale dams and canals were built to regulate and stabilise water supply. There are many examples, where these measures have indeed increased and stabilised agricultural production. The long-term sustainability of these effects, however, is subject to a controversial debate. Many of the roughly 45,000 large dams in the world reveal technical problems, e.g. through sedimentation. Cost-benefit ratios ex post are often much worse than originally planned and expected. Environmental damages, economic risks, and social disruption caused by re-settlements have changed the perspective of international donor organisations over the last decades (WCD 2000). Still, large infrastructure projects for long-distance water transport are being planned and implemented, e.g. in Spain and China.

Institutional reforms

Institutional and political measures are further important building blocks for improved water management. In many regions, water is seriously under-valued, especially in the agricultural sector. This is one major reason for over-use and wastage. There is often a lack of well-defined property rights or, if they exist on paper, they are not implemented or strongly enforced. Largely free or heavily subsidised water use is in many countries an important component of government support for farmers and, hence, is strongly defended by the beneficiaries. The issue of water pricing cannot be isolated from the general political and economic circumstances (Rothenberger and Truffer 2002). Tradable user rights for irrigation water provide a possible way towards a more appropriate valuation of scarce water resources.

Virtual water trade

International trade with goods, especially agricultural and food products which contain a significant amount of "virtual water" could play an important role for increasing the global efficiency of water use (Hoekstra and Hung 2002). Water-scarce regions could increase their imports of water-intensive products, like cereals, so that more water would be available for non-agricultural purposes. International trade flows are mainly driven by economic forces. If appropriate regional water prices would serve as realistic indicators for water scarcity, this would be reflected in the economic calculations of producers and traders. A well-functioning trading system also serves as a kind of insurance scheme against production risks, because it is rather unlikely that huge harvest losses due to floods or droughts would occur simultaneously on a global scale in several important production regions. This function could become even more important under future conditions of severe climatic change.

In this study we focus on the possible policy options to reduce the pressure on blue water. Blue water is defined as the total runoff formed by surface runoff and groundwater recharge (Falkenmark, 2003 and Rockstöm et al., 1999). In the following chapter we describe the model set-up and the scenario implementation. In chapter three the results are presented with a focus on the water shadow price and technological change rates. In the last chapter we draw the conclusions from our analysis.

2. Modelling approach

2.1. General Description of MAgPIE

For the analysis in this paper we use the model MAgPIE (Model of Agricultural Production and its Impact on the Environment), which is a nonlinear recursive dynamic optimization model (Lotze-Campen et al. 2008, 2009). It is coupled to a grid-based dynamic vegetation model, to simulate spatially explicit land-use and water-use patterns. This approach provides a high flexibility to integrate various types of biophysical constraints into an economic decision-making process. Monetary and physical units and processes can be directly linked within the model. Instead of using statistical yield functions based on past observations, potential crop productivity and related water use are explicitly derived with a process-based crop model (see below). The dual solution of the mathematical programming model provides valuable insights into the internal use value of resource constraints. The model computes a shadow price for binding constraints in specific grid cells, e.g. in this case related to land and water availability, reflecting the amount a land manager would be willing to pay for relaxing the constraint by one unit.

The objective function of the land-use model is to minimize total cost of production for a given amount of regional food and bioenergy demand. Regional food energy demand is defined for an exogenously given population in ten food energy categories (cereals, rice, vegetable oils, pulses, roots and tubers, sugar, ruminant meat, non-ruminant meat, and milk), based on regional diets (FAOSTAT, 2004). Food and feed energy for the ten demand categories can be produced by 20 cropping activities (temperate cereals for food or feed, maize for food or feed, tropical cereals for food or feed, rice, five oil crops, pulses, potatoes, cassava, sugar beets, sugar cane, vegetables/fruits/nuts, two fodder crops) and 3 livestock activities (ruminant meat, non-ruminant meat, milk). Feed for livestock is produced as a mixture of grain, green fodder produced on cropland, and pasture. Fiber demand is currently fulfilled with one cropping activity (cotton). Cropland, pasture and irrigation water are fixed inputs in limited supply in each grid cell, measured in physical units of hectares (ha) and cubic meters (m^3). Variable inputs of production are labour, chemicals, and other capital (all measured in US$), which are assumed to be in unlimited supply to the agricultural sector at a given price. Moreover, the model can endogenously decide to acquire yield-increasing technological change at additional costs, if otherwise there is no feasible solution (i.e. land use pattern) under a given set of resource constraints.

For future projections the model works on a time step of 10 years in a recursive dynamic mode. The link between two consecutive periods is established through the land-use pattern. The optimized land-use pattern from one period is taken as the initial land constraint in the next. If necessary, additional land from the non-agricultural area can be converted into cropland at additional costs. Potential crop yields for each grid cell are supplied by the Lund-Potsdam-Jena dynamic global vegetation model with managed Lands (LPJmL) (Bondeau et al., 2007). LPJmL endogenously models the dynamic processes linking climate and soil conditions, water availability and plant growth, and takes the impacts of CO2, temperature and radiation on yield directly into account. LPJmL also covers the full hydrological cycle on a global scale, which is especially useful as carbon and water-related processes are closely linked in plant physiology (Rost et al., 2008).

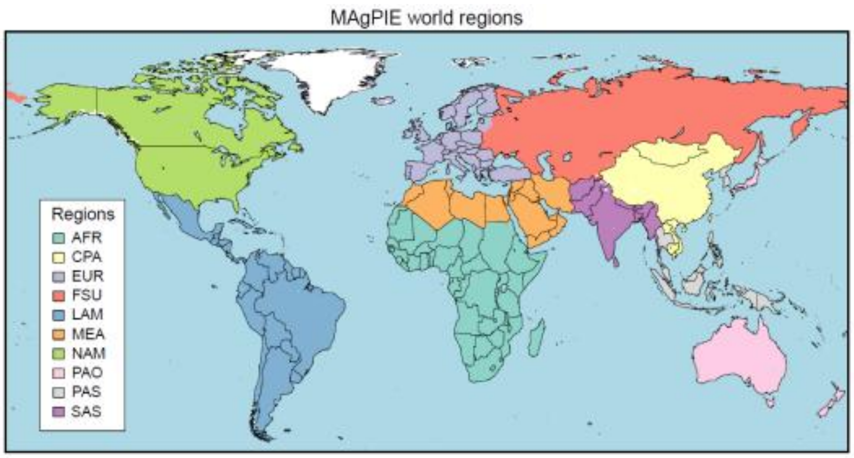

Figure 1: The ten world regions in MAgPIE [2]

Each cell of the geographic grid is assigned to one of ten economic world (see Figure 1). The regions are initially characterized by data for the year 1995 on population (CIESIN et al., 2000), gross domestic product (GDP) (World Bank, 2001), food energy demand (FAOSTAT, 2004), average production costs for different production activities (McDougall, 1998), and current self-sufficiency ratios for food (FAOSTAT, 2005). While all supply-side activities in the model are grid-cell specific, the demand side is aggregated at the regional level. Aggregate demand within each region, defined by total population, average income and net trade, is being met by the sum of production from all grid cells within the region.

Land conversion activities provide for potential expansion and shifts of agricultural land in specific locations. Under exogenous future scenarios of population and income growth, MAgPIE calculates food and bioenergy demand and allows for future projections of spatially explicit land-use patterns, for deriving future technological change rates, and for valuating constraints on land and water availability or trade restrictions.

A mathematical description of the model is provided in Appendix A.

[2] AFR = Sub-Sahara Africa, CPA = Centrally Planned Asia (incl. China), EUR = Europe (incl. Turkey), FSU = Former Soviet Union, LAM = Latin America, MEA = Middle East and North Africa, NAM = North America, PAO = Pacific OECD (Australia, Japan and New Zealand), PAS = Pacific Asia, SAS = South Asia (incl. India)

2.2. Trade Implementation

We implemented international trade in MAgPIE by using flexible minimum self-sufficiency ratios at the regional level. Self-sufficiency ratios describe how much of the regional agricultural demand quantity has to be produced within a region. For instance, a ratio for cereals of 0.80 means that 80% of cereals are produced domestically, whereas 20% are imported. To represent the trade situation of 1995 we calculated the self-sufficiency ratios ($p_{i,k}^{sf}$) for each region *i* and production activity *k* from the food balance sheets of FAO for the year 1995 (FAOSTAT, 2010) (see Appendix A).

We implemented two virtual trading pools which allocate the global demand to the different supply regions (Figure 2). The demand which enters the first pool is allocated according to fixed criteria. Self-sufficiency ratios determine how much is produced domestically, and export shares determine the share of each region in global exports. The export shares are generated for every crop for the year 1995 and are taken from FAO (FAOSTAT, 2010) (see Appendix B). However, although the initial self-sufficiencies for this pool stay constant over time, the final self-sufficiencies do change since domestic demand and population development change over time. The demand which enters the second pool is allocated according to comparative advantage criteria to the supply regions. The parameter p^{tb} defines the share of trade which flows into both pools.[3] If p^{tb} is equal to 1, the total demand will be distributed according to fixed self-sufficiencies and export shares to the supply regions. If p^{tb} is equal to 0, all trading quantity will end up in the second pool and is distributed according to comparative advantage criteria to the supply regions.

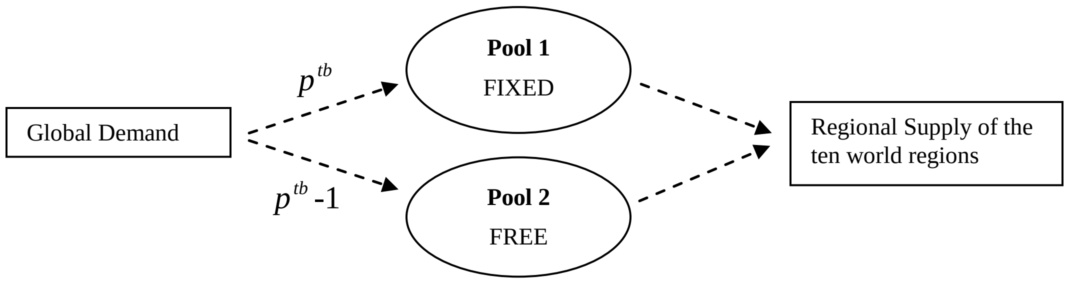

Figure 2: Trading pools in MAgPIE. The fixed pool allocates demand according to fixed criteria (self sufficiency ratios and export shares). The free pool allocates it according to comparative advantage criteria.

The following equations demonstrate the same procedure in mathematical terms. Equation (1) shows the global food balance, where the aggregated regional supply f^{prod}

[3] We call p^{tb} the "trade barrier reduction factor" (see below)

adjusted by the seed share p^{seed} [4] has to be equal or bigger than the aggregated regional demand f^{dem}.

Global trade balance:

$$\sum_i \frac{f_{t,i,k}^{prod}(x_t)}{1+p_{i,k}^{seed}} \geq \sum_i f_{t,i,k}^{dem}(x_t) \qquad (1)$$

with x as the variable for production, i as region, t as time and k as production activity. Subsequently, we introduced excess demand and supply equations. The global quantity of excess demand p^{xd} for each production activity k is calculated by subtracting domestic demand (f^{dem}) from domestic production for the importing countries (for self-sufficiency ratio p^{sf} < 1) (equation 2). Domestic production is calculated by multiplying domestic demand with the self-sufficiency ratio ($f^{dem} \cdot p^{sf}$). The calculated excess demand is distributed to the exporting regions according to their export shares p^{exshr} (equation 3).

Excess Demand:

$$p_{t,k}^{xd} = \sum_i f_{t,i,k}^{dem}(x_t) \cdot (1 - p_{i,k}^{sf}) \qquad : p_{i,k}^{sf} < 1 \qquad (2)$$

Excess Supply:

$$p_{t,i,k}^{xs} = p_{t,k}^{xd} \cdot p_{t,i,k}^{exshr} \qquad (3)$$

The trade balance equation (4) assures that demand and supply are balanced at the regional scale. In the case of an exporting region, the regional supply has to be greater or equal than the domestic demand plus the exported quantity. In the case of an importing region, the regional supply has to be greater or equal than the domestic demand times the self-sufficiency. This holds true, if the trade barrier reduction factor p^{tb} is equal to one. If p^{tb} is equal to zero, the equation becomes zero and everything is solved via the global trade balance (equation 1).

Trade Balance Equation:

$$\frac{f_{t,i,k}^{prod}(x_t)}{1+p_{i,k}^{seed}} \geq p^{tb} \begin{cases} f_{t,i,k}^{dem}(x_t) + p_{t,i,k}^{xs} & : p_{i,k}^{sf} \geq 1 \\ f_{t,i,k}^{dem}(x_t) \cdot p_{i,k}^{sf} & : p_{i,k}^{sf} \end{cases}$$

[4] The seed share accounts for the produced quantity which is used as seeds for the next farming season.

2.3. Irrigation Efficiency

Irrigation Efficiency in MAgPIE is implemented by a factor which comprises the management factor, conveyance efficiency, and application efficiency. Efficiency data come from Rohwer et al (2007), who modelled the efficiency levels on country level. Through a regression analysis we determined that the efficiency level depends on the welfare level (measured in GDP per capita) in each country (World Bank, 2001). Figure 3 shows the result of the regression analysis.

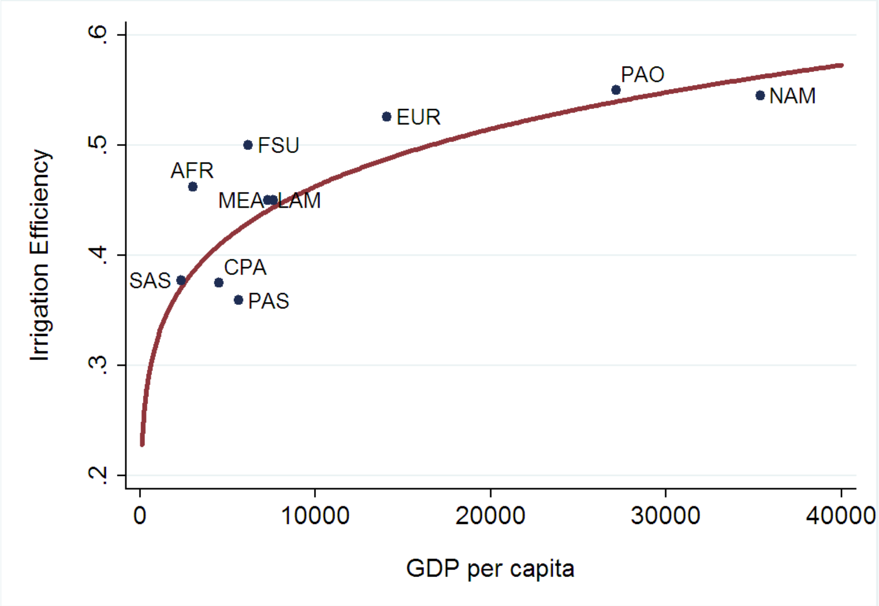

Figure 3: Regression between GDP per capita [in US$ PPP] and irrigation efficiency (ep)

We estimated a power function with an exponent of $ep = 0.134 \cdot gdp^{0.137}$
The p-value of the constant is 0.017 and the p-value of the exponent is 0.005. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the regional values for irrigation efficiency obtained from the regression analysis.

Region	*1995*	*2005*	*2015*	*2025*	*2035*	*2045*
AFR	0.37	0.37	0.37	0.38	0.39	0.41
CPA	0.39	0.44	0.47	0.49	0.51	0.52
EUR	0.47	0.52	0.54	0.55	0.56	0.57
FSU	0.39	0.42	0.44	0.46	0.48	0.50
LAM	0.41	0.46	0.47	0.48	0.50	0.51
MEA	0.40	0.44	0.45	0.47	0.48	0.50
NAM	0.55	0.56	0.57	0.58	0.59	0.60
PAO	0.51	0.53	0.55	0.56	0.57	0.58
PAS	0.39	0.43	0.45	0.47	0.49	0.51
SAS	0.37	0.38	0.40	0.42	0.44	0.46

Table 1: Irrigation efficiency based on the regression with GDP/capita

2.4 Consumption Patterns

Future trends in food demand are computed as a function of income (measured in terms of Gross Domestic Product (GDP)) per capita based on a cross-country regression. The procedures for model calibration and validation are described in detail in Lotze-Campen et al. (2008).

In MAgPIE, demand for agricultural products is fixed for every region and every time step and cannot be influenced by the optimization process. The drivers for the share of livestock products in total caloric intake are income, population growth and time. For income and population, we use different scenarios (like ADAM or SRES) which were downscaled to country-level by CIESIN et al (2000). Within livestock products, the share of different products (Ruminant meat, chicken meat, other meat, milk, eggs) is held fix at 1995 levels. The same is valid for the share of crops.

The share of livestock product calories in total caloric demand is estimated using a linearized linear regression model (LLRM) with gdp, time and their interaction as factors.

$$lvst\_shr_{regr} = \exp\left(a + b * \ln(gdp) + c * year + d * \ln(gdp) * year\right)$$

$with\ lvst\_shr_{regr}$ as share of calories from livestock products, gdp as GDP per capita in constant 2005 international dollar at purchase power parity and year as the year for which the projection shall be made (e.g. 1995). The paramters a, b, c and d area estimated with the following values:

$$lvst\_shr_{regr} = \exp\left(-30.73 + 3.95 * \ln(gdp) + 0.0126 * year - 0.00176 * \ln(gdp) * year\right)$$

The regression is based, first, on total calorie demand per country and livestock calories per country (FAOSTAT, 2010). Calorie demand does not match caloric intake. Calorie demand is the amount of calories in agricultural products which leave the wholesale level for the purpose of food consumption, as registered by FAO. Calorie intake is only a share of that, as a large share of total calories is wasted at local distribution, food service and household level. The second indicator is GDP per capita, constant 2005 international dollar at purchase power parity (World Bank, 2001). For the regression we used 3601 combinations of GDP and calorie demand of 149 different countries in the period from 1980 to 2008.

2.5 Scenarios

We consider one reference scenario and five policy scenarios. The reference scenario (*M0a*) is based on the population and GDP outlooks defined in the ADAM (Adaptation and Mitigation Strategies) project (van Vuuren et al, 2009). Food demand and animal consumption share are also based on data from the ADAM project. The trade balance is kept constant over time which means that trade increase is only triggered by an increasing global food demand (Schmitz et al., 2011).

Trade Policy	**Meat Consumption**	**BAU meat** *[0]*	**Fairmeat** *[2]*
Constant Trade *[a]*		*M0a*	*M2a*
Policy *[b]*		*M0b*	*M2b*
Liberalisation *[c]*		*M0c*	*M2c*

Table 2: Scenario Definition

Table 2 show the scenario matrix with trade scenarios as rows and scenarios on meat consumption as columns. We simulate three trade scenarios. The constant trade implementation *[a]* keeps trade constant over time and no further trade liberalisation takes place. The policy scenario *[b]* follows a historically derived pathway of trade liberalisation. Taking into account various literature sources we decided that a 10% trade barrier reduction each decade until 2045 reflects a realistic policy scenario for the future (Healy et al, 1998; Conforti and Salvatici, 2004)[5]. This is also supported by the general trade study of Dollar and Kraay (2004), who found a 22% tariff cut for non-globalizing countries, 11% for globalizing countries, and 0% for rich countries[6] between the 1980s and 1990s. Finally, we introduced a full trade liberalisation scenario, in which trade is

[5] In the course of the Uruguay Round, tariff lines have been reduced at least by 15 % for developed countries, 10% for developing countries, and 0% for least-developed countries (Healy et al, 1998).
[6] „Rich countries refer to the 24 OECD economies before recent expansion plus Chile, Hong Kong, Korea, Taiwan, and Singapore. Globalisers refer to the top one-third in terms of their growth in trade relative to GDP between 1975–9 and 1995–7 of a group of 72 developing countries for which we have data on trade as a share of GDP in constant local currency units since the mid-1970s. Non-globalisers refer to the remaining developing countries in this group." (Dollar and Kraay, 2004, p. 23)

fully liberalized until 2045. Table 3 shows the development of the trade balance parameter over time in the different trade scenarios.

Year	1995	2005	2015	2025	2035	2045
reference scenario	1	1	1	1	1	1
policy scenario	1	0.9	0.81	0.73	0.66	0.59
liberalisation scenario	1	0.8	0.6	0.4	0.2	0

Table 3: Trade barrier reduction factor in different trade scenarios over time

The meat consumption scenarios assume different shares of livestock in the diet. Table 4 shows the meat consumption share for the two scenarios in different regions in the year 2045.

Region	M0	M2
AFR	12.0%	19.8%
CPA	28.2%	18.9%
EUR	27.7%	17.1%
FSU	28.1%	18.2%
LAM	23.1%	19.4%
MEA	15.9%	19.4%
NAM	27.8%	19.0%
PAO	24.0%	14.7%
PAS	15.9%	18.9%
SAS	16.5%	19.7%

Table 4: Meat consumption share in different meat scenarios in every region in 2045

3. Results

3.1. Regional Water Scarcity

Figure 4 shows the regional water shadow price for the ten world regions. In South Asia water shadow prices are highest with values around 0.32 US$ per m³. By looking on the differences in the five scenarios (Figure 5) it can be seen that in trade as well as lower meat consumption leads to lower water shadow prices. In only some cases the price increases to a low extent. Europe and South Asia profit most. However, whereas Europe has the lowest water shadow prices in the low meat scenario with constant trade (M2a), India profits most from trade liberalisation (M0c and M2c).

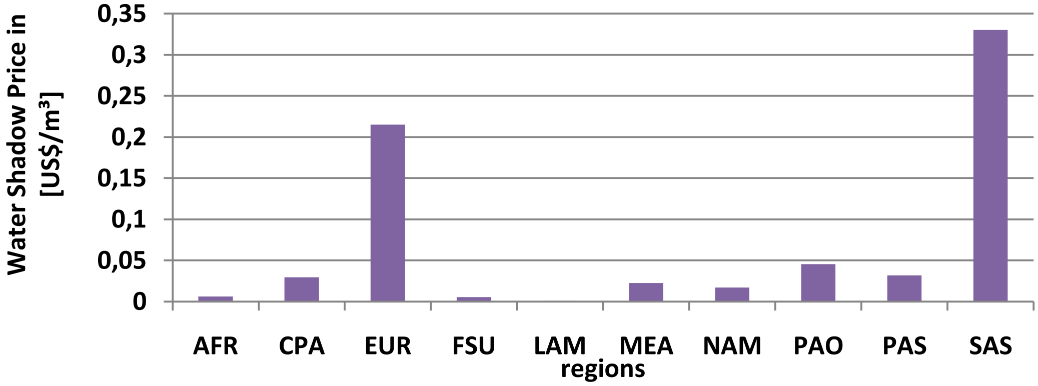

Figure 4: Regional Water Shadow price in the reference scenario in 2045

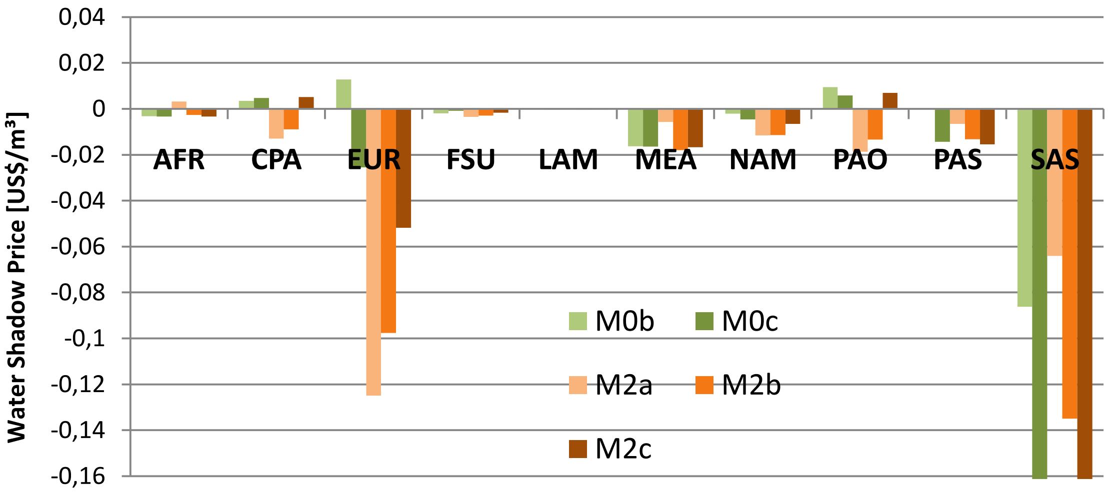

Figure 5: Difference in regional water shadow price (in US$/m³) in the scenarios M0b – M2c compared to the reference scenario (M0a) in selected world region in 2045

3.2. Cell-specific Water Scarcity

By looking on the cell-specific allocation of the water shadow price we differentiate between cells with irrigation and without in the year 2005 (Figure 6) and 2045 (Figure 7).

colored = irrigation area with shadow price > 0
grey = irrigation area with shadow price of 0
white = non-irrigation area with no shadow price

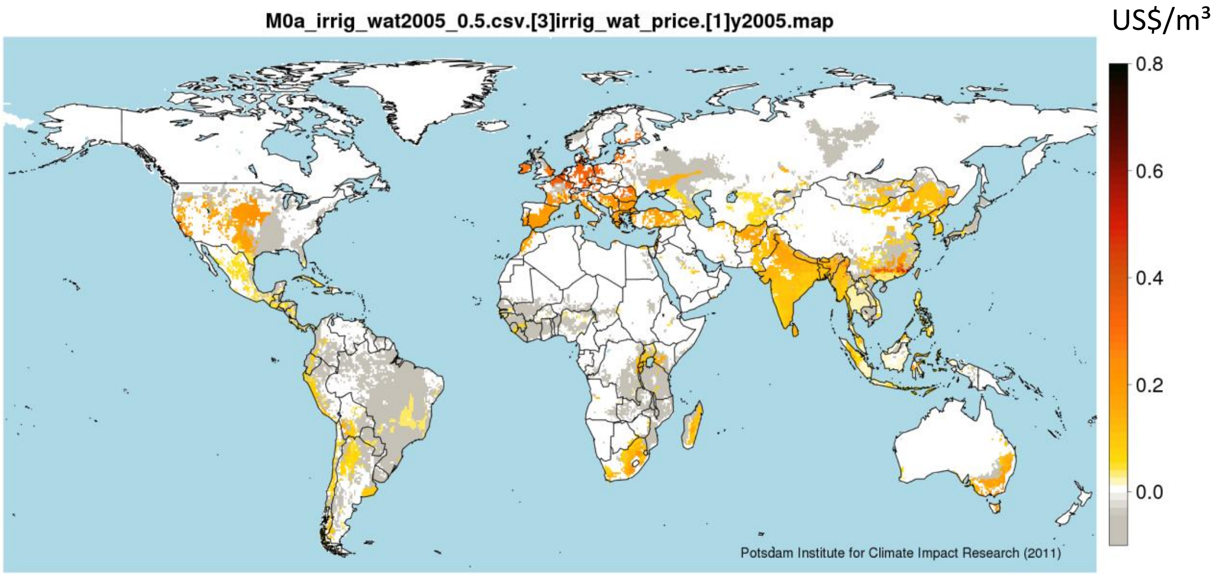

Figure 6: Regional Water Shadow price in 2005 on a 0.5 grid basis

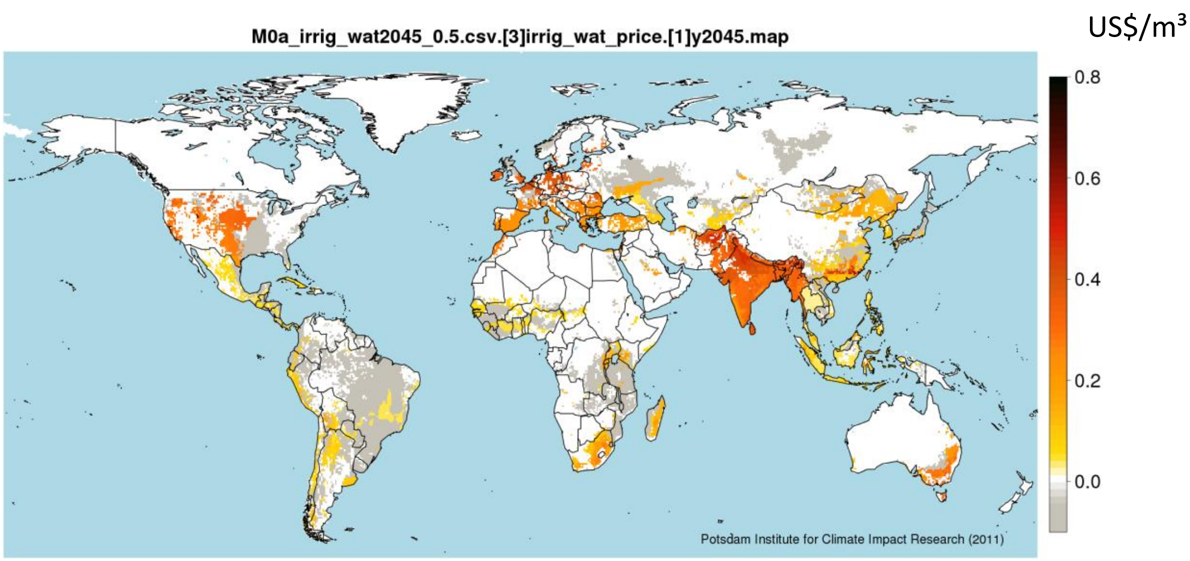

Figure 7: Regional Water Shadow price in 2045 on a 0.5 grid basis

Figure 10 shows the difference maps, which show the absolute difference in the water shadow price between the reference scenario and the five simulation scenarios.

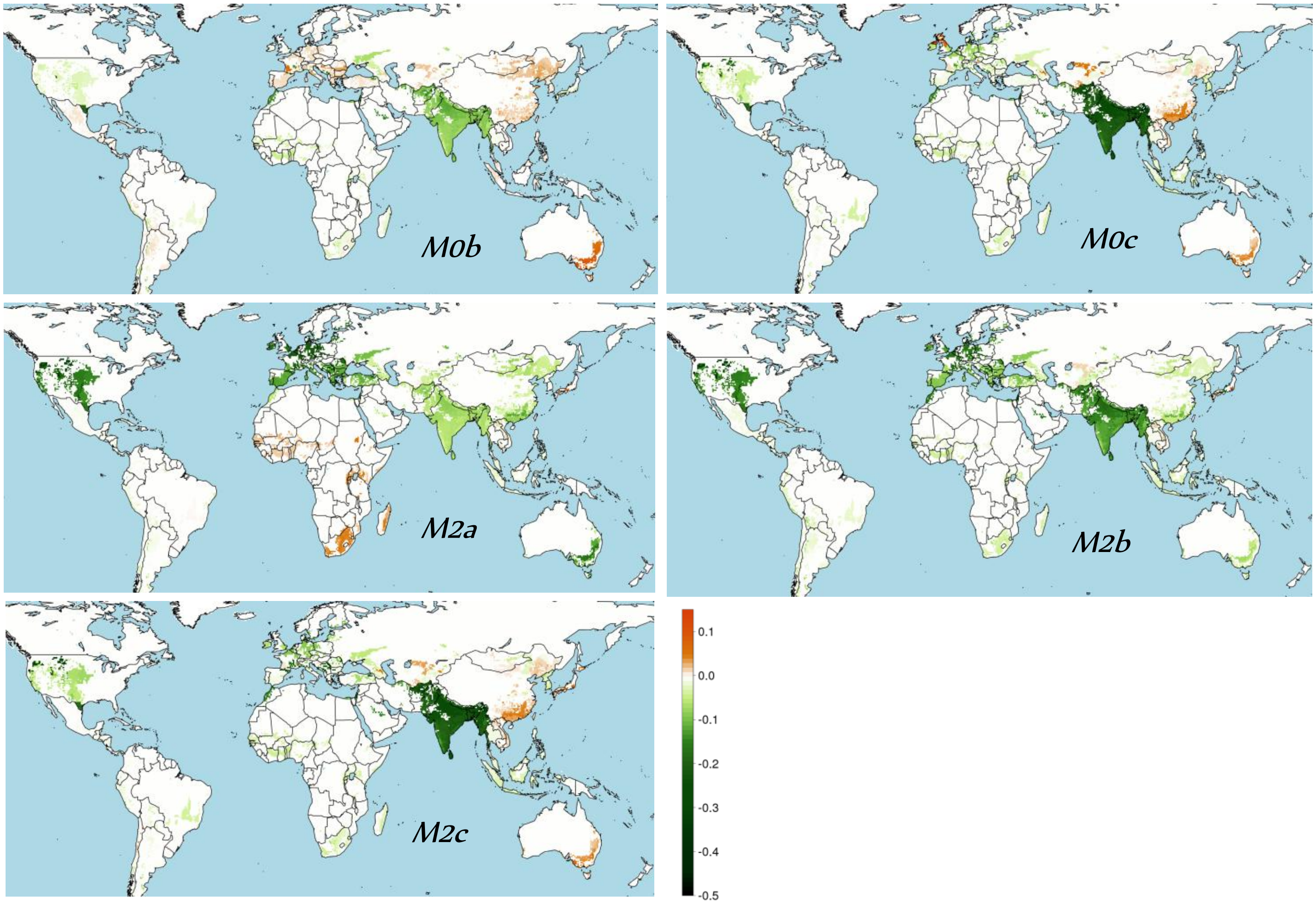

Figure 8: Differences in the cell-specific water shadow price in the scenarios M0b – M2c compared to the reference scenario (M0a) in 2045 on a 0.5 grid basis

3.2. Technological Change

Figure 9 shows average annual technological change (TC) rates of the ten world regions for the reference scenario, which are required to fulfil food demand over the period of 2005-2045. MEA has the highest TC rates over this period with an average value of almost 1.5%. AFR, CPA and SAS have as well high rates with values over 1%. LAM, PAO and FSU have the lowest values.

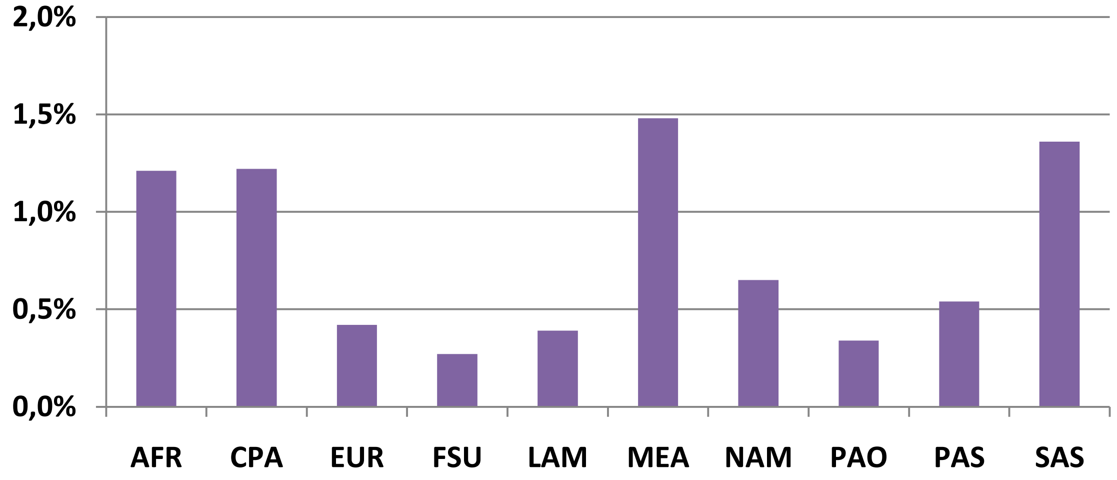

Figure 9: Regional technological change rates in the reference scenario (M0a) over the period 2005-2045

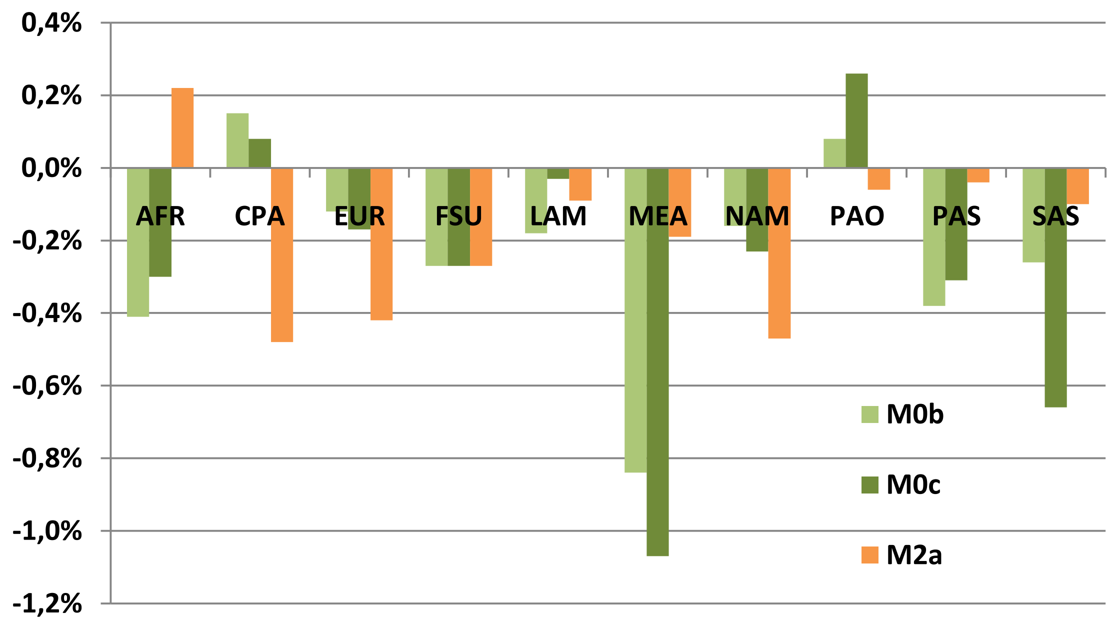

Figure 10: Differences in the regional technological change rates of the M0b, M0c and M2a scenarios compared to the reference scenario (M0a) over the period 2005-2045

4. Conclusions

Water is essential for food production. In many regions of the world water is already today a scarce resource. Due to insufficient price signals this is not yet recognized in all its consequences by most social actors. Many developing countries, which are heavily dependent on the agricultural sector and located in dry areas, are especially affected by water shortage. These countries will also be strongly affected by climate change in the form of altered precipitation patterns, which could further exacerbate their situation in the future. Water shortage could lead to higher food prices and negatively affect regional food security.

Our analysis shows that the re-allocation of agricultural land use after strong trade liberalization in the long run can help to reduce regional water scarcity, especially in world regions where water will become extremely scarce over the coming decades. The pressure on agricultural productivity increase can also be reduced. However, the total effects of trade on regional water use efficiency in the short- to medium term should not be overestimated. A large share of global trade activities currently occurs between rich countries, which either have no water shortages or sufficient potential means for adaptation. Moreover, international agricultural trade is heavily dominated by political preferences and influences, which are rarely concerned with resource use efficiency and which change only slowly over time. Poor, water-scarce countries also face the problem that increased imports of water-intensive goods or "virtual water" would have to be financed with foreign exchange. This would require the development of competitive export sectors, which many developing countries, especially in Africa, failed to achieve in the past.

An important policy option for reducing the pressure on blue water is the investment in technological advancement. Investments in higher crop productivity (by constant water requirements) and investments into efficient irrigation infrastructure and equipment lead to a significant reduction of the pressure on water. Lastly, the impact of a shift in consumption, especially away from livestock products, reduces the total amount of water. Especially North Africa, the Middle East and India, which are hit hardest be water scarcity, would benefit from water-related policy measures, described in this paper.

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Appendix

Appendix A: Mathematical Description of the model MAgPIE

MAgPIE (Model of Agricultural Production and its Impact on the Environment) is a nonlinear recursive dynamic optimization model that links regional economic information with grid-based biophysical constraints simulated by the dynamic vegetation model LPJmL. A simulation run with the simulation period T can be described as a set

$$X = \{x_t \mid t \in T\} \subseteq \Omega$$

of solutions of a time depending minimization problem, i.e. for every time step $t \in T$ the following constraint is fulfilled

$$\forall y \in \Omega : g_t(x_t) \leq g_t(y)$$

where the goal function for $t \in T$

$$g_t(x_t) = g(t x_t x_{(t-1)} \ldots x_1 P_t)$$

depends on the solutions of the previous time steps $x_{(t-1)} \ldots x_1$ and a set of time depending parameters P_t. We may interprete a MAgPIE simulation run $X = \{x_t \mid t \in T\} \subseteq \Omega$ as an element of the vector space $\Omega_T = \Omega \times T$.

Sets

The dimension of the domain Ω_T depends on the following sets:

- $T = \{\text{time steps } t\}$: Simulation time steps, where $t$denotes the current time step, $t-1$ the previous time step and so on. The first simulated time step is $t = 1$.
- $I = \{\text{world regions } i\}$: Economic world regions in MAgPIE.
- $J = \{\text{spatial clusters } j\}$: Highest spatial disaggregation level in MAgPIE.
- $K = \{\text{simulated products } k\}$: Union of vegetal products $V$and livestock products L($K = V \cup L$).
- $L = \{\text{simulated livestock products } l\}$: Products simulated within the livestock sector of MAgPIE.
- $V = \{\text{vegetal products } v\}$: Products simulated within the crop sector of MAgPIE.
- $W = \{\text{water supply types } w\}$: Currently two types are implemented: rainfed 'rf' and irrigated 'ir'
- $C = \{\text{crop rotation groups } c\}$: Groups of crops, which have similar requirements concerning crop rotation criteria.

To highlight the substance of our model equations with regard to the agricultural and economic contents, we split our variable $x_t$into

$$x_t = \left(x_t^{area} \in \Omega^{area} x_t^{prod} \in \Omega^{prod} x_t^{tc} \in \Omega^{tc}\right) \in \Omega$$

where the respective domains can be identified as the following vector spaces

$$\Omega^{area} = \mathbb{R}^{|J|} \times \mathbb{R}^{|V|} \times \mathbb{R}^{|W|}$$
$$\Omega^{prod} = \mathbb{R}^{|J|} \times \mathbb{R}^{|L|}$$
$$\Omega^{tc} = \mathbb{R}^{|I|}$$

As a result, we may specify the dimension of the solution space for each time step as $dim\Omega = |J| \cdot |V| \cdot |W| + |J| \cdot |L| + |I|$ and the dimension of $\Omega_T = \Omega \times T$ as $dim\Omega_T = |T| \cdot dim\Omega = |T| \cdot (|J| \cdot |V| \cdot |W| + |J| \cdot |L| + |I|)$.

In the following, variables and parameters are provided with subscripts to indicate the dimension of the respective sub domains. Subscripts written in quotes are single elements of a set. The order of subscripts in the variable, parameter and function definitions does not change. The names of variables and parameters are written as superscript.

Variables

Since MAgPIE is a recursive dynamic optimization model, all variables refer to a certain time step $t \in T$. In each optimization step, only the variables belonging to the current time step are free variables. For all previous time steps, values were fixed in earlier optimization steps. As we have seen above, we currently distinguish three variables $x_t^{area} \in \Omega^{area}$, $x_t^{prod} \in \Omega^{prod}$ and $x_t^{tc} \in \Omega^{tc}$ that can be described as follows:

- x_{tjvw}^{area}: The total area of each vegetal production activity v for each water supply type w, each cluster j and each time step t [ha]
- x_{tjl}^{prod} : The total production of each livestock product l, for each cluster j at each time step t [ton dry matter]
- x_{ti}^{tc}: The amount of yield growth triggered by investments in R&D [-]

Parameters

Besides variables, the model is fed with a set of parameters P_t. These parameters are computed exogenously and are in contrast to variables of previous time steps fully independent of any simulation output. Although most parameters are time independent, there exist also some parameters which are time dependent.

- p_{tjvw}^{yield}: Yield potentials for each time step, each cluster, each crop and each water supply type taking only biophysical variations into account and excluding changes due to technological change [ton/ha]
- p_{tik}^{dem}: Regional food and material demand in each time step for each product [10^6 ton]
- p_{ilk}^{fbask} : Feed basket parameter describing the share of each product k in the feed basket related to livestock product l and corresponding transformation from GJ feed in ton dry matter [ton/GJ]
- p_{il}^{feed} : Feed requirements for each livestock product l in each region i [GJ/ton]

- p_{ikl}^{byprod}: Feed energy delivered by the byproducts of $k$that are avaiable as feedstock for the livestock product l[GJ/ton]
- p_{iv}^{frv}: Area related factor requirements for each crop and each region based on the technological development level in the initial time step [US$/ha]
- p_{il}^{frl}: Production related factor requirements for livestock products for each livestock type and each region [US$/ton]
- p_{i}^{lcc}: Area related land conversion costs for each region [US$/ha]
- p^{tcc}: Technological change cost factor accounting for interest rate, expected lifetime and general costs [US$/ha]
- $p_{iv}^{\tau 1}$: τ-Factor representing the agricultural land use intensity in the first simulation time step for each crop in each region [-]
- p^{exp}: Correlation Exponent between τ-Factor and technological change costs [-]
- p_{iv}^{seed}: Share of production that is used as seed for the next period calculated for each crop in each region [-]
- p_{tik}^{xs}: Regional excess supply for each product and each time step describing the amount produced for export [10^6 ton]
- p_{ik}^{sf}: Regional self sufficiencies for each product [-]
- p^{tb}: Trade balance reduction factor with $0 \leq p^{tb} \leq 1$which is used to relax the trade balance constraints depending on the particular trade scenario.
- p_{j}^{land}: Total amount of land available for crop production in each cluster [10^6 ha]
- $p_{j}^{ir.land}$: Total amount of land equipped for irrigation in each cluster [10^6 ha]
- p_{jk}^{watreq}: Cluster-specific water requirements for each product [$m^3/ton/a$]
- p_{j}^{water}: Amount of water available for irrigation in each cluster [$m^3/ton/a$]
- p_{c}^{rmax}: Maximum share of crop groups in relation to total agricultural area [-]
- p_{c}^{rmin}: Minimum share of crop groups in relation to total agricultural area [-]

[all ton units are in dry matter]

Sub-Functions

To simplify the general model structure, some model components which appear more than once in the model description and depend on the variables of the current time step t are arranged as functions:

$$f_{ti}^{growth}(x_t) = \prod_{\tau=1}^{t} (1 + x^{tc})$$

$$f_{tik}^{prod}(x_t) = \sum_{ji} \begin{cases} x_{tjk}^{prod} & : k \in L \\ \sum_w x_{tjkw}^{area} p_{tjkw}^{yield} f_{ti}^{growth}(x_t) & : k \in V \end{cases}$$

$$f_{tik}^{dem}(x_t) = p_{tik}^{dem} + \sum_l p_{ilk}^{fbask} \left(p_{il}^{feed} f_{til}^{prod}(x_t) - \sum_\kappa p_i^{byprod} f_{ti\kappa}^{prod}(x_t) \right)$$

f_{ti}^{growth}: Growth function describing the aggregated yield amplification due to technological change compared to the level in the starting year for each year $t$and region i
.
f_{tik}^{prod}: Function representing the total regional production of a product $k$in region $i$at timestep t. In the case of vegetal products, it is derived by multiplying the current yield level with the total area used to produce this product. In the case of livestock products, it is represented by the related production variable.
f_{tik}^{dem}: Function defining the demand for product $k$in region $i$at timestep t. It consists of an exogenous demand for food and materials $p_{tik}^{dem}$and an endogenous demand for feed, which is calculated as the feed demand generated by the livestock production minus the feed supply gained through byproducts.

Goal Function

$$g_t(x_t) = g(t x_t x_{(t-1)} ... x_1 P_t)$$

The goal function describes the value that is minimized in our recursive dynamic optimization model structure in each timestep. It is time dependent, i.e. it differs for each time step, depending on the solutions of the previous time steps. We define the goal function as follows:

$$\begin{aligned} g_t(x_t) = &\sum_{iv} \left(p_{iv}^{frv} f_{ti}^{growth}(x_t) \sum_{j_i w} x_{tjvw}^{area} \right) \\ &+ \sum_{il} \left(p_{il}^{frl} f_{til}^{prod}(x_t) \right) \\ &+ \sum_{i} \left(p_i^{lcc} \sum_{j_i v w} \left(x_{tjvw}^{area} - x_{t-1jvw}^{area} \right) \right) \\ &+ p^{tcc} \sum_{i} \left(x_{ti}^{tc} \left(\frac{1}{|V|} \sum_{v} p_{iv}^{\tau 1} f_{ti}^{growth}(x_t) \right)^{p^{exp}} \sum_{j_i v w} x_{t-1jvw}^{area} \right). \end{aligned}$$

The function describes the total costs of agricultural production. The total costs can be split in four terms: 1. area depending factor costs of vegetal production, which increase with the yield gain due to technological change; 2. factor costs of livestock production depending on the production output; 3. land conversion costs which arise, when non-agricultural land is cleared and prepared for agricultural production; 4. investment costs in technological change to increase yields by improvements in management strategies and other inventions. The technological change costs are proportional to total cropland area of a region and increase disproportionately with yield growth bought in the current timestep and the agricultural land-use intensity.

Constraints

Constraints describe the boundary conditions, under which the goal function is minimized.

Global demand constraints

(for each activity k)

$$\sum_i \frac{f^{prod}_{tik}(x_t)}{1+p^{seed}_{ik}} \geq \sum_i f^{dem}_{tik}(x_t)$$

These constraints describe global demand for agricultural commodities: Total production of a commodity $k$adjusted by the seed share required for the next production iteration has to meet the demand for this product.

Tradebalance

(for each region i and product k)

$$\frac{f^{prod}_{tik}(x_t)}{1+p^{seed}_{ik}} \geq p^{tb} \begin{cases} f^{dem}_{tik}(x_t) + p^{xs}_{tik} & : p^{sf}_{ik} \geq 1 \\ f^{dem}_{tik}(x_t) p^{sf}_{ik} & : p^{sf}_{ik} < 1 \end{cases}$$

The trade balance constraints are similar to the global demand constraints, except that they act on a regional level. In the case of an exporting region (self sufficiency for the product $k$is greater than 1), the production has to meet the domestic demand supplemented by the demand caused due to export. In the case of importing regions (self sufficiency less than 1), the domestic demand is multiplied with the self sufficiency to describe the amount which has to be produced by the region itself. In both cases the demand is multiplied with a so called "trade balance reduction factor". This factor is always less than or equal to 1 and is used to relax the trade balance constraints depending on the particular trade scenario for the future.

Land constraints

(for each cluster j)

$$\sum_{vw} x^{area}_{tjvw} \leq p^{land}_j$$

$$\sum_{v} x^{area}_{tjv'ir'} \leq p^{ir.land}_j$$

The land constraints guarantee that no more land is used for production than available. The first set of land constraints ensures the land availability for agricultural production in general. The second one secures that irrigated crop production is restricted to areas that are equipped for irrigation.

Water constraints

(for each cluster j)

$$\sum_v x^{area}_{tjv'ir'} p^{yield}_{tjv'ir'} f^{growth}_{ti(j)}(x_t) p^{watreq}_{jv} + \sum_l x^{prod}_{tjl} p^{watreq}_{jl} \leq p^{water}_j$$

The output of animal products as well as vegetal products under irrigated conditions requires water. The required amount of water is proportional to the production volume. The whole water demand in each cluster must be less or equal to the water available for production in this cluster.

Rotational constraints

(for each crop rotation group c, cluster j and irrigation type w)

$$\sum_{v_c} x_{tjvw}^{area} \leq p_c^{rmax} \sum_{v} x_{tjvw}^{area}$$

$$\sum_{v_c} x_{tjvw}^{area} \geq p_c^{rmin} \sum_{v} x_{tjvw}^{area}$$

The rotational constraints are used to prescribe typical crop rotations by defining for each vegetal product a maximum and minimum share relative to total area under production in a cluster.

Chapter 6:
Water Pricing Strategies in an Integrated Water Services Management Framework

Kristina Bernsen

1. Introduction

This paper will be a short presentation of the hotly discussed and pressing problem of pricing water in the face of multiple and conflicting objectives, which water prices are supposed to pursue, and the various resistances to reform. This topic is prevailing in industrial countries like the European Union member states, as the emphasis on economic instruments in the Water Framework Directive (WFD) demonstrates, as well as in developing countries, where local preconditions like economic, social or technical issues pose special challenges to the pricing of water[1]. A water pricing strategy needs to reflect these local particularities as well as the various conflicting objectives, which water prices need to take into account as it has oftentimes been recognized in the political discussion (OECD 2010), through the various pricing instruments which are available. The next section will shortly introduce the notion of a water pricing strategy and the main research questions which are worth examining. Section three will then describe the most important elements of a water pricing strategy. Firstly, the various and conflicting objectives of water prices will be delineated, followed by a "toolbox" of water pricing instruments, which contribute to these objectives to varying degrees, and finally the external framework conditions, which are essential in shaping a water pricing strategy in that they influence a society's objectives and prioritizing thereof will be assessed. Finally, some conclusions will be given.

2. The idea of a water pricing strategy

As the title shows, the emphasis in this study will lie on the pricing of water services, while the term "integrated" points to a focus on the water consumption as well as on the pollution side. By water services here means the drinking water use by private households and

[1] These questions are examined in a research project at the University of Leipzig and the Helmholtz-Centre for Environmental Research, Leipzig.

sanitation, water use and pollution emission in industry as well as agricultural irrigation through public networks and private wells. As has been emphasized many times (McNeill 1998, Briscoe 1996), water should be "managed as an economic good", meaning that economic ideas from neoclassical welfare theory, which call for an efficient allocation of (environmental) goods by the means of prices to maximize social welfare should be taken into account in water resources management. Concurrently, it has been noted that water prices need to fulfill various conflicting objectives like economic efficiency, equity, ecological sustainability or the cost recovery of water services providers, "taking into consideration specific local conditions" (OECD 2009), while it has also been recognized that water pricing reforms are subject to various political-economic challenges (Dinar 2000). Thus, we have a very clear and simple general principle which is supposed to guide water pricing policies, which has however also been criticized from various sides (e.g. Hampicke 1992), despite many developments in economic theory like the New Institutional Economics, the New Political Economy or the standard-price-approach just to name a few[2], for its simplicity which blanks out many real world problems like the importance of the resilience of ecosystems, questions of distribution or already existing environmental policies, institutions, actors and interest groups: According to welfare economics, the state should leave all questions of equity to a redistributive welfare policy and leave relative prices undistorted (Kleinewefers and Henner 2008), which exactly opposes the view that water prices should take into account different objectives. Antipoles to neoclassical environmental economics exist in the form of alternative approaches like ecological economics (e.g. Daly and Farley 2004, Hampicke 1992) or human rights centered approaches (Gleick 1998), which at times oppose the notion of water as a "commodity" and therefore also its pricing. The position here is that welfare economics should still be the principle of any rational and efficient water policy, but that it should be enhanced by components of New Institutional Economics: The idea is to analyze the tradeoffs which are experienced in practice from a theoretical perspective, and relate these to the existing pricing instrument, which should lead to a pricing strategy which could realistically implemented. Saleth and Dinar (2004) for instance have analyzed water problems from an institutional economics perspective, whereby they identify as the main institutions which influence a water allocation policy the

[2] Additionally, the conflict between marginal cost pricing and the cost recovery of a natural monopoly has been thoroughly examined in regulation theory (Spelthahn 1994).

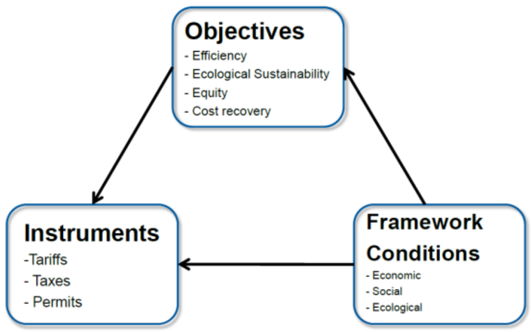

Figure 1: Objectives, Instruments and Framework Conditions.

existence and distribution of water rights, the technical environment and the possibility to install water meters, the existence of water markets and conflict resolution mechanisms, as well as the possible existence of water user associations. But also basic social norms like the concept of human rights (see for the case of water the International Covenant on Economic, Social and Cultural Rights (*http://www2.ohchr.org/english/law/cescr.htm*) as well as General Comment No. 15 issued by the UN Economic and Social Council (*http://www.unhchr.ch/tbs/doc.nsf/0/a5458d1d1bbd713fc1256cc400389e94*)) or notions of what is equitable or fair can be viewed as institutions, which have to be taken into account in the implementation of a water pricing strategy. This leads to the conflicting objectives which have been mentioned above: while in neoclassical welfare economics, questions of efficiency and distribution should be separated, while, as has been mentioned above, it is not the role of prices but of social policy to pursue social objectives, in an institutional economics analysis a price sometimes has to reconcile both objectives to make a reform even feasible (Gawel and Bretschneider 2011). Thus, a water pricing strategy is a further development of the neoclassical pricing paradigm, this time with a multidimensional set of objectives. The goal is not to calculate a single price which maximizes welfare or profit in a river basin, but to give advice for political strategies in the implementation of a water pricing reform from the perspective of neoclassical and new institutional economics. Therefore, it would be an interesting research task to delineate very general relationships between the various objectives that a water price is expected to fulfill and the choice of water pricing instruments. The objectives, which are prioritized in a certain context are in turn influenced by the external conditions which prevail in a certain country or region, which leads to the general diagram in figure one. Thus, it would be worthwhile to analyze the relationship between the given framework conditions in a certain region, divided into economic, social, and ecological factors, the resulting prioritizing of objectives, and the consequences for the choice of instruments: Since there exists a multitude of case studies analyzing separate aspects of water pricing in a certain region, but no overall assessment of these general relationships, this gap should be filled. As an example for a water pricing strategy, again the approach of the EU WFD can be cited as an example, since here also reference is made to the conflicting objectives in water management: The foremost aim of the WFD is full cost recovery in the pricing of water services, including environmental and resource costs. However, social and economic issues may be weighed against these primary objectives by the member states, taking into account their specific regional situation.

3. Elements of a Water Pricing Strategy

3.1 Water Pricing from the Perspective of Neoclassical Economics

Firstly, neoclassical economics as a principle in environmental policy should be reassessed to answer the question which factors in the pricing of water services can be reflected in economic models, and which factors cannot. This aspect is not supposed to be a critique of welfare economics or neoclassical environmental and resource economics, but only serves to give a starting point.

3.2 The four objectives of water pricing

The OECD (2009) has identified the four main objectives that a water price needs to fulfill, as well as the possible tradeoffs between these objectives, as can be shown by figure 2.

A more detailed assessment is needed of what exactly these objectives imply in the case of water services pricing, and where exactly the tradeoffs between these objectives lie. For this, the different components of the objectives can be delineated. Already the objective of efficiency can be the source of some confusion, as in practice usually the term is equated to technical efficiency in production or the provision of a service, while welfare economics offers a set of marginal conditions which need to be fulfilled to maximize welfare like efficiency in the employment of factors, efficiency in consumption or efficiency in exchange, whereby a temporal dimension (dynamic efficiency) or the presence of external effects may be added as well. Like the objective of efficiency, other objectives have several aspects as well and cannot be reduced to one single dimension. If one views, for instance, the objective of equity as equity in exchange, that is, the polluter or the user makes a "fair" contribution

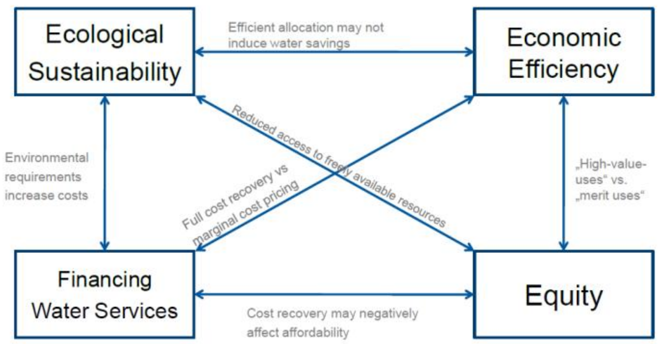

Figure 2: The Four Conflicting Objectives of Water Pricing.
(Source: Leflaive 2009)

according to his or her claim to a resource, there does not need to exist any tradeoff regarding the objective of efficiency (Gawel 2001). If on the other hand, objectives of redistribution are involved or the concern over a minimum of water services for the poor, this task lies out of the scope of a price instrument, according to the efficiency objective. Likewise, the case of merit goods has been discussed widely in public finance theory (e.g. Head 1988), because the provision of these goods touches upon question of allocation and distribution, and this concept has also been applied to water services (Opschoor 2006). Based on a more refined definition of the four objectives, a tradeoff analysis which assesses a bit more closely the actual conflicts and complementarities between the objectives presents an interesting research question.

3.3 Elements of a Water Pricing Strategy – A Toolbox

Different pricing instruments are available in the "toolbox" of economic instruments in water management. In the pricing of water services, different pricing tools like tariffs in their various forms, transfers, taxes or even tradable permits can be thought of, which contribute to the achievement of the four objectives to varying degrees. The question as to how different tariff structures and pricing tool contribute to various objectives has been approached by some (Cornish et al. 2004, Mann 2009) but can be developed further. Uniform block rates based on marginal costs for instance are thought to pursue the objective of efficiency, while increasing block rates are at times deemed most suitable to pursue the objective of equity, if they provide a "subsistence block" at a low price. Based on the questions, which should be the assessment base of the price, and which institutional preconditions are needed (metering, information, means test, …), which should be the desirable price level (marginal costs, average costs, a certain percentage of users' income, …), and finally the price structure (uniform tariffs, flat rates, increasing block tariffs, …), an instrument-objective-matrix can be developed, which reflects the contribution of pricing instruments to the four objectives.

3.4 Framework Conditions and their Influence on Social Objectives

The next question refers to how the different objectives are weighted, that is, which factors lead to the prioritization of certain objectives. To answer this question, the framework conditions in a certain region have to be examined, based on economic, social and ecological criteria, since these determine the most pressing problems and thus the most important objectives to be pursued in a society. Some of the most important indicators are of course the ecological framework conditions like an arid or a humid climate, the distribution and occurrence of water resources, as well as current qualitative water problems. Next, institutional preconditions and governance structures need to be assessed, since these determine the possibility of implementation of a water pricing strategy. Furthermore, socio-economic indicators are important determinants which shape the priorities of a region. A region might depend on agriculture or rather employ its water resources in the industry or household sector, grow rapidly or rather stagnate on a high level of economic development. Social indicators which influence the objectives of a water pricing strategy are for instance population growth, income inequality or the rate of access to water and sanitation services. To examine the relation between the objectives of water pricing, the available instruments or tools and the existing framework conditions which is depicted in the diagram on page two, the attempt is to develop a typology of water related problems. As figure one shows, the external conditions determine the most pressing problems and therefore the prioritized objectives, which in turn determine the choice of instruments. Examples of types which could be examined in the study are a water rich industrial country with low population and moderate economic growth, a low proportion of water use in agriculture and a near universal access to water services. On the other hand, this case could be compared to an arid developing country with a high dependence on agriculture, high population growth and "bad governance", or a fast growing transition country. In a fast growing economy with a high dependence on agriculture, for instance, the objective of efficiency may be more important than in a water rich industrial country, which may be more concerned with the recovery of infrastructure costs or the attainment of specific environmental objectives (for instance the good water status in the European Water Framework Directive). What is more, depending on the context, various challenges in the implementation of a water pricing strategy may arise, such as technical difficulties (for instance the non existence of water meters), illegal connections and theft, political economic obstacles to reform from citizens, farmers or other interest groups, or even corruption and bad governance, which of course have to be taken into account.

Finally, one of the types can be chosen for an "artificial case study" to examine more closely the relationships mentioned above.

4. Conclusions

The idea of a Water Pricing Strategy is to take neoclassical environmental economics as a principle, but to bring this principle closer to reality by recognizing the importance of pursuing multiple objectives in the implementation of an actual reform. The focus of this study is the role of these multiple objectives as well as the tradeoffs and conflicts between the objectives, whereby an attempt is made to examine the relationship between the external framework conditions in a society, its prioritization of objectives and the choice of instruments, which will be approached by developing a typology of water problems. The main question which should be examined is how the various pricing instrument which are available can contribute to reconciling the conflicting objectives, which are oftentimes evoked in the political discussion, or if there are in fact objectives which can be pursued more effectively by other policy means, an analysis which has never been conducted in a broad and general way. Examining these questions could lead politics a little closer to the drawing up of realistically implementable water pricing strategies.

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Chapter 7:
The right to water from an economic point of view

Wolfgang Bretschneider*

I. Introduction

Enough has been written and said to emphasize that the issue of an equitable provisioning of potable water is a major concern and challenge for this century of superlative importance. There is no reasonable way to deny it. Just like for many other publications it is the starting point of reflection for this paper.

In the light of this diagnosis it appears *very plausible* that there is a wide movement which intends to strengthen a human right to water. In recent years a remarkable number of publications were released working on the issue how the human right to water might help to accomplish the social concern mentioned above. This discussion is on a state where the question of the 'implementation' is tried to be answered. But somehow there appears to be some stagnation. On the other hand it appears *very implausible* at first sight that the OECD mentions three more objectives of water policy additionally to that social concern. These three other objectives are *economic efficiency*, *ecologic sustainability*, and *financial sustainability* (see OECD 2010: 26). But how can they be as important as the social concern of provisioning?

The answer might be given two ways. The first way implies a competing relation to the other objectives. Even if there is an objective of existential importance, other objectives cannot be just ignored, implying – if so – existential concerns as well. The avoidance of water wastage affects other users that need potable water too, different socially important uses though not vital (both *economic efficiency*), and of course the *ecologic sustainability*. If it is assumed that the government helps out for financing as the case may be the avoidance of financial wastage affects the multitude of governmental responsibilities that have to be financed too. The second way implies a functional relation to the other objectives. The three other objectives are to a certain extent prerequisites to the provisioning of potable water. In other words they are instrumental objectives that render the provision possible in the first place. This concerns the watercourses, which must not be overstressed ecologically. And it concerns the water services which have to be financed. For institutional design though it is to be noted that although there

* Dipl.-Vw., University of Leipzig, Institute for Infrastructure and Resources Management.

is this functional relation to a certain extent, the four objectives have to be handled *as if* they were competing objectives.

In an economic perspective both views are taken seriously: The overwhelming importance of provisioning of drinking water considering as a human right and the consideration of the three other objectives. The reason for this synthesis is – this is the basal thesis – that the concretion of the human right is positively reliant on its competing objectives. This article intends to present a mind-set for the concern of the right to water that is able to cope with its competing objectives. The paper is structured as follows. Section II presents a prevailing perspective of the human right to water. This mind set potentially impedes a concretion of the right to water's concern. In Section III a contractual-economic mind-set is presented which might be a (more) useful framework. Section IV presents three conclusions.

II. A Prevailing Perspective of the Right to Water: Vertical Commitment

In this section the somehow conventional argumentation of the human right to water will be sketched. It always starts with the consideration of the existential meaning of water. It is reasonable to describe the importance in terms of superlatives: Water is „essential for life, crucial for relieving poverty, hunger and disease“[1], it is „necessary for the survival of all life on earth“[2] – Again, there is no reasonable way to deny or to limit the importance of water.

This positive diagnosis is linked with the normative postulation that no human being should suffer from essential scarcity of potable water, in a way that threatens his or her life and dignity. It is almost self-evident that for this universal concern a relation to human rights is being looked for. In the early declarations the right to water is not explicitly mentioned. However some articles contain certain norms, which might imply a right to water, like Article 11 of the *Covenant on Economic, Social, and Cultural Rights* (*ICESCR*) of the year 1966:

> "1. The States Parties to the present Covenant recognize the right of everyone to an adequate standard of living for himself and his family,[…] and to the continuous improvement of living conditions. […]“

What is deflating in the light of this normative standard is that it just does not happen everywhere. In many corresponding publications one can read superlative numbers of people who do not enjoy such a standard regarding water, just like in *Hardberger* (2005):

[1] U.N. Department of Technological Cooperation for Dev. Water Resources; so zitiert in *McCaffrey* (1992: 5).
[2] *Hardberger* (2006: 534).

> "[O]ver one billion of the world's more than six billion people do not have available sources of clean water for drinking. An additional 1.6 billion people […] do not have sufficient water for health and hygiene. Over two million people die every year to a lack of safe water."[3]

How can one bring together the standard and the reality which are apparently far away from each other? The systematically first step was to expatiate the human right to water. *Gleick* diagnosed: "A transition is underway making a right to water explicit."[4] In a row of others over the decades, the *General Comment* No. 15 is a central document, which is a right to water-related interpretation of the Articles 11 and 12 of the mentioned *ICESCR*.

The systematic objective of this explication is to make a commitment possible. The right to water should be 'guaranteed', 'acknowledged', 'recognized', or 'reaffirmed'. For this commitment there prevails implicitly a conception of, so to say, a vertical commitment (see fig. 1). It is the intention, that all relevant institutions and organisations are committed to the, more and more expatiated, human right. In this sense ideally constitutions are committed to the human right, governments are committed to their constitutions, and water utilities are committed to governmental rules in order to serve needy people with sufficient drinking water.

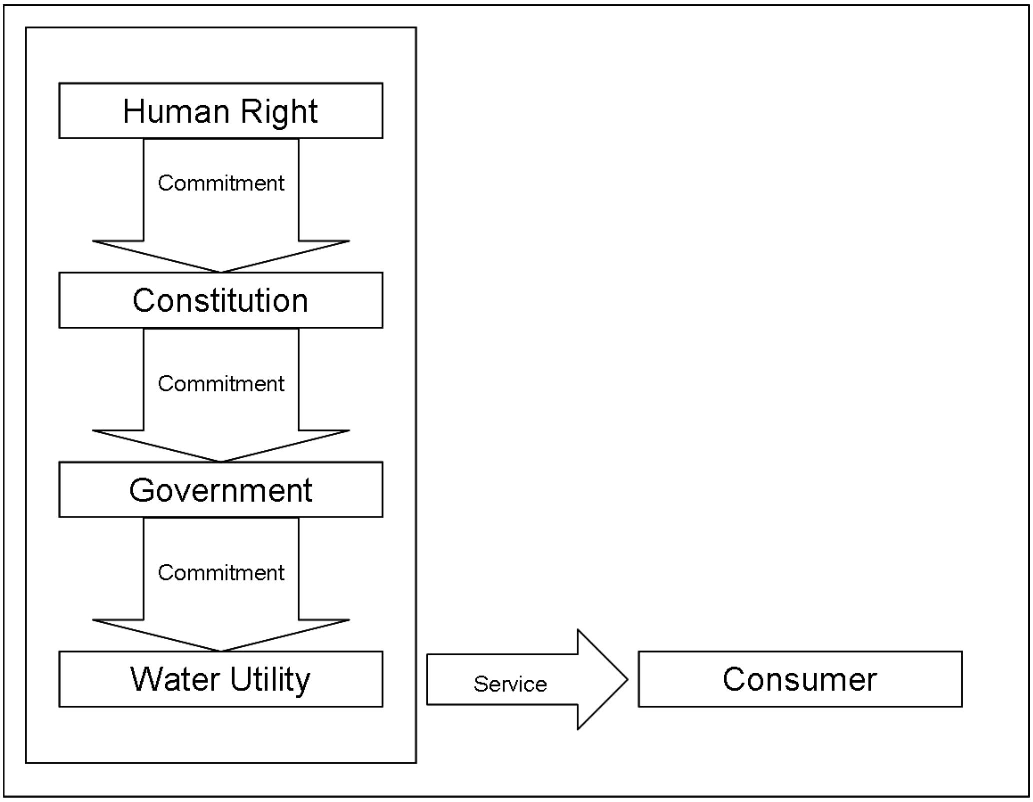

Fig. 1: Vertical commitment of the right to water.

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[3] *Hardberger* (2005: 331).
[4] *Gleick* (1999: 488).

It can be observed that this vertical chain is somehow a conceptual vehicle to get the ideal of sufficient potable water for basic needs into reality, from the global norm to implementation on location. There is somehow an understanding that the problems of undersupply still exist, especially in many development countries, in spite of explication and reaffirmation. The perspective of vertical commitment concludes that the commitment is not hard enough. The strategy for implementation equals then a "road to justiciability"[5], which promises the individual to skip the levels of unwilling water utilities and governments and to make the human right and constitutions advocates that may force lower levels to implementation.

There are obviously some obstacles for the implementation of the right to water. At this point it is argued that for the discussion about implementation, a different mind-set than the one of 'vertical commitment' is helpful. What is proposed here is an approach that might be called 'succeeding contract'. It bases upon the economic transaction, focuses – like with the aid of a magnifying glass – on the lower part of fig. 1. It is therefore in a way more 'horizontal' and has the potential to take the competing objectives into account.

III. A Contractual-Economic Perspective of the Right to Water: Succeeding Contract

The term access is central in the debate of the right to water. Sometimes it is used in the sense of the physical access of consumer to the water intake point, i.e. the distance plus all troubles and risks. Elsewhere it is used as an integration of physical and economic access.

Here a third understanding of access is proposed, access as a succeeding contract. For the realization of the right to water it might be also important that different statutory corporations and organizations acknowledge the right. But in the end it is crucial whether the contract, the transaction between supplier and user is successful. This implies that there is no vertical one-way road, the concept of vertical commitment suggests. Rather the user with his capabilities becomes relevant too. "[I]t is important to bear in mind that human beings are responsible for themselves and their own well-being."[6]

What kind of contract is meant here? Human rights and constitutions are actually contracts too. However, they are *social* contracts that apply to all members of the society. The contract at this point is rather an *individual* contract, paradigmatically concluded on a market.

[5] *Pejan* (2004).
[6] WHO (2001).

However, from the normative right to water-point of view it is different, there are risks lying in this efficiency-discrimination; namely two:

- The first risk is that the contract as such does not come about. This happens when at least one party refuses the contract. This explains why there are places in the world without water suppliers. They do not exist at places where they decide not to invest. From an economic point of view, it is not at all preferable that a contract comes about. It is rather economically necessary that potential interests are excluded. Not all needs should be satisfied, only those whose fulfilment is efficient. For potable water needed for basic uses the situation is normatively a different one of course.
- The second risk is that the contract comes about but with normatively unacceptable conditions. One might accept them anyway if one heavily depends on consumption of this good. For water this might be the case in many situations (inelastic demand).

A succeeding contract is a contract which is able to dissolve these two kinds of risks. While the right to water-perspective focuses on the risks for the user, it is shown that there are risks for the supplier too.

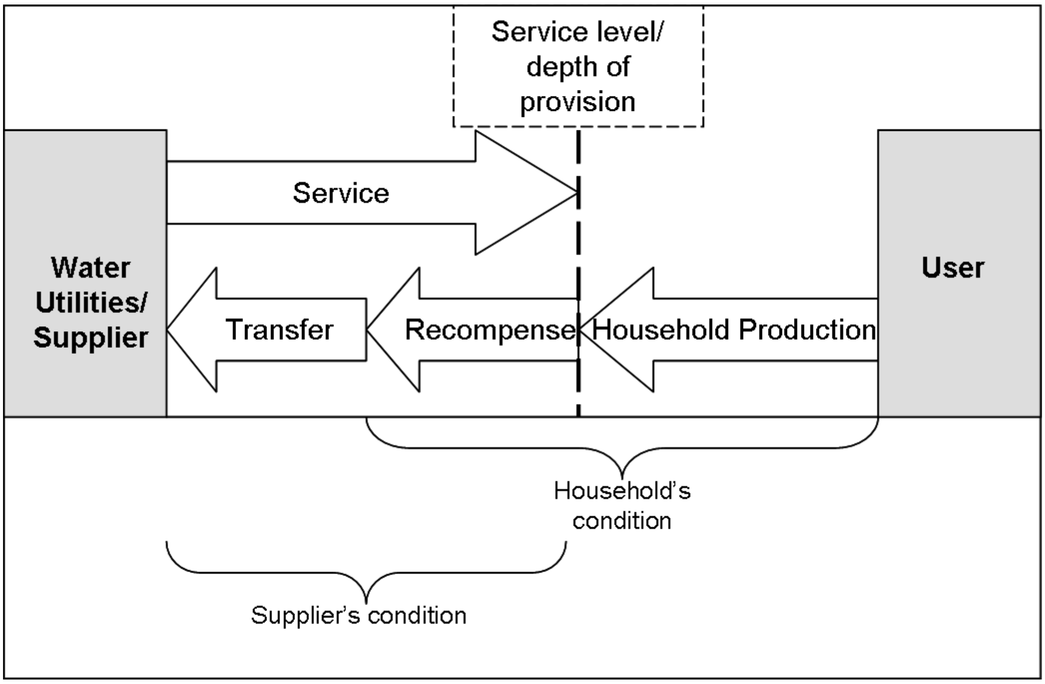

Fig. 2: Access to water as succeeding contract.

Fig. 2 shows the transaction of water supplier and user. In there we find the components of an ordinary transaction: The service, delivered by the supplier, and the user's recompense. A crucial question for water services is the service level that is demanded by the right to water. This level determines the suppliers costs, i.e. his conditions out of the contract. The consideration of the right to water demands to add two further components. There is the household production, what we mentioned before as ‘physical access’. In a different terminology one may call it non-pecuniary costs. The higher the service level of the supplier is, the smaller is the necessary household production et vice versa. This relation is important especially for water services in developing countries. Household production and recompense together are the household’s condition out of the contract. Another aspect is the possibly necessary transfer, maybe from other water consumers, maybe from taxpayers.

Within this framework – this is our thesis – the right to water may be adequately concretized. There are needed four normative definitions, that relate to each other like communicating pipes (see again fig. 2). The service level is to be defined (1). This defines implicitly the necessary household production (2). Then the ‘affordable’ recompense of the user is to be defined (3), which defines *uno actu* – given a certain service level – the needed transfer (4), to refinance the service.

Thus this is a concretion in the light of the three competing objectives. The requirement of financial sustainability is very obvious. The defined or realized service level has to be refinanced, by whatever source. But also the objectives of *economic efficiency* and *ecologic sustainability* are taken into account. The household’s conditions are wattles that functionally discourage from the consumption. That leaves parts of the resource for other users.

One part of the household’s conditions, one wattle, is the recompense, the economic price, the pecuniary costs. Prices set boundaries and this fact is a major challenge for the objective of equitable water provisioning. They do exclude and discriminate, they decide who can consume potable water and who not. The tendency of price increases over the past years speaks in favor of the three other objectives, but is however a problem for equitable water provisioning.

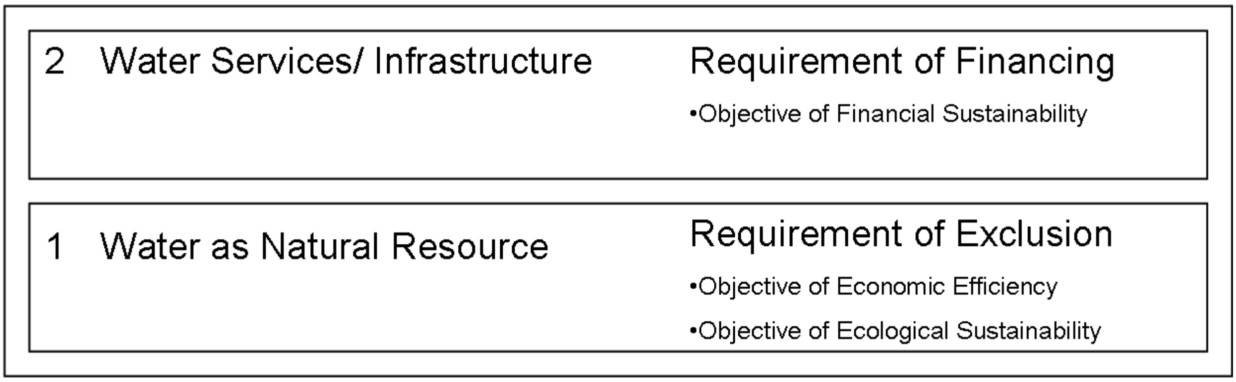

Fig. 3: Two levels on the side of water supply.

In spite of the concern of equitable provisioning it is important to be aware of price functions and their significance for the supply of potable water. There are two functions that are to be stressed here, which affect two levels of the supply side, see Fig. 3; on the first level water as natural resourse, as water course ('Wasserdargebot') and water services, the needed infrastructure.

1. Regarding the level of water as natural resource it is necessary to exclude. In the light of water scarcity it is necessary to keep certain, 'inefficient' potential uses and users from the resource. This affects the objective of *economic efficiency* as well as – over time – *ecologic sustainability*. The economic price is a possible institution to decide which use is worth to be realized. Users pay an *exclusion price*.

2. Regarding the level of water services it is necessary to financing is relevant. The water courses as such do not fulfill the standard of the right to water in most cases. Rather an adequate infrastructure is needed. Necessary are procurement, retention, treatment, and distribution of water. Especially the latter requires high costs. The economic price is a possible institution to finance the needed services. Users pay a *financing price*.

Basically these two functions could be fulfilled also by other, 'less economic' institutions. E.g. exclusion could be realized by the first come-first served principle; and financing could be realized by public taxes. However what remains certain is that these two functions have to be fulfilled anyhow.

IV. Three Conclusions

In order to realize equitable water provisioning much is left to do. A broad movement is on the way to stand up for this fundamental concern. It is quite near-by to refer to the human rights. The challenge is still and will be for the following decades to transform this global norm into realization on location. For that transformation the economic perspective is able to give some advice, namely three:

- If one is interested in the realization of equitable water provisioning, one should have an eye for the three competing objectives of water policy, especially since they support the provisioning in the long run. Or in a negative expression: If one does not care for the competing three objectives, the right to water's concern will be fallen short.
- If one is interested in the realization of equitable water provisioning, it is important to look beyond the conception of only vertical commitment and to switch to the perspective of the succeeding contract. This makes the conditions of the user visible and its relation to the service level. There is no reason for ignoring that there are certain conditions for the consumer. With these conditions the three competing objectives find their way into the right to water-issue. It is a framework for the fine-tuning of what can reasonably be claimed by the right to water, in the light of the competing objectives.
- If one is interested in the realization of equitable water provisioning, one has to find ways for financing and exclusion. A pecuniary price for potable water might fulfill these functions. If the legitimacy of an economic price is called into question, an answer has to be given, how these functions might be fulfilled differently.

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Chapter 8:
Can climate change mitigation reduce water stress?

Monika Prasch
Department of Geography, Ludwig-Maximilians-Universität, Luisenstrasse 37, 80333 Munich, Germany, m.prasch@lmu.de

Introduction

Global climate change will impact future human livelihood as well as demographic, economic and land-use changes (IPCC 2007). In order to reduce global greenhouse gas emissions (GHGs), or at least to stabilize them, and accordingly to prevent unlimited future climate change impacts (mitigation), the United Nations Framework Convention on Climate Change (UNFCCC) entered into force in 1994. While the convention only encourages their 195 parties (165 signed) to stabilize GHGs, the Kyoto Protocol commits them to do so. It was adopted in 1997. Currently, 192 parties ratified, accepted, approved or accessed, and 84 parties signed the Kyoto Protocol (UNFCCC 2011). To comply with the commitment, a variety of mitigation policies, measures and instruments are applied or under development, ranging from regulations and standards, new technologies, taxes and charges, financial incentives to voluntary agreements and information instruments (IPCC 2007). Although water related issues are not addressed directly in the IPCC mitigation report, which discusses the sectors of energy supply, transportation and its infrastructure, residential and commercial buildings, industry, agriculture, forestry, and waste management (IPCC 2007), they are affected by mitigation measures. The measures influence water resources and their management, both in quality and quantity, and vice versa, so that water management measures can impact on GHG emissions in strengthening or weakening the reduction / stabilizing efforts (BATES ET AL. 2008).

Since future freshwater availability is a key factor for regional development, as not only drinking water but also food and energy production, health, and industrial development are all, to a certain extent, based on sufficient fresh water supply, the relationship between mitigation instruments and water resources determines future development. In the following, a general overview of the links of mitigation measures and water resources is given, focussing on renewable energies. Accordingly, various issues of the impact of mitigation options on water resources under future climate change are discussed.

General overview

The utilization of bio-fuels, biomass electricity, hydropower, ocean energy, geothermal energy, unconventional oil, and carbon dioxide capture and storage (CCS) for energy production, water cooling systems in buildings and industry as well as wastewater management are identified as mitigation options related to water resources, following BATES ET AL. (2008) and EDENHOFER ET AL. (2011). This also includes changes in land-use and its management. The measures can influence both, water quality and water quantity in a positive and negative way, and reduce, respectively increase water stress. In some cases, both, positive and negative impacts are possible results of one mitigation measure.

Especially, the sector of renewable energies plays an important role in reducing CO2 emissions. The *Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN)*, which will be released by June 14th 2011, assesses diverse aspects of six renewable energy sources to the mitigation of climate change (EDENHOFER ET AL. 2011). Since the utilization of renewable energies for electricity, thermal energy, mechanical energy and fuel supply is a growing sector, in particular after the failure of the nuclear power plant in Fukushima in March 2011, the impacts on water resources of hydropower plants and bioenergy as the largest renewable energy sources are discussed in detail. In 2008, renewable energies accounted for 12.9% of the total primary energy supply on a global basis. Biomass (10.2%, approximately 60% traditional biomass used in cooking and heating in developing countries) was the largest contributor, followed by hydropower (2.3%), whereas other renewable energy sources accounted for 0.4%. For global electricity supply about 19% was produced by renewable energies (16% hydropower, 3% other) in 2008. 2% of biofuels contributed to global road transport fuel supply, whereas traditional biomass (17%), modern biomass (8%), solar thermal and geothermal energy (2%) together provided 27% of the total global demand for heat (EDENHOFER ET AL. 2011).

For the sake of completeness, the relation of the other mitigation measures to water resources is briefly introduced first. Leaking CCS could degrade groundwater quality, but consequences of this technique are not yet completely known. The utilization of geothermal steam and hot water fields for heating also can affect (ground-)water quality when extracting the water. In the cases where no or not enough water is available to produce steam and accordingly energy, water is injected to hot dry rocks. These techniques increase water consumption and a significant reduction of water availability in regions with limited resources is possible. This is also the case when using water for cooling buildings or industrial plants in such regions. Additionally, when returning cooling water to rivers or coastal waters, the heat loads increase water temperature and indirectly impact water quality, in particular in considering increasing water temperatures due to ongoing climate change (BATES ET AL. 2008).

The generation of oil from oil shale or sand requires a lot of water and thus places an extra pressure on water availability. Furthermore, the process leaves many pollutants, disturbs the area and decreases water quality. Waste treatment plants as mitigation option can have negative effects on water quality in the case of improper management. Nevertheless, positive effects outweigh by reducing water pollution from untreated discharges. Additionally, reusing treated wastewater increases water availability (BATES ET AL. 2008).

Another renewable energy source is provided by the potential, kinetic, thermal and chemical energy of seawater. Various technologies, ranging from barrages for tidal range, submarine turbines for tidal and ocean currents, heat exchangers for ocean thermal energy conversion and a variety of devices to harness the energy of waves and salinity gradients are possible, but many of them are not yet in the operational phase (EDENHOFER ET AL. 2011). Besides structural interventions in construction works, tidal barrages can impact water quality and the fauna in creating large seawater lakes behind the barrages (JOHANSSON ET AL. 2004).

Hydropower, covering dam projects with reservoirs, run-of-river and in-stream projects, has many positive, but also negative impacts on water quantity. The construction of both, storages and run-of-river power plants has ecological impacts for flora, fauna and the landscape. Although no water is consumed for cooling or growing plants for bio-fuels, flow regimes are affected by hydropower plants with reservoirs. On the one hand, conflicts with other water users, e.g. navigation, irrigation or water supply for households and industry might arise during low flow periods. On the other hand, water stress can be reduced in using reservoir management for flow regulation and flood control. If the reservoir is filled during heavy rainfall, often in combination with snow melting periods, a reduction of the flood peak along the adjacent river is possible. Contrary, during droughts a filled storage can augment low flow, and navigation, agriculture and water supply can profit despite user conflicts. The possibility of balancing the magnitude of extreme events by hydropower reservoirs exist, always assuming appropriate operation (BATES ET AL. 2008).

The mitigation field of using biomass and bio-fuels for energy production as renewable resources has diverse relationships to water reservoirs. Bioenergy can be produced from a variety of biomass feedstocks, including forest, agricultural and livestock residues, short-rotation forest plantations, energy crops, the organic component of municipal solid waste, and other organic waste streams (EDENHOFER ET AL. 2011). In order to grow biomass, land-use often is changed and impacts both, water quantity and quality. Besides concerns about biodiversity when concentrating on only a few, particularly profitable crops and thus forcing monocultures, this also enables an easier spread of parasites and plant diseases, which in turn require more pesticides, and decrease water quality when draining into the groundwater. Additionally, soil is deteriorated, more fertilizers are applied and again water quality is reduced. Deforestation for increasing agricultural land or reforestation change both, water availability and quality, too. While in semi-arid and arid regions reforestation can reduce groundwater recharge, most effects reduce water stress. Since forests have a high infiltration and water retention capacity, the flow regime is smoothed. Not only flood peaks are reduced, but also low flow during the dry season can be augmented and water scarcity decreased. Furthermore, groundwater and surface water quality can be enhanced through forests because of their filter capacities. They not only act as sinks for CO2, but they also control nitrate or phosphorus. Especially riparian forests enhance the water quality of rivers (LOWRANCE ET AL. 1997). Besides land-use changes for growing biomass, other changes as restoration measures such as forestation or wetland restoration have similar effects on water quality and quantity as described above (BATES ET AL. 2008).

The water need for growing energy crops can both reduce and increase water stress. Depending on the prior land-use more or less water is required. This impacts groundwater recharge and runoff, and can decrease, respectively increase water availability. In particular, irrigation of bio-crops can reduce water availability and increase water scarcity. Contrary, in applying good agricultural practice in growing biomass, an increase in water stress can be avoided and water use efficiency promoted. This includes planting proper crops for the regional water availability, crop rotation systems, applying fertilizers, pesticides and irrigation in the required amounts and at the appropriate phenological stages as well as the preparation of seed beds. For example hedging and ditching or adequate crop rotation can reduce erosion processes, soil degradation and inflow into surface waters. This in turn can also influence extreme events and decrease flood peaks. Additionally, surface water quality might also be affected by surface runoff and erosion in a positive or negative way, depending on the management and the grown cultures. There are also bidirectional effects for applied fertilizers and pesticides, which could, according to the management, drain into the groundwater and decrease its quality or vice versa (BATES ET AL. 2008).

Finally, a further positive effect for water availability in using biomass for energy production is the reduction of cooling water discharge to surface water streams by using the renewable energy resource in comparison to fossil power plants where cooling water is required (BATES ET AL. 2008).

Table 1. Summary of the positive (+) and negative (-) influence of mitigation options on water quality and quantity (modified after BATES ET AL. (2008), p. 118).

Water aspect	Energy	Buildings	Industry	Agriculture and Forests	Waste
Quality	CCS (+/-) Bioenergy (+/-) Geothermal energy (-) Unconventional oil (-) Ocean energy (-)	Cooling water (-)	CCS (+/-) Cooling water (-) Bioenergy (+/-)	Bioenergy (+/-) Land-use change (+/-) Land-use management (+/-)	Wastewater treatment (+/-) Bioenergy (+/-)
Quantity	Hydropower (+/-) Bioenergy (+/-) Geothermal energy (-) Unconventional oil (-)	Cooling water (-)	Cooling water (-)	Bioenergy (+/-) Land-use change (+/-) Land-use management (+/-)	Wastewater treatment (+/-)

Conclusion

As shown above, mitigation options have various impacts on water resources. Both, water quality and quantity are affected in positive and negative ways. Since many measures are not clearly unambiguous, their implementation must be evaluated in detail. Thereby present and future water availability in its seasonal course should be taken into account. In regions where drinking water is already scarce, a further water demand must be avoided. In fact, mitigation measures saving water would be appropriate. For example, this effect can be reached depending on the cultures by changing land-use for growing biomass. Multi-year rotations, drought-tolerant plants or at least relatively water efficient crops can be grown and better use varying water availability than conventional crops. Further advantages are reduced evaporation and surface runoff, enhanced infiltration and accordingly reduced water stress (BERNDES 2010). Thereby, water quality enhancement due to the uptake of potential water pollutants in the soil is possible, too, unless the application of fertilizers and pesticides is reduced to a minimum.

Further challenges for growing biomass are competing user interests in land-use not only for food production, but also with areas for preservation of natural ecosystems. In particular, when competing with food crops and under the assumption of ongoing population growth, a careful priority check is required (EVANS ET AL. 2010). Contrary to the land demand for growing biomass, the population growth from almost seven billion today to over nine billion people by 2050 (FORESIGHT 2011) requires land, water and energy for growing food. The competing interests together with the impact of climate change will create new pressures and challenges. This means to balance future food demand and supply on a global scale, and, simultaneously, maintain biodiversity and ecosystem services (FORESIGHT 2011). To reach this aim, political decisions towards a global, sustainable system are required. This in turn needs an integrative analysis of environmental, economic, social, technical and ethical issues. In regard to water availability, currently approx. 70% of the total global *blue water* is withdrawn for agriculture and the demand is still rising. There are already areas where natural water reservoirs are exploited, as in Egypt, Libya or Australia. In order to fulfil food demand and to reduce water stress, new technologies and exchange via trade could help (FORESIGHT 2011).

Uncertainties in biomass energy production, particularly in regard to future climate change impacts, such as altered soil conditions, changes in the amount and seasonality of precipitation and many other factors determining crop productivity must be considered (EDENHOFER ET AL. 2011). The mitigation goal of reducing GHG emissions is complex, depending on prior land-use, construction, transport, machining, treatment and waste products. Accordingly, a detailed assessment and integrated planning is needed in taking account all the various connections of biomass energy production towards a sustainable concept (EVANS ET AL. 2010). In the worst case, mitigation measures on GHG emissions can even increase GHG emissions. For example, although irrigation can enhance yields and carbon storage, the energy used to deliver the water to the fields can counteract the carbon storage increase (BATES ET AL. 2008).

Variations across regions and within countries in the natural preconditions and in the impacts of global change on water availability must result in differentiated decision making for each single region. Fig. 1 shows possible future climate change impacts related to freshwater across the Earth's countries. Future restrictions for mitigation measures because of water stress are illustrated as well.

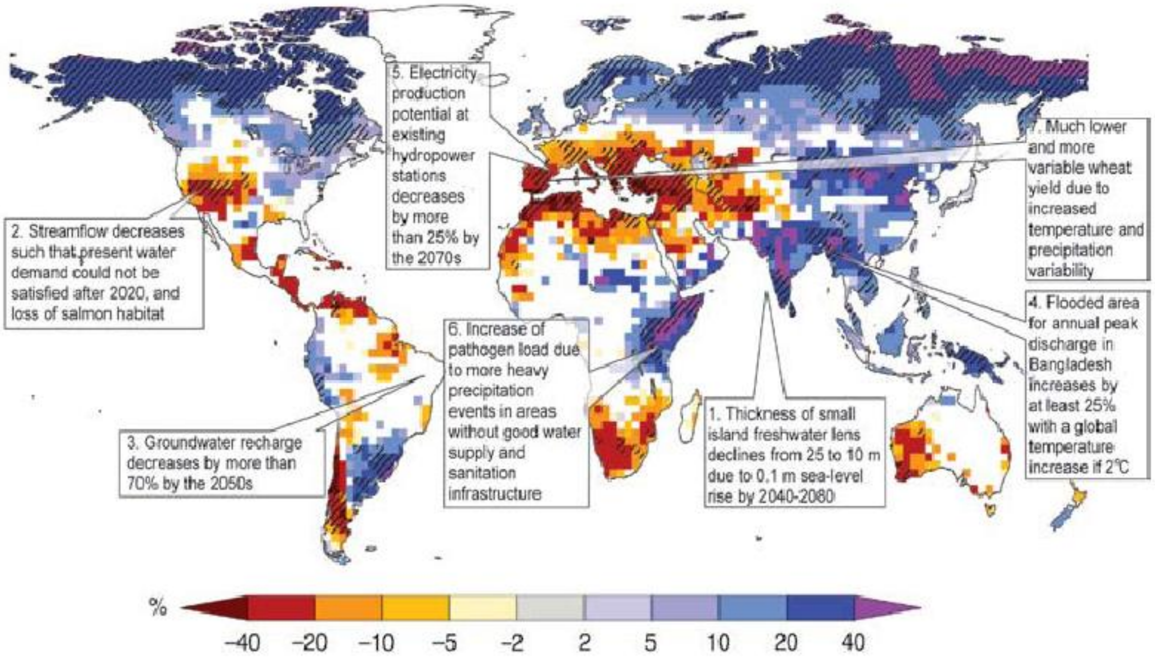

Fig. 1: Future climate change impacts related to freshwater which threaten the sustainable development. Red (blue) colours indicate the decrease (increase) of annual runoff between present (1980 to 1999) and future SRES A1B (2090-2099) conditions (BATES ET AL. 2008, p. 47).

Competing interests among water uses such as irrigation, drinking water, hydropower, freshwater reservoirs, cooling water and many more applications may require the identification of priority rankings (STERNBERG 2010). In this regard, policy regulation mechanism might be required to avoid conflicts. Continuous monitoring and re-evaluation of implemented mitigation measures are necessary, not only to adapt to changing conditions, forced by Global Change (climate impacts, population growth, economic issues), but also to reduce conflicts.

Summing up, appropriate mitigation measures always should carefully be selected in assessing present and future impacts on both, water quantity and quality to reduce or at least, to stabilize water stress. Instead of an *Integrated Water Resources Management* an *Integrated Natural Resources Management* (MAUSER 2010), taking into account environmental, technological, social and ethical issues and its correlations is required towards sustainability. Although there are risks to increase water stress by climate change mitigation, the opportunity to mitigate GHG emissions and climate change in simultaneously reducing water stress is given as well.

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Chapter 9:

Virtual water trade in a globalised world: applicability of regulatory incentive schemes

Nico Grove[1)]

ABSTRACT

The paper focuses on the identification and elimination of welfare losses from inefficient use of the resource water, represented in actual worldwide virtual water streams. In the meanwhile, there exist successful regulatory concepts for the internalization of negative externalities like pollution for industrialized production and individuals' utility maximization constraints. However, a traditional regulatory quantity based approach - like in international carbon trade - will not work. In contrast to carbon, fresh water is a locally concentrated resource which is plentiful available in one area and absolutely untraceable in another. The main area of research is now to identify the causes for the inefficient virtual water flows in order to develop a concept combining reallocation incentives and a resource efficient use of fresh water resources.

1) Assistant Professor for Infrastructure Economics & Management, Bauhaus-University Weimar

1 Introduction

During the past decades, securing access to crude oil has been a primary reason for international conflict, political discussions and the enormous transfer of international wealth. Water is no different in this respect, except that it is a resource that can neither be reproduced nor substituted. And while the drinking water supply infrastructures alone will cost trillions of dollars, the real challenge will be ensuring an adequate food supply through sufficient agricultural water or *virtual water*. Fresh thinking will be required if the mega-city dwellers and rapidly increasing populations are to be provided with drinking water, municipal water, water for industry as well as for agricultural production. Clearly, the world needs well-managed virtual water.

1.1 Area of research

This study focuses on the identification of welfare losses from inefficient resource water use, represented in worldwide virtual water streams. There are established regulatory frameworks for the internalization of negative externalities like pollution for industrial production and individuals' utility maximization constraints. The best-known example is international carbon trade, which – along with the intention to reduce carbon dioxide emissions – is leading to positive side effects like innovations in environmental protection and increased resource efficiency. But in contrast to carbon, fresh water is a locally concentrated resource which is plentiful in one area and untraceable in another. Therefore, a framework based on reduction[2] (e.g., carbon trade) cannot work for virtual water. Moreover, this local component – including the option to use much more water – must form part of a regulatory approach to virtual water.

1.2 Methodology and structure

This study takes a conceptual, inductive approach to the identification of a feasible regulatory system in order to significantly contribute to a more sustainable and resource-efficient usage of local resource fresh water. By integrating data from water distribution, consumption and product inclusion, different theoretical regulatory

[2] See Gleick (1993), p. 79.

measures are tested for their application to, and feasibility for, virtual water[3]. A comparative analysis reveals applicability to the realities, especially in developing countries. I apply Whetten's approach to making conceptual contributions[4].

The paper is structured as follows. Chapter 2 introduces into negative externalities of the inefficient use of virtual water based on the phenomenon that has become known as *the tragedy of the commons*[5]. Having developed a theoretical framework for the relocation of efficient virtual water production capacities, Chapter 4 applies existing regulatory mechanisms to virtual water. The paper ends with a summary of additional implications as well as feasibility and political recommendations.

2 The tragedy of virtual water

Citizens of developed countries tend to take access to drinking water for granted. We may place access to water in the same class of public goods like public television, banking or national defense. A public good or resource is characterized by non-excludability and non-rivalry[6]. However, fresh water is perfectly excludable and rivalry as many examples can prove. Some people could die of thirst next to an irrigated field fenced with barbed wire and protected by armed guards. The same is true of virtual water. A country's virtual water trade balance could be negative while the majority of its population lacks access to clean drinking water. These issues cannot be solved by regional fresh water savings. They need to be anchored internationally by improving the efficiency of local fresh water use and, thus, virtual water trade.

2.1 The tragedy of commons

Negative externalities of location-dependent inefficient fresh water use arise when more fresh water is used than what is available in that area in terms of acceptable, sustainable usage levels. One reason for negative externalities is individuals' tenden-

3 See Miles (1979).
4 See Whetten (1989).
5 See Hardin (1968, p. 1244.
6 See Frank (1999) and Samuelson (1954), p. 387f.

cies to rational maximization schemes which generally underestimate negative externalities, especially in the long term.

In what has become known as *the tragedy of the commons*, Hardin described a public pasture. Every farmer will try to keep as much cattle as possible on this commons. According to Hardin, every farmer's adding of another animal to the pasture has a positive and a negative component[7]:

1. Positive: Every farmer receives all the proceeds from this additional animal, equivalent to +1.
2. Negative: Every additional animal will contribute to overgrazing and reduce overall utility by –1. However, every farmer is just affected by a fraction of –1.

In this example, all farmers will continue to send cattle to the common to graze until it is depleted due to overgrazing. According to Hardin:

"Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."[8]

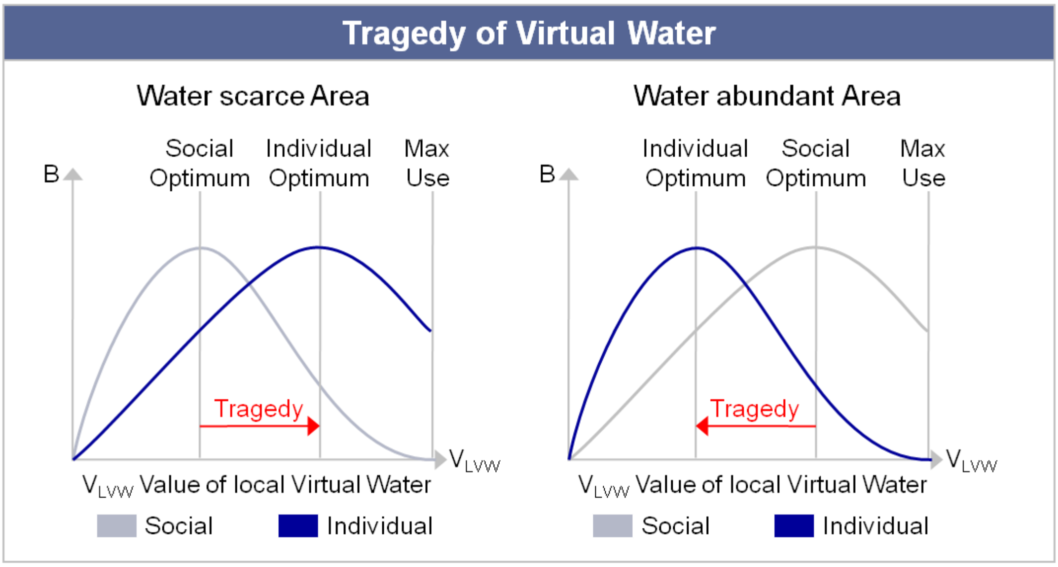

Figure 1: The tragedy of the commons in water-abundant and water-scarce areas

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[7] See Hardin (1968), p. 1244.

[8] Hardin (1968).

Hardin's description fits the virtual water phenomenon. However, another perspective is added. Besides overexploitation of fresh water in a water-scarce area, fresh water is used less where it is abundantly available, as depicted in Figure 1. The horizontal axis indicates the value of local virtual water (V_{LVW}) contained in products produced, in relation to the fresh water consumption. The vertical axis indicates the individuals' and/or overall social benefit (B).

For this interdependency, the following case serves as an example: In a water-scarce area, fresh water use (e.g., animal breeding and other water-intense production processes like denim fabric production) is optimized by the optimum individual water consumption but exceeds the social optimum fresh water usage. Fresh water is used by the factory owner and turned into virtual water contained in the resulting products in a quantity that is much higher than the overall social optimum for the population living in that area. Some people may even be excluded from access to fresh water. This is the tragedy that results from an individual producer's access to local virtual water resources, which is much higher than the social optimum. On the other hand, in a water-abundant area, an individual does not internalize the negative externalities of water-scarce areas due to a lower production output of goods high in virtual water, which could in turn be transported or exported to water-scarce areas. The tragedy lies in the lower individual optimum production capacities than required by the social optimum.

In short, for the water-scarce area described in the left-hand graph in Figure 1, Hardin's pasture model works perfectly. Local water resources are first exploited, then exported from the area because each individual rationally maximizes his or her individual utility. However, the social optimum lies below that level, as the water should be used as drinking water and for the production of goods that require less blue water. For a water-abundant area, the opposite is true. Here the individual optimization constraint leads to an underusage of fresh water as a resource. Herein lies the tragedy[9] of virtual water. Instead of goods high in virtual water being produced, goods low in virtual water are also produced and exported to water-scarce areas, which trade them

9 See Akerlof (1997).

for goods high in virtual water[10]. Therefore the overall social optimum would involve focusing on the production of goods high in virtual water, which will increase the quantity.

Now the question is: Is there a framework that allows for the internalization of these negative externalities into the individual utility constraint, i.e., that can overcome the tragedy of virtual water? A theoretical regulatory scenario is discussed in order to curb the continued exploitation of water-scarce areas; this will help answer the question.

2.2 Virtual water redistribution goals

While at present the agricultural and industrial production process does not internalize virtual water consumption in the production process[11], the production function does include the cost of local fresh water sourcing. Therefore, an economic frontier depends on the availability of fresh water in a specific region. Keeping cattle in a desert would not be economically viable. However, production does not take worldwide resource efficiency into account. As shown in the previous chapter, overall welfare would be much higher if goods that require large quantities of fresh water are grown in water-abundant areas. These goods can be exported to water-scarce areas in exchange for products requiring low quantities of fresh water[12]. Because of the real-world dualism of water scarcity and water abundance, the simple allocation of virtual water trade – as suggested by Hoekstra [13] will not help overcome individual utility maximization constraints. However, according to Stigler, integration is a precondition for a working regulatory scheme[14]. Therefore, an idealistic virtual water flow regulatory model – as depicted in Figure 2 – was developed.

This model is based on Ricardo's notion of comparative advantages[15]. The export of goods containing large quantities of virtual water has to be supported in the case of water-abundant areas and restricted in the case of water-scarce areas. Similarly, the

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[10] See Word Water Council (2004), p. 12 as well as Hoekstra and Chapagain (2003).

[11] See Wild Farm Alliance (2003), p. 4.

[12] See Chapagain and Hoekstra (2008a), p. 43.

[13] See Hoekstra (2003), p. 13.

[14] See Stigler (1971), p. 3f.

[15] See Ricardo (1821), p. 41f.

export of goods containing low quantities of virtual water must be supported in the case of water-scarce areas. In order to keep the international supply of goods containing low quantities of virtual water at a constant level, their export from water-abundant areas must be restricted. The model's ultimate target is to reverse the actual virtual water trade balance between water-scarce and water-abundant areas, leading to a negative virtual water trade balance for water-abundant areas and a positive virtual water trade balance for water-scarce areas. Due to the fact that domestic demand for the goods under *trade restrictions* will not increase, prices will fall and production capacity will decrease. For the goods under *trade support*, the opposite will happen as international demand for these goods will increase. In the end, production capacities will be shifted from products with high quantities of virtual water to goods with low quantities of virtual water in water-scarce areas, and vise versa in water-abundant areas.

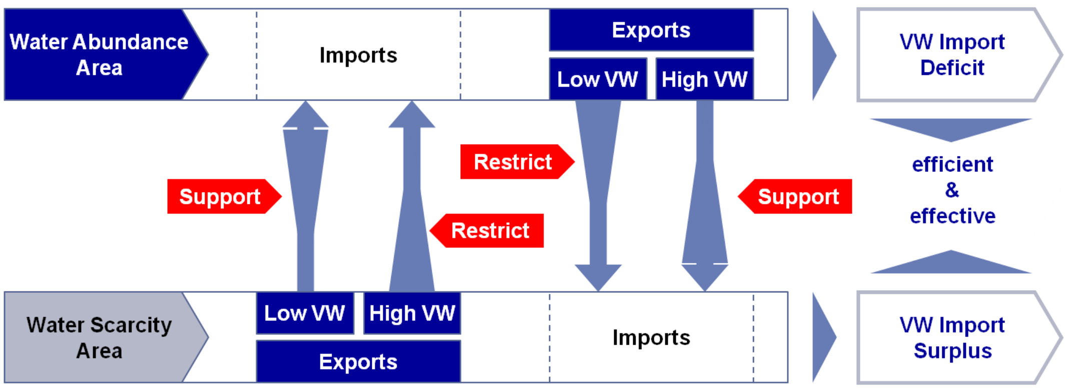

Figure 2: Idealistic model of virtual water flow regulation

What would this mean in practice? Imagine a water scarce country with a competitive advantage in skin and hide production. This industry is using enormous quantities of blue water resources. Furthermore, the demand for livestock (the input factor in the skin and hide production) is supplied for by breeding cattle locally[16]. Putting these cattle in a water-abundant area would lead to a more resource-efficient use of local fresh water without diminishing the water scarce country´s competitive advantage and

[16] See Ofcansky and LaVerle (1991).

income. Moreover, the remaining water will serve the local population as drinking water and contribute to products low in virtual water.

The theoretical model developed contains options for the integration of location-dependent resource-efficient virtual water consumption into the production function in order to increase overall welfare. The challenge is now to transfer this theoretical concept into practice and establish its fit with reality. This will be discussed in the next chapter.

3 The applicability of regulatory concepts

A wide range of regulatory concepts is helping us reduce the negative externalities of private or industrial consumption (which are harmful to the environment). The focus is on proven environmental models, including legislation and interdiction, consumer and/or producer taxation, and permission rights. If these concepts can successfully be transferred to virtual water, their applicability to virtual water resource use efficiency can be tested. Compared to the reduction of pollution levels[17], for example, the complexity of global virtual water regulation is due to three major factors, which have to be addressed by the regulatory mechanisms:

- Location (water-scarce area or water-abundant area)
- Fresh water consumption patterns (industrial or private)
- Income levels (poor nation or rich nation)

The resulting regulatory mechanism(s) must fulfil these major requirements in order to shift production from goods high in virtual water to water-abundant areas and from goods low in virtual water to water-scarce areas, in relation to the location and the amount of fresh water resources used in production. However, this will only work if the mechanisms consider the income disparities between countries (i.e., developing and developed countries). Furthermore, it must be considered that fresh water and virtual water can be viewed as interchangeable at the production site. However, if the resulting product is consumed in a region outside the region of production, a transfer of virtual water occurs that must be reflected in the regulatory framework.

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[17] See Byrne and Glover (2000).

In the following, mechanisms for the prevention of negative externalities are introduced and extrapolated to virtual water. This approach highlights the advantages and disadvantages of the applicability and effectiveness of increasing virtual water location-dependent fresh water usage.

3.1 Rules and laws

Many environmental issues are addressed by means of legislation. There are a great many environmental laws and transnational agreements. One famous example is the case of the interdiction of halogenated hydrocarbons by the Montreal Protocol on substances that deplete the ozone layer signed by 195 countries on 1 January 1989[18].

In the case of law, virtual water would need an internationally agreed framework and an implementation in national law. In the case of rules, virtual water would primarily need rules restricting the production of goods high in virtual water in water-scarce areas. This focuses the reduction of a deadweight welfare overall loss. In addition, rules are likely to increase people's sensitivity to the issue of virtual water and thus lead to a change in consumption patterns. In water-scarce regions, prices for locally grown goods high in virtual water will increase, as their production – and, thus, availability – will be restricted.

At the end of the day, laws and rules will only be effective measures if they are able to change the individual production and consumption behavior in developed and especially developing countries As the latter are home the majority of the world's population). Figure 3 presents an individual maximization scheme for virtual water consumption.

[18] See OECD (2006), p. 6.

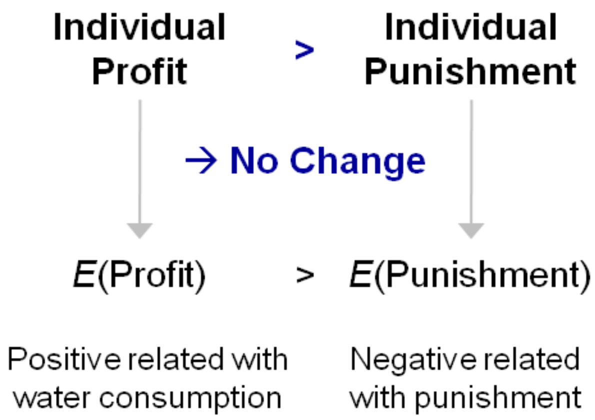

Figure 3: Individual maximization scheme for virtual water consumption

As long as the individual's profit from using a higher-than-allowed quantity of virtual water is not lower than the individual sanction, rules and law will not lead to any change in consumption patterns.

In deriving the individual profit maximization scheme, the expected profit (*E*) depends on water consumption as more water in the production function generates more output. Thus, expected profit and fresh water consumption are positively related. However, the individual will stop producing restricted goods if the expected cost – in the form of sanctions or punishment – is higher than the expected profit. Therefore, the expected costs depend on the probability of being caught as well as the nature of the sanctions.

As long as the expected individual profit is higher than the expected costs of sanctions, laws and rules will not improve virtual water efficiency. Furthermore, ensuring enforcement is tougher in developing countries than developed countries. The introduction of sanctions will also impact citizens of developing countries more. After the introduction of virtual water laws, a farmer in Africa – who faces higher risks than farmers in developed countries – will need to decide to stop farming or to continue farming with even higher odds and higher risks than before.

Moreover, laws and rules are always beset by adverse selection, moral hazards and/or hold-up problems[19]. In the end, poor people might be adversely affected by the changes and dislocations brought about by virtual water sanctions and laws.

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[19] See Picot, Reichwald and Wigand (2008), p. 58f.

3.2 Consumption-related taxation

Consumer taxation or tariffs are used to internalize the external effects (and their costs) of changing consumption patterns. By increasing market prices through governmental intervention, the intention is that the good be bought and used less, and that the gained taxes be used to compensate for negative externalities.

Examples are taxes on fuel, which can set incentives to reduce carbon emissions by regulating driving patterns, for example[20].

The introduction of a consumer tax on virtual water containment will increase the prices of goods high in virtual water. Such a tax will depend on the quantity of virtual water contained in the good, i.e., the amount of fresh water used for its production. This could lead to a situation where – for example – meat (15 000 liter virtual water per kg) will carry a tax burden that is 7,5 times higher than that of bread (2 000 liter of virtual water per kg). As illustrated in Figure 4, the consumer has to pay a higher price – *P'* instead of *P* by the amount of *t* – for a good high in virtual water. The tax (*t*) is prescribed by a central authority. This will reduce demand for goods high in virtual water from *Q* to *Q'*. In contrast, prices for goods low in virtual water will be subject to lesser price increases. Supplier price levels will remain the same.

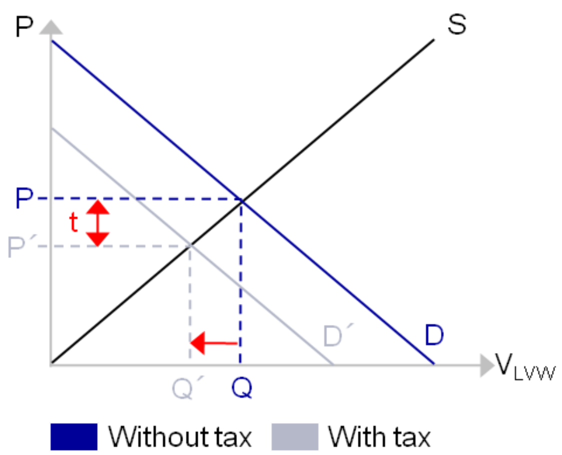

Figure 4: Consumer tax on virtual water[21]

The advantages of this approach include clear consumer knowledge regarding virtual water containment as this is reflected in price levels. As a result, the consumer will

[20] See Dornbusch and Poterba (1991), p. 72.

[21] Based on Varian (1999), p. 282.

internalize virtual water containment in his or her consumption behavior. The biggest drawback is the fact that the effects of regional disparities in water scarcity and water abundance are not considered. Furthermore, this would lead to distortions in local water prices as fresh water, for example, would be taxed equally in areas where fresh water is abundant and areas where it is scarce. Grey markets, which are the biggest sector in developing countries[22], are also not included.

In short, while shifting the virtual water tax burden to consumers internalizes virtual water containment, it does not consider that redistribution effects would prejudice water-scarce areas. The acceptance of a virtual water tax is therefore likely to be low, especially in water-scarce areas.

3.3 Production-related taxation

Production tariffs incentivize markets to reduce a specific production function or produce fewer of a specific good. These taxes are sometimes referred to as *Pigouvian taxes*[23]. In contrast to consumer taxation, these taxes are paid by the producer according to his or her output quantity. Examples include carbon emission tariffs and harmful substance waste disposal[24].

Applying production tariffs to virtual water will increase the costs of producing goods high in virtual water. These tariffs are also prescribed by a central authority. The impact of such tariffs will be low on goods low in virtual water and high on goods high in virtual water. This would lead to a situation where a certain amount (t) is paid by the producer for every liter of fresh water used in production that is turned into virtual water during production. The higher the water consumption (for example, per kg of goods produced), the higher the amount payable. The producer tariff taxation model is set out in Figure 5.

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[22] Currently, in the Third World, only the wealthy farmers produce crops for sale, while the rest is trade-based. See Fafchamps (1992), p. 90.

[23] See Frank (1999), p. 577.

[24] See Newbery (2005), p. 10.

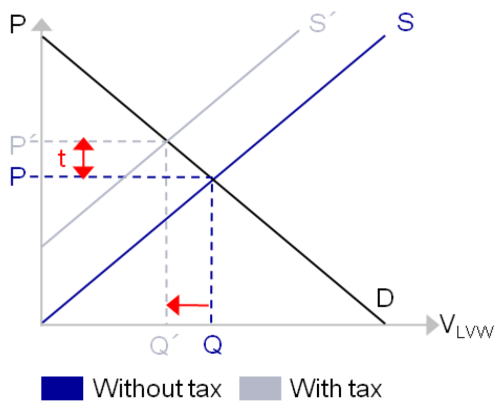

Figure 5: Producer tax on virtual water[25]

The major advantage of a producer tariff is a clear focus on mass producers, which are much easier to incentivize to produce lesser goods high in virtual water. In addition, the producer tariff model will incentivize innovative production processes that require less fresh water and thus less virtual water. However, due to moral hazard problems in production due to profit maximization, the risk of fraud would be higher. The major disadvantages of the model are that producer tariffs would increase production costs[26] without limiting the virtual water waste through setting specific targets as well as the non-existence of redistribution incentives of water consuming production capacities.

And producer tariffs would not work in developing countries as the grey market will not be included.

3.4 Tradable permits for virtual water

The notion of tradable permit rights is a further development of producer tariffs based on the the Pigouvian tax model[27]. The carbon emissions trading scheme (e.g., in the European Union) is a good example of a tradable permit system[28]. A central authority issues a certain amount of emission rights, which also serves as a maximum cap. These rights or permits, which are allocated to the producers under a specific distribution scheme, can be reduced over time. These permits are tradable, which allows companies producing more emissions to buy permits from a company that produces

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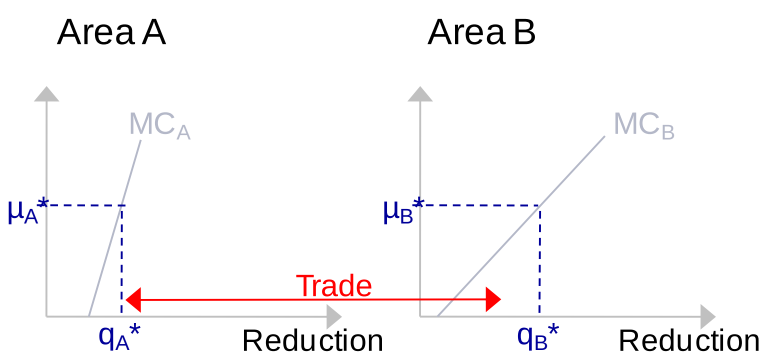
[25] Model based on Frank (1999), p. 56.
[26] See Varian (1999), p. 566.
[27] See Quiggin (1988), p. 1072.
[28] See, for example, European Commission (2004).

less emissions and that is willing to sell permits at a specific price – the market price for pollution allowances[29]. Introducing a tradable virtual water permit system will also require a central authority to issue these rights, depending on fresh water availability in a specific region. The negative externalities of inefficient fresh water use would be represented in the amount of permission rights, which permit a specific amount of fresh water use in a specific region. At this stage, I will introduce a simplification for the analysis: Switching costs to goods lower in fresh water are higher in water-abundant areas than in water-scarce areas. This might be due to high investments (e.g., in the buildings and machines required for breeding cattle.

As depicted in Figure 6, allowing trade between companies and between regions leads to the desired relocalization effect of fresh water usage, positively related to fresh waster abundance, as explained in the following. The abscissa indicates the reduction of fresh water used for production (*q*). The ordinate describes the price (μ) related to the reduction. The individual marginal costs (*MC*) for the reduction of fresh water use (and thus virtual water product containment) are depicted in the model with a linear function for each producer (*A* and *B*). Introducing trade establishes a given market price for the fresh water usage rights of μ*. Hereby, each area (*A* and *B*) will reduce its fresh water consumption as long as marginal costs (*MC*) are lower than the costs for the required amount of tradable permits. As soon as $MC = \mu^*$, it becomes cheaper for the area to buy the rights instead of reducing its fresh water consumption. This will lead to a reduction level of q_A* and q_B* respectively in the equilibrium. q_B* in the water-scarce area is much higher than q_A* in the water-abundant area due to the lower marginal cost of reduction.



[29] See Gunasekera and Cornwell (1998), p. 11f.

Figure 6: Tradable permission rights for virtual water[30]

A major advantage of the trade model is its higher welfare – compared to the taxation model – due to a self-allocation mechanism that efficiently generates a given level of reduction at the lowest overall costs[31]. This will be proved by applying theory to virtual water, which will also serve as an example for this theoretical model. Therefore, the existing system of carbon-tradable permit rights, which is location-independent, will be extended to a location-dependent dimension, as required in the case of virtual water regulation.

The overall welfare gains of the virtual water tradable permit system are illustrated in the example in Figure 7. Let us imagine two farms: Farm A is located in a water-abundant area and farm S in a water-scarce area (where the relative value of fresh water is much higher than in a water-abundant area). Each of the farms has an initial fresh water consumption of 1 000 m^3. This is not a problem in the water-abundant area, but in the water-scarce area, some people might have been excluded from access to drinking water. The interchangeability of fresh water and virtual water product containment during the production process must again be considered. Regulation is now introduced by a central authority, which lowers the overall virtual water product containment to 1 800 m^3 (which, at the production site, equals the same amount of fresh water). It is again assumed for this example that switching costs to goods requiring less fresh water for production are higher in water-abundant areas. This may be the case due to high investments (e.g., in buildings and machines required for breeding cattle). As pointed out, this limitation will be removed later.

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30 Model based on Frank (1999), p. 612.

31 See Tietenberg (1985), p. 18f. and Schärer (1999), p. 143.

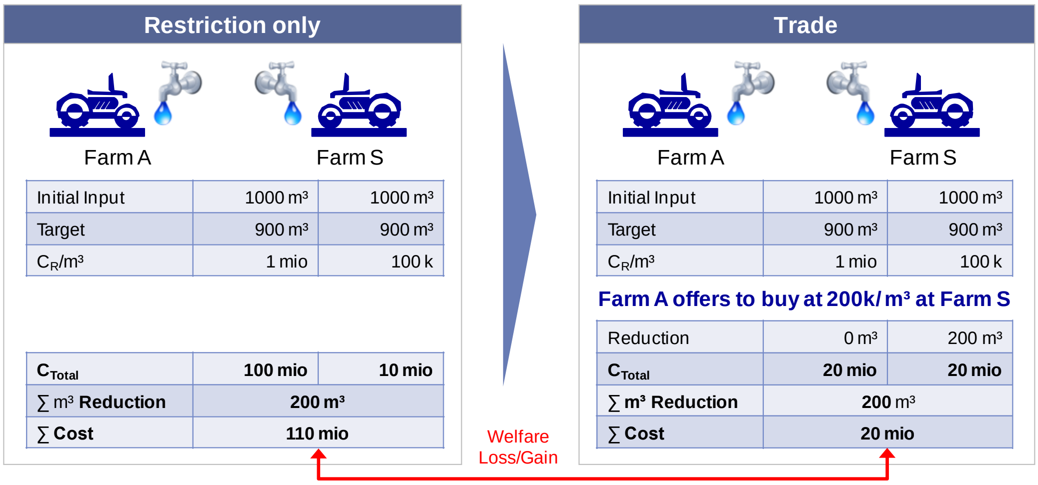

Figure 7: The welfare gains from virtual water trade compared to restrictions

In case of *reduction* only, each farm must reduce its virtual water product containment by 100 m³, hence 100 m³ of fresh water for production. Costs for farm A are much higher, at 1 million per m^3, compared to 100 k per m^3 for farm S. In the case of reduction, to fulfil the reduction requirements, farm A will have costs of 100 million and farm S of 10 million. The overall reduction of fresh water consumption will be 200 m³ for a total cost of 110 million.

In case of *trade*, the regulator issued both farms with tradable virtual water permits. Nevertheless, the overall amount of virtual water product containment by both farms may not exceed 1 800 m³. Farm A is aware of its high reduction costs and will search the market for virtual water rights below the price of 1 million per m³. As farm S offers to sell virtual water rights at a price of 200 k per m³, farm A will buy these virtual water rights for 100 m³ at a price of 20 million, which is much less than the 100 million farm A would cost the reduction at its own production site. Farm S must reduce water consumption to 900 m³ plus the 100 m³ originally from farm A. Therefore, farm S will have a reduction cost of 20 million. However, the entire cost is paid by farm A, which imposes a financial burden of zero on farm S in the water-scarce area. The overall reduction of fresh water use is 200 m³, at an overall cost of 20 million, paid by farm A to farm S. In the case of *trade* (when compared to the case of *restriction*), the overall welfare gain is more resource-efficient water use. Fresh water consumption was reduced only in the water-scarce area and former additional unnecessary cost of 90 million did not occur due to trade.

To conclude, tradable virtual water permits allow for internalization and self-regulated market efficiency levels simultaneously. Unfortunately, the *trade* option is accompanied by concerns of controllability, the private sector and moral hazards in production[32]. Especially in developing countries, it is not easy to integrate a large number of producers into a worldwide trade model[33]. The next chapter deals with an introductory potential real-life application of the models presented.

4 Shortcomings and recommendations

The actual use of fresh water without taking into account the local relative value leads to massive negative impacts on overall welfare. Improving resource efficiency in international virtual water flows contributes significantly to sustainability and conditions of access to drinking water, especially for people in the developing world. The notion of, and framework for, virtual water regulation through combining tariffs and trade via a supranational virtual water regulatory authority seeks to provide a starting point for further research and future debate.

In contrast to the case of carbon trade, where the location of pollution does not matter[34], the local conditions of water availability in a subnational perspective are crucial, and have to be supported by the model. A tariff and trade model might fit as an *incentive-based approach*. New and cheaper products and processes will decrease fresh water requirements and lead to additional benefits in terms of reduction. The trading of permits might *generate a new market sector*, which will create employment, for the marketplaces and in the producing companies (in terms of permit management).

In terms of methodology, the virtual water trade was looked at from a neoclassical perspective only. Hence, very important influence factors have been neglected in the analysis. However, the model presented shall give room for further ongoing discussion by integrating these dimensions and lift the topic on an interdisciplinary level. The model has to be enhanced with very important influence factors: The political

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32 See Tietenberg (1985).

33 In developing countries, the level of 'aggregation' farmers must address the effect on small farmers. See Fafchamps (1992) for farming structures in the Third World.

34 See Klaassen (1999), p. 92f.

acceptance on international, national and subnational level have to be addressed in the same way as impacts to international trade, climate conditions and ecological factors of farming or individual cultural backgrounds or even transport capabilities of specific products. In addition, e.g. international relations theory can help create sustainable water solutions.

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Chapter 10:

Managing land and water resources

K. Waha[1], H. Lotze-Campen[1], D. Gerten[2]

[1]Potsdam Institute for Climate Impact Research (PIK), Research Domain on Earth System Analysis
P.O. Box 60 12 03, D-14412, Potsdam, Germany

[2]Potsdam Institute for Climate Impact Research (PIK), Research Domain on Climate Impacts & Vulnerabilities
P.O. Box 60 12 03, D-14412, Potsdam, Germany

Background

Increased future demands for food, fibre and fuels from biomass can only be met if the available land and water resources on a global scale are used and managed as efficiently as possible. The main routes for making the global agricultural system more productive are through intensification and technological change on currently used agricultural land, land expansion into currently non-agricultural areas, and international trade in agricultural commodities and processed goods. Land in crop production is expected to increase by 120 Mha until 2030 (FAO, 2003) and an additional expansion in world's cropland by 142-454 Mha assuming a potential bioenergy production of 26-174 EJ yr^{-1} is expected in 2050. As agriculture already account for about 70% of the freshwater withdrawals in the world (FAO, 2003) and additional water demand potentially arise from land expansion and intensification it is questionable whether there will be sufficient freshwater to satisfy the growing needs of agricultural and non-agricultural sectors. The area equipped for irrigation will expand by 40 Mha until 2030 in developing countries (FAO, 2003) and an additional amount of 1481-3880 yr^{-1} irrigation water ("blue water" e.g. from rivers, aquifers and lakes) necessary for irrigation of biomass plantations would already double current blue water consumption (Beringer et al., 2011). In the view of this situation two questions have to be asked: “How much productivity increase is required under different pressures on agricultural land?” and “How can this productivity increase be achieved by managing land and water resources carefully and sustainably?”

Scenarios for increasing pressure on agriculture

The global bio-economic land use allocation model MAgPIE with a special focus on spatially explicit land and water constraints as well as technological change in agricultural production allows for analyzing such trade-offs and synergies between land expansion, land intensification and international trade (Lotze-Campen et al., 2010; Lotze-Campen, 2008). For different scenarios on population and income trends, climate change, bioenergy demand, and spatially explicit land and water constraints, the model calculates the required rate of productivity increase on agricultural land. Aggregate demand in ten world regions is defined by total population and average income, reaching 9 billion people and 15.000 US$ (in 1995 purchasing power parity terms) in 2055 as well as net trade. On the supply side data on potential crop yields and freshwater availability is used from the global dynamic vegetation and water balance model LPJmL (Bondeau et al., 2007; Gerten et al., 2004; Sitch et al., 2003) on a regular grid with a resolution of three by three degrees (~300km by 300km at the equator). Bioenergy crops are of three different types: vegetable-oil-based from various oil crops, starch/sugar-based from cereals and sugar crops, and cellulose-based from specialized grassy and woody bioenergy crops. The MAgPIE model typically runs in six 10-year time steps from 1995 to 2055.

The issue of technological change in production is of crucial importance for the modeled spatial patterns of land and water use. In contrast to most other modeling approaches assuming a future trend in productivity growth and then deriving the economic and environmental consequences MAgPIE derives the minimum rate of technological change (i.e. productivity increase) required to meet certain constraints. It is assumed that if necessary, additional land from the non-agricultural area appropriate for crop cultivation can be converted into cropland at additional costs. Hence, the main question behind the scenarios described here is: "How much yield increase is required to fulfill future global demand for bioenergy and food under different spatial restrictions on land and water use?" In the scenarios, the pressures are added up to show their combined cumulative effects. Scenarios analyzed in MAgPIE are as follows (see for more detail Lotze-Campen et al., 2010).

(1) Business as usual (baseline): Global population increases to 9 billion people in 2055. Total calorie consumption per capita and the dietary share of animal calories increase in relation to rising per-capita income from progressing economic growth. The process of globalization and further trade liberalization is expected to continue. We model this by doubling the share of agricultural trade in total production over the next 50 years. Expansion of cropland is expected to continue at historical rates of about 0.8% per year. There are no climate impacts on yields in the baseline scenario. Note that all of these conditions are implemented specifically for each of the ten regions.

(2) + Reduced trade: The share of agricultural trade in total production is kept constant at 1995 levels of about 7%.

(3) + Bioenergy 100 EJ: Demand for bioenergy is continuously rising until it reaches 100 EJ globally in 2055. Bioenergy is region-specific and assumed to be fulfilled within each region.

(4) + Avoided deforestation: Cropland expansion is reduced by excluding intact and frontier forests from conversion, i.e. some effective measures for avoiding deforestation are expected to be implemented.

(5) + Climate change impacts on yields (CC with full CO_2 effect; CC with constant CO_2 effect): Climate impact results from the global dynamic vegetation LPJmL are fed into the MAgPIE model, and the average effects on the need for additional technological change are simulated with and without CO_2 fertilization.

Results show that in the business-as-usual scenario the required productivity increases in agriculture of 1% p.a. worldwide is below past observations of 1.4% p.a. (Figure 1). With increased bioenergy demand of 100 EJ in 2055 and additionally rising attempts to protect intact forest ecosystems the required productivity rate rises by up to 1.5% p.a. and 1.6% p.a., respectively, which exceeds past trends. The impacts of climate change on future productivity change depend on the assumptions about CO_2 fertilization effects on crop yields. If a constant CO_2 effect is assumed a productivity change of 1.8% p.a. is required because mean crop yields worldwide decrease on average whereas a smaller productivity increases of 1.4% p.a. is necessary if crops benefit from a full CO_2 effect. The cumulative pressure of increased bioenergy demand and avoided deforestation on agricultural land can be reduced with full CO_2 effects and global demand for food and bioenergy can be fulfilled.

In sub-Saharan Africa and Middle East/North Africa already in the business-as-usual scenarios productivity increases of 2% p.a. and 3.5% p.a. are required to fulfil the global demand in 2055. The Former Soviet Union is most affected by rising bioenergy demand and avoided deforestation whereas climate change impacts without CO_2 fertilization effect are expected to be strongest in South Asia and Pacific Asia. In regions with low population growth projected until 2055 like Europe, Centrally-planned Asia, North America and Latin America pressures on land resources are rather small. Moreover current productivity levels are already high in these regions and cannot be easily improved.

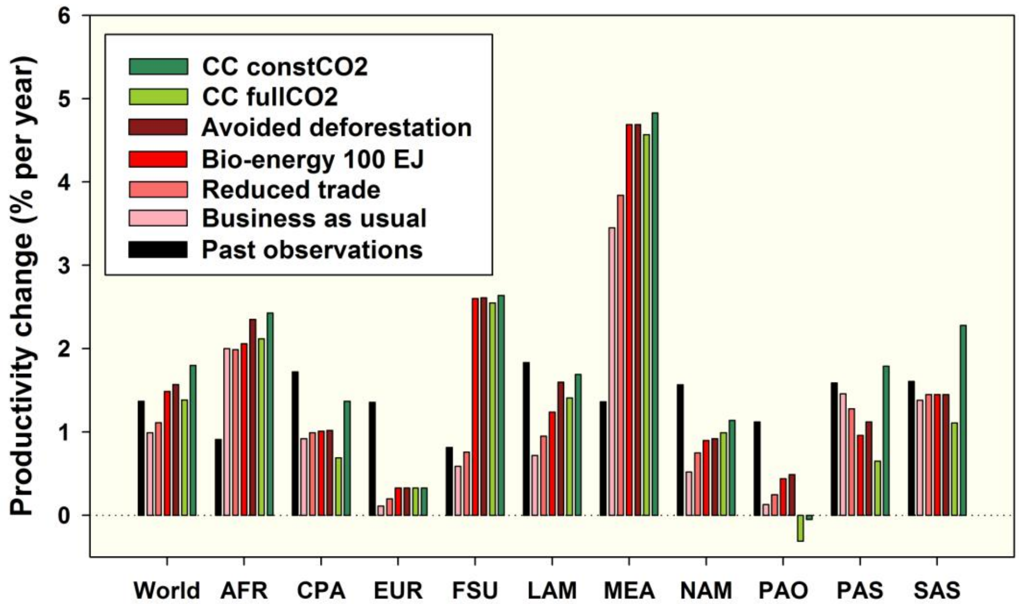

Figure 1: Region-specific required future productivity increase under increasing pressures on land and water use (<u>cumulative effects</u> of reduced trade, 100 EJ bioenergy demand in 2055, avoided deforestation, and climate change). Taken from Lotze-Campen *et al.* (2009).

Water-limited crop production

The current water consumption in global agriculture as well as the current and possible future water limitations to crop production were estimated based on simulation results from the global dynamic vegetation and water balance model LPJmL (Bondeau et al., 2007; Rost et al., 2008). All simulation runs are based on the CRU TS2.1 climate dataset for the 30-year period 1971 to 2000 to represent current climatic conditions and three global circulation models (ECHAM5, HadCM3, and CCSM3 under the SRES A2 emission scenario) for the 30-year period 2041 to 2070 to represent future climatic conditions around 2055. Results presented in the following are taken from the study of Rost *et al.* (2009).

Agriculture on rainfed and irrigated land currently consumes almost 17000 km^3 yr^{-1} of freshwater, about half of which is from cropland and pasture (Table 1). The major share of water consumption on cropland is from green water (precipitation stored in soil), which highlights the significance of rainfed agriculture in global food production.

Origin of water	**Consumption (km^3 yr^{-1})**	**Share of total consumption (%)**
Green and blue, cropland and pasture	16,759	100.0
Green and blue, cropland	8,501	50.7
Green and blue, pasture	8,258	49.3
Green, cropland	7,242	43.2
Blue, cropland	1,258	7.5
Green, pasture	8,122	48.6
Blue, pasture	106	0.7

Table 1: Water consumption on global irrigated and rainfed cropland and pasture (1971–2000 average). Data are taken from Rost *et al.* (2008).

Comparing the net primary production (NPP) of crops in water-limited and water-unlimited conditions worldwide gives an idea of the current level of water-limited crop production (Figure 2). Crop production is strongly water-limited over large geographical domains, especially in the subtropical and inner-continental regions of Central Asia, southern Europe, southern and eastern Africa and the Sahel, in parts of the U.S. and South America, and in many parts of Australia.

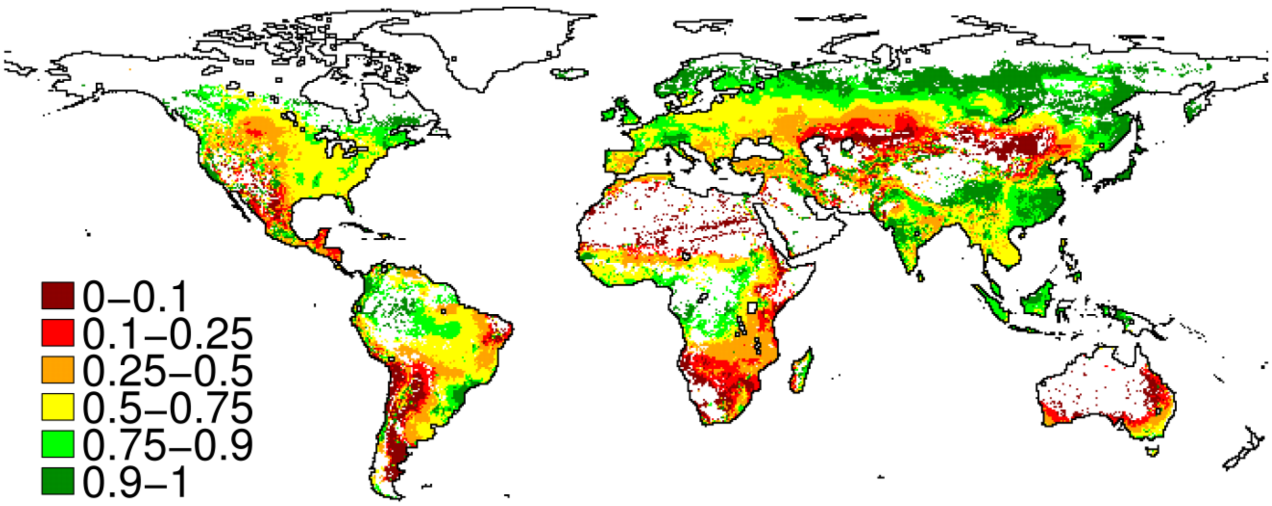

Figure 2 Water-limited crop production expressed as the ratio of actual water-limited NPP and theoretical water-unlimited NPP under present climate and management conditions (irrigation in areas equipped for irrigation). A value of 0 (1) indicates maximal (absence of) water limitation. Figure is taken from Rost *et al.* (2009).

Adaptive water management options

For many regions it is unknown if the presently extracted water volumes for irrigation can be guaranteed in the future in the view of regional limitations of water resources, climate change impacts, and adverse ecological and social side-effects. As worldwide productivity increases of 1.4-1.8% p.a. are required until 2055 to fulfill global food and bioenergy demand under limited land resources water use efficiency improvements in rainfed agriculture will have to be taken into account.

Methods for increasing water use efficiency include low-tech solutions such as the collection of rainwater (by cisterns, ponds, small dams, etc.) during wet periods and its later use during dry-spells ("rainwater harvesting" techniques); and the increase of productive plant transpiration by avoidance of unproductive soil evaporation, e.g. through mulching and other tillage ("vapor shift" techniques). Moreover, adapting the sowing date to a shifted start of the wet season will ensure optimal growing conditions and low risk of drought at important crop growth stages and, therefore, allow for better use of rainwater and potentially increased crop yields (Van Duivenbooden et al., 2000). Switching to more suitable crops with a shorter growing period, heat tolerance or drought resistance might also lower the negative impact of climate change. Accordingly, we performed several simulations to estimate the degree to which worldwide crop production could be increased through different management strategies on present rainfed and irrigated cropland, under both present and potential future conditions (details in Rost *et al.* (2009) and in Waha *et al.* (2011)):

- Vapor shift: Simulations representing strategies to achieve a vapor shift from evaporation to transpiration by reducing soil evaporation during the growing periods by, respectively, 25% (assumed to be a technically and logistically feasible potential) and 85% (a theoretical potential).
- Rainwater harvesting: Simulations representing rainwater harvesting strategies that store, respectively, 25% and 85% of (sub-)surface runoff from cropland over a year for potential use via micro-irrigation during periods of crop water limitation.
- Vapour shift and rainwater harvesting: Simulations combining both management strategies.
- Sowing date adaptation: Simulations with sowing dates adapted to changing climatic conditions instead of a constant sowing date.
- Cropping system adaptation: Simulations with the highest-yielding crop grown on available rainfed area in locations with production declines and in all locations worldwide.

Applying these management strategies globally would increase global crop production by more than 50% under present climatic conditions and more than 30% under future climatic conditions if both vapor shift and water harvesting techniques were combined at a level of 85% each (i.e. the theoretical potential).

However, it is very unlikely that this theoretical potential can be accomplished at large scale. More moderate scenarios suggest an increase by 6% to 19% for water management strategies and 0.7% to 3.8% for sowing date and cropping system adaptation (Table 2).

Adaptation option		1971-2000	2041-2070
Vapor shift	25%	6.0	3.9
	85%	24.6	15.7
Rainwater harvesting	25%	11.4	7.1
	85%	30.6	21.2
Vapor shift and rainwater harvesting	25%	18.7	12.7
	85%	52.8	37.3
Sowing date adaptation		0.8	6.1
Cropping system adaptation		4.6	6.2
Sowing date and cropping system adaptation		5.4	11.7

Table 2 Achievable increases in global crop production (%) through different water management strategies as compared to the current state (including irrigation on equipped areas), under both present climate conditions (1971–2000 average) and under future climate and CO_2 change (average of three climate change models under the A2 emissions scenario, 2041–2070).

In sum, there is a huge potential to increase crop production already in rainfed agriculture by applying low-tech water and land management strategies. The CO_2 fertilization effect may only benefit crop yields under optimal growing conditions including sufficient nutrient supply and therefore it remains unclear if expected crop yield increases in regions with low management intensity like e.g. sub-Saharan Africa can be achieved (Long, 2006; Tubiello, 2007). In the most ambitious water management strategy considered here (vapor shift + rainwater harvesting) global production increases on current cropland of 0.6-0.8% p.a. can be achieved but will not be sufficient compared to required productivity changes of 1.4-1.8% p.a. Thus, the remaining productivity increases need to be achieved through e.g. investments in research and development in the agricultural sector in order to improve water use efficiencies, the use of fertilizer and seeds.

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Chapter 11:
The water/food/trade/energy nexus - the epitome of the next phase of 'green capitalism'

Martin Keulertz, King's College London

Water has gained increased interest in the past few years by the private sector (McKinsey, 2009; Porter, 2010) and economic aspirants from the 'global south'. Drawing on Kondratieff's 'long wave cycle theory' and Kuznet's 'twenty-years-cycles' (Rostov 1975), it will be argued that we are now at the beginning of a new economic cycle where the water/food/trade/energy nexus will be crucial to understandfor its analysis. Whether there will be an 'Asian age' in the global economy will be heavily determined by sustainable applications of the nexus. For the purpose of this paper, I will first provide a brief overview of the 'economic wave cycles' literature and then apply it to a new Asian 'tiger economy', Qatar. I will argue that Qatar has understood its enormous challenges to harness its revenues from gas in order to lead its economy from a mere rentier state to an active global player in international food and raw materials trade. The most crucial challenge will be however whether the Qatari decision-makers will be able to leverage their economy by making use of a sound application of the water/food/energy/trade nexus.

Have not those who disbelieve known that the heavens and the earth were joined together as one united piece, then We parted them? And We have made from water every living thing. Will they not then believe? (Surah 21:30)

It is needless to mention that water is the source of all life. In particular, cultures who were founded in geographical areas with low water availability such as in the Middle East, have traditionally perceived water as one of the most precious goods. The excerpt from the Holy Qur'an should therefore be viewed as the underlying cultural fundamental for Middle Eastern water perceptions.

Five cycles to explain economic boom and bust

The global capitalist economy of the outgoing twentieth century was in a state of constant growth. After the collapse of communism, the global economy witnessed an era of unprecedented growth until 2009, which laid the foundations for the globalised world we live in today. Whereas Western economies benefited from the revolution of information technology, the supplying economies and thus 'work benches' in the East experienced an era of increasing trade surpluses. Globalisation turned China and India not only into major suppliers of Western consumerism but also into new economic aspirants. The Middle East functioned once again as the ventricle of this era by pumping the required amounts of oil into the global economy's essential systems. The metabolism of the past twenty years worked with ever-increasing velocity turning the previous periphery into another core of the international political economy.

As hinted above, I argue that one should reflect upon 'economic cycles' theory to understand the impact of water resources in the twenty-first century. The first economist to point the academic world to such patterns of economic growth and eras was Nikolai Kondratieff, who conceived the notion that 'long cycles' determine the period of economic boom until it gradually fades into bust. Technological innovations enabled the capitalist economy to see new waves of growth (Rostov 1975). The first wave was triggered by the invention of the steam engine and the subsequent industrial revolution in Europe from 1787 to 1842; the second by railway and steel from 1842 to 1897; the third by chemicals and electrical engineering from 1897 to 1939; the fourth cycle by petroleum and automobiles starting in 1940 until to date and the fifth by information technology from 1980 until to date. However, the hey days of the fourth and fifth cycle ended in 1973 and in 2001 respectively. According to Kondratieff, these waves lasted up to fifty years (Moody and Nogrady 2010). Schumpeter (1942) linked Kondratieff's assessments on waves with innovation. What he labeled as 'creative destruction' stood for the outgoing era of boom, the tipping point between the old and the new cycle. Kondratieff as well as Schumpeter did not use statistical analysis to underpin their arguments, hence they received widespread criticism from the mainstream economists of their days. Simon Kuznet (Rostov 1976) applied this missing link in examining 'long cycles' of an economic era by analyzing the correlation between prices and production spans. *He found that primary trends in production and prices reflected systematically the life cycle of a given technical innovation (or opening up of a new territory or natural resource); that is, a phase of rapid, then decelerating, increase in output; of rapid, then decelerating, decrease in price* (Rostov, 1976:422). Kuznet coined the term that those industries, which were most successful in such a period led the way of development. One of the most significant aspects about any economic cycle was the role of transaction costs, which the leading industries managed to decrease. I will return to this point at a later stage when discussing the relevance to the water/food/trade/energy nexus.

The creative destruction of the fifth cycle

The fifth cycle ended as early as 2001 when the IT bubble burst during the dot.com bust. However, Joseph Stiglitz (2010) links the fiscal policy of the Federal Reserve under Alan Greenspan in the early 2000s to the creation of the next bubble, which caused the most severe economic crisis after the Great Depression. In the absence of regulation, the next bubble was created by unsolicited investments in US and UK property markets. The bankruptcy of Lehman Bros in 2008 marked the final end of the artificially prolonged fifth cycle. The taxpayers, who may have risked the welfare state for the survival of the economy, almost exclusively paid the following bailout of American and European banks. The question that remains is what will follow after the fifth cycle.

The year 2008 did not only witness the worst financial crisis in history. It also included an overlooked phenomenon (because it has been hardly experienced since the end of the Second World War) by Western consumers: food price spikes. For the first time since the 1970s, staple food prices rocketed on the global financial markets (Wright, 2009). This led to growing concerns amongst decision-makers in the global south, where consumers were most affected. One consequence of these price spikes was the beginning of a new era in capitalist thinking. For the first time in decades, inward investment in land reached new heights. Developing countries were the major targets of investors from other economies in transition, who benefitted from the previous economic cycles. It is therefore no surprise that capital flows originated from Middle Eastern, South Asian and East Asian economies. This poses a number of institutional problems in relation to the current economic cycle, where institutions to regulate such capital inflows are absent. It is likely that the price of such missing 'rules of the game' (North, 2005) will be paid by the environment.

Water as it will be shown in the next paragraphs will be the Achilles heel of the global economy. Former British Prime Minister Margret Thatcher once remarked that 'socialism is fine, until you run out of money.' Her economic policies were based on neoliberal thinking prone to deregulation to create the institutional basis for the fifth cycle. Despite the many critics of the age of neoliberalism during the fifth cycle, it was also embraced by the political left in Europe, most notably by Tony Blair and New Labour, who conceived Third Way Politics to reconcile social justice with economic growth (Heffernan, 2003). However, they did not re-regulate the financial sector, which resulted in the credit crunch in 2008. This was the final breath of the fifth cycle.

The next cycle is currently in its conception stage: the sixth cycle or the green economy. At the heart of this cycle will be resource efficiency because the preceding cycle over-consumed our resources. I would call the past thirty years the 'instant age', where consumer-demand did not take resources sufficiently into account. The changing global order, climate change, resulting resource scarcities and increasing demand for global food supplies make a leap into a new economic cycle inevitable. Cutting waste to increase resource efficiency and substitution will be the major facet of this next cycle, which is hoped to lead to even greater economic returns than the previous cycles (Moody and Nogrady, 2010, UNEP, 2011).

'Capitalism is fine until you run out of water'

The water/food/trade/energy nexus will be the greatest challenge to the sixth cycle. Especially water resources will face severe pressures if global food security should be achieved by the year 2050 when 9 billion human beings will dwell on this planet. When Thatcher remarked socialism would eventually run out of money, the neoliberal thinking of the fifth cycle could be the gravedigger of water resources. If current thinking and behavior persists in the coming twenty years, the world will require 6.9 trillion cubic metres of water - 40% more that can be provided by available water resources (Chartres and Varma, 2010). The solutions of the previous cycles would have an increase of the supply-side through desalination of water resources by using nuclear power or fossil energy. Fossil energy such as oil and gas may have peaked or will peak in the coming years through more demand from East Asia (OECD, 2010). Moreover, the tragic events in Fukushima in Japan have exposed the severe vulnerabilities of nuclear power. Technological solutions of the past cycles may therefore be poorly suitable to fill the water gap.

The energy enigma in conjunction with the deregulated economy of the late fifth cycle therefore poses grave threats for the inception phase of the sixth cycle. Moreover, the previous cycles were characterized by economically unviable resource inefficiencies. In UK supermarkets, 30% of the products on shelve are not being sold to customers but end up in huge bins normally positioned in close proximity to the car park. In addition, UK consumers and the food supply chain also have a resource inefficiency of 30% (Food Aware, 2011). Between 1997 and 2001, the UK's water footprint totaled 73 billion cubic metres of water (Hoekstra and Chapagain, 2008). One third of it got wasted through the absence of economic efficiency in the private sector, where food is produced, traded and eventually consumed (Allan, 2011). Allan highlights the ignorance of agents in the food supply chain with regards to their role in global water trade (ibid).

Another phenomenon of the fifth cycle has been the pace of development in former developing economies. If the BRICS economies only catch up to similar living standards and water inefficiencies as the Western world, water would ultimately the most severe economic growth constraint (McKinsey, 2009).

A poor man's response to water scarcity

Most of European countries are net virtual water importers (Hoekstra and Chapagain, 2010). Nevertheless, the EU could potentially provide food security for basic staple foods such as grain, diary and meat to its people if required. The Gulf economies are in a very different situation. I will now present the case of Qatar where holistic concepts to achieve food and water security through moving on to the sixth cycle have been introduced. Qatar offers a unique case study due to its severe water poverty and dependence on food imports. It is also perhaps the most researchable case for sixth cycle strategies at present.

The island in the Persian Gulf imports over 90% of its food requirements, which is mainly because of its very limited water resources of roughly 56 million m3/per year leaving every single of the 1.7 million Qatari population with 32 m3/per year (QNFSP, 2011; AQUASTAT, 2011). Despite this endowment Qatar has one of the highest GDPs per capita, the Gulf state is a water pauper. However, Qatari decision-makers have understood the epic challenge and introduced a National Food Security Programme. This initiative is amongst placing the water/food/trade/energy nexus at the centre of its approach. Within the next ten year, Qatar seeks to increase domestic agricultural production by 30-60% through desalination plants powered by solar energy. Financed through natural gas exports (Qatar holds the largest gas field in the world), the natural resource wealth is used to transform the economy from food and virtual water import dependent to levels reaching self-sufficiency (Interviews, 2011).

The missing link in the equation is viewed in foreign direct investment in land and water in North America, Eastern Europe, Africa, and New Zealand (Interviews, 2011). In other words, Qatar intends to increase its virtual water imports through overseas land (and water) acquisitions to make full use of its fossil energy wealth. Moreover, concepts to cut waste in the supply chain are developed with supermarket chains to decrease waste and increase resource efficiency. Qatar is thus an example of an economy on the way into the sixth economic cycle. The decision-makers view this strategy crucial to maintain economic prosperity reconciled with economic justice.

Source: QNSFP, 2011

The risks of the sixth cycle

The above-mentioned investments in overseas land pose also significant risks to the ambitious strategy of the State of Qatar. Through its state fund, the country is going to invest one billion US Dollar in Sudan to raise fodder for meat production (Interviews, 2011). On approximately 100.000 ha, the state fund plans to irrigate 'alpha-alpha' and other crops using one billion cubic metres of Nile water. Without going into the analysis of the Nile water question, this strategy may lead to further political and economic challenges in North Africa due to Egypt's dependency on the Nile. The investment in Sudan reveals the urgent need for institutional arrangements for foreign direct investments in land. The Qataris may easily be able to finance these plans through the rent gaining experience of the fourth and fifth cycles.

The focus on blue water for the production of crops is a typical facet of old-style economic thinking of the neoliberal days of a deregulated economy. However, if the same paradigms of the Thatcher days are applied, the sixth cycle may not be able to unleash its full potential as desired by proponents of the next era in global capitalism. The enhancement of green water productivity as a sustainable avenue for overseas food production has not gained currency in current thinking of investors from Qatar, which may be the greatest weakness of the highly progressive concepts conceived in the Gulf state.

The water/food/trade/energy nexus may therefore have a great appeal to economies blessed with high natural resource revenues but may face its most severe constraints through the absence of timely 'rules of the game' and willingness to take risks with regard to environmental justice. It must be added that the current wave of foreign direct investment in land in Africa offers annual returns between 15-25%. It is needless to mention that the absence of regulation through institutional arrangements make these returns possible.

In this paper, I have argued that the global economy is at the beginning of a new economic cycle, which requires increases in resource using efficiency at a time of looming resource scarcities triggered by rapid demographic changes and economic prosperity in Asia. This resource efficiency also unveils the weaknesses of the private sector, which is highly resource-inefficient at present time. I have tried to illustrate that awareness of the water/food/trade/energy nexus will be one of the most crucial elements determining the success or failure of the next cycle in capitalism. We currently see the birth pangs of a new era in the global economy. The resource giant Qatar is amongst the most progressive economies in its evaluation of the challenge of how to turn their economy green. However, governments in recipient countries will decide upon the success or failure of such concepts.

As Douglass North (2005) stressed '*Institutions are the humanly devised constraints that structure human interaction. They are made up of formal constraints, informal constraints and their enforcement characteristics. Together they define the incentive structure of societies and specifically economies*'. Whether or not decision-makers will find the right incentive structures of the future at the global strategic scale will be determined by the our understanding of the operation of the water/food/trade/energy nexus.

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PART III:

REGIONAL EXAMPLES

Chapter 12:
How does water flow into politics?
Scrutinizing the water/conflict nexus in South Sudan

Julia Ismar, MSc
Institute for Social and Development Studies, Munich School of Philosophy

As the dust settles after the euphoric celebrations of the independence of "Africa's youngest state" on July 9, 2011, a sober assessment reveals a fragile nation faced with a flood of challenges. Decades of civil war and mind numbing violence have brought forth a state struggling with dramatic deficits in infrastructure, development and good practices of governance. The 2005 Comprehensive Peace Agreement, reached after decades of fighting and millions of victims, has failed to bring about (even negative) peace, outbreaks of violence are still shaping North-South as well as domestic South Sudanese relations, and international assistance is considered vital for rendering the newly emerging political setting feasible and stable.

Among the many factors feeding into the complex crisis that have shaped the history of the modern Sudan, questions of resource management and governance have increasingly shifted into the focus. During the war with Khartoum, but also since the signing of the peace agreement, water issues are said to be a significant source of instability and hostility in the South. Even though South Sudan can theoretically draw on a great potential for development due to its (water) resources, disputes over access to water, predominantly in combination with land, are often cited as triggers for local conflicts – with possible regional and national repercussions. There are few effective mechanisms to resolve disputes over water resources peacefully. While this is certainly a consequence of the institutional weakening during the civil war, current political practices are arguably not contributing to resolve this issue.

The question whether conflicts over water are a result of how politics and water resources interact is crucial in understanding the dynamics that have caused inconceivable suffering in the past, and is arguably key to a peaceful evolution of the newborn state. Is there a viable connection between the access to water resources and the occurrence of political conflict[1]? And if so, how does this mechanism work? How are the (evolving) political institutions addressing, (or influencing) this issue? And how do these strategies shape the lives of the citizens of South Sudan? The paper will shed light on the current theoretical discourses on resources, conflicts and the attempts to understand

[1] The present paper endorses a rather wide understanding of "conflict": a situation qualifies as a conflict when "two or more parties believe or perceive that their interests, needs or values are incompatible, express hostile attitudes or take action that damages other parties' ability to pursue their interests." (Bildhäuser, 2010, 7) It is the result of parties acting on the basis of these perceived incompatibilities (International Alert, 2003, Section 2:3). A conflict turns violent when the actors involved no longer follow their ends by peaceful means, but resort to violence instead.

the nexus between the two. Anecdotal evidence is to support the theoretical discourse. As a second step, by drawing on a livelihood analytical framework, the project aims to develop a conceptually rich and contextually informed understanding of how water and politics interact in South Sudan.[2, 3]

1. From resource-based conflicts to livelihoods analytical frameworks

How does water scarcity, or the management of scarce resources in general, relate to violent conflict? There has been a sheer unmanageable amount of literature oscillating around this question - arguably without ever closing in on a satisfactory answer. Irrespective of a complete lack of evidence, the discussion on international conflicts over water has received widespread attention in academia and the media ever since Boutros Boutros Ghali famously evoked the notion of looming water wars in the Middle East and Africa. Despite the wide and popular acceptance and evolution of this Malthusian discourse, mainly in the 1990ies (see Homer-Dixon, 1994; Gleick, 1993), it is now widely accepted that the most pressing issues in relation to water are to be found on the sub-state level: according to Carius and Wolf (2004), the level of conflict and the likelihood and intensity of violence are inversely related. Not only are domestic conflicts over water more likely to erupt, but also highly relevant to questions of development, human security and stability, and this trend will continue in the future. Whereas there is no historical precedent for international conflicts over water, "intra-national social struggles fuelled by water inequality and injustice [are] unlikely to diminish in the foreseeable future" (Castro, 2007, 109).

1.1 Understanding domestic water "conflicts"

As Houdret (2010) laments, the study of domestic water conflicts has been rather "unsystematic" up to this point, with a focus on efficiency of institutions and the states' capability to govern/manage the resource.

> Water problems are not water problems alone, but are in large measure products of the relative ability or inability of different states and societies to address their economic and social problems, water problems included. And it is this differential capacity of different societies to control and produce water in accordance with social needs [...] that one must above all concentrate on, if one wants to understand the roots of water crisis (Selby, 2005, 333).

The vibrant discourse on weak state capacity as a driver of conflict has generated important insights in the role of the political environment, in which (local) conflicts arise. The lack of effective conflict resolution mechanisms, exploitation of power

[2] The paper will predominantly deal with the conflict setting in the South. However, the impact of the conflict with the GOS in Khartoum and the violent clashes between the North and the South need to be taken into account in order to provide a comprehensive assessment of the situation. The ongoing conflict in Darfur, however, shall be excluded from this paper as its impact on Southern Sudanese politics is rather limited.

[3] At this point of the project, the paper can only provide evidence derived from literature to support the assumptions that have shaped the research questions. Qualitative research to generate the necessary information is planned to take place from February 2012 onwards.

vacuums and the inability to ensure the human security of its citizens are central to the discourse: "When basic components of human security are threatened, evidence shows that one result is increasing pressure on increasingly stressed government structures. People need a responsive state to respond to their needs. When it cannot, conflicts over a narrowing resource base cannot be resolved. This produces social conflict and political instability." (Smith, 2010, 25) Whereas this linkage provides a useful additional perspective, it does not significantly move beyond deterministic considerations underlying the water wars scholarship. The strong emphasis and securitization of water and of water management have only limited analytical scope as they rely on monocausal explanations for violent conflicts and do not sufficiently take the political and social context of the region suffering from water stress into account.
Contextualizing water issues however, is a prerequisite to understand them: "rather than being simply another environmental input, water is regularly treated as a security issue, a gift of nature, or a focal point for local society. Disputes, therefore, need to be understood as more than "simply" over a quantity of a resource but also over conflicting attitudes, meanings, and contexts" (Priscoli, Wolf, 2009, 27) and as dynamically depending on the overall social and political developments in a given society.

Most importantly, the causal mechanisms between environmental factors and conflict need to be explored further, only then can the study of environmentally induced conflicts, if such a thing exists at all, contribute to our understanding of violent strife: before it produces a violent conflict, resource scarcity or environmental change have to be 'translated' into a social phenomenon (Libiszewski, 1996). From a state centric perspective, and often advocated in publications of international organisations, this link is the governance of a given resource. "Water conflicts are part and parcel of wider social and political confrontations between alternative, often antagonistic societal projects, confrontations that are at the heart of the process of governance." (Castro, 2007, 110) The concept of governance ties aspects such as political power structures, institutions, legal frameworks and informal rules into the analysis, hence creating a more politically conscious picture of water management as part of the social and political processes that shape society. The case of semiarid Sudan is a good example to highlight that the reason for insufficient water resources is not scarcity as such, but rather the inadequate legal framework, a lack of enforcement and distributive mechanisms that reflect unequal power relationships. Thus, the paper necessarily will (albeit very critically) engage with the notion of governance in water services. The officially recognized definition of water governance as put forward by the United Nations Development Program (UNDP, 2006) includes "the range of political, social, economic, and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society".[4,5]

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[4] It is only by bringing in the notion of "good governance" that the process is given a normative dimension. The principles of good water governance are, as listed in the UNDP Water for Life Report: participation, transparency, equity, accountability, coherency, responsiveness, integration, and ethics. In its strictest sense, good governance of water is not to bring about good results, but results that are more aligned with societal aims. It is an instrument, but it is not an end in itself. Even though there are many different conceptions of the notion of governance, the paper will understand and apply the term as a descriptive one.

[5] The current international discourse holds that "the water crisis is a crisis of governance" (Plummer, Slaymaker, 2007, 3). The flip side of this widely accepted paradigm, is that good governance could prevent the lingering water crisis. Moreover, governance of water is often seen as a "key to much wider issues of governance and political development" (Franks, 2007,

This paper holds that in addition to analysing water governance, it is the view outside the "water box" that opens the door for useful analysis: empirical research of local water-related conflicts indicates that they tend to reflect broader, more general structural problems, in the sense that those stakeholders and concerns who tend to become marginalized in society at large are also those most likely to fall victim to inequitable water management (See Coser, 1965; Ravnborg, 2004, 4). Consequently, an analysis of conflicts over water needs to scrutinize the links between water and its social and political environment and look at the social geography of water, at the dynamics at all levels, including the individual or local level.

1.2 The Livelihood Analytical framework

In order to move beyond deterministic, state centric models to help to grasp the dynamics of water-related conflicts, Lautze and Raven-Roberts (2006) have proposed the Livelihoods Analytical framework, which links the availability and the stress deriving from a given resource to the human and political conditions on the ground. Looking at the issue-area from a livelihoods-inspired perspective is to serve as the theoretical lever to open up the Pandora's box that is water management in South Sudan and to allow for a more comprehensive understanding of possible triggers for conflict. The following illustration is an attempt to sketch the dynamics and to provide a general orientation of the manifold linkages:

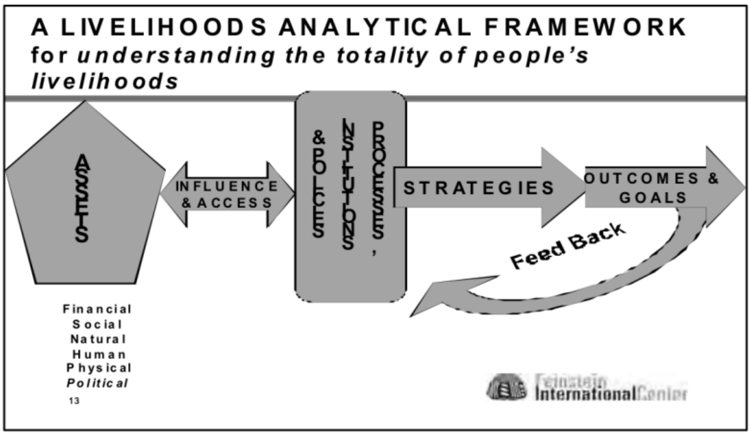

Figure 1: Livelihoods analytical framework. Source: Lautze and Raven-Roberts, (2006)

What distinguishes this model is that it differentiates between the resource (assets), the means through which these are managed (policies, institutions and processes, PIP) and the activities that people are applying (strategies). By linking these three stages, the model facilitates an understanding of how both natural resources and the modes of their governance are affected by conflict. It further provides room to assess the changes people make in their livelihood strategies in response to conflict, all too often choosing short-term over long-term strategies (Bromwich, 2009). The feedback loop, which illustrates the dynamics by which the environment is rendered a victim of the conflict as

296) as water is intrinsically linked to many functions of the state and the society. However, the issue is not as simple as the dominant discourse proposes, as the term governance masks many political and power-related factors. For a thorough discussion of the discourse on water governance and its conceptual flaws, refer to: Castro, 2007; Franks, Cleaver, 2007; Mollinga, 2008.

well as a potential/additional driver, provides a more informed description of the possible resource – conflict nexus that has been (rather insufficiently) addressed by the many theories presented above. The feedback loop is not limited to internal effects but may also be shaped by external influences that affect the dynamics of the cycle, such as different political conditions or climate change.
Focusing on livelihoods and their link to political decisions invites to look behind the facade of concepts such as tribal conflicts, resource based conflicts or governance failure and allows to cross the boundaries of the relating discourses. By taking the livelihoods and their political determinants and consequences into account, one is more likely to grasp that "water conflicts" have much broader dimensions than just the struggle over a (scarce) resource.

> Livelihood groupings often coincide with groups of tribes, which allow important issues to be discussed. Such issues relate to groups of livelihoods rather than groups of tribes, thereby disaggregating the complex issue of ethnicity from the local level of conflict. Depersonalising the discussion of environment and livelihoods from the discussion of the conflict like this facilitates the sensitive analysis of conflict at the local level (Bromwich, 2009, 113).

Applying this framework to South Sudan is certainly a very ambitious undertaking, especially since much of the large amounts of information needed is not yet available: the government of South Sudan yet has to become fully operational and implement the policies laid out during the transitional period. Further research for the paper will predominantly focus on the political dimension of the framework: which kinds of institutions carry out what kind of policies, which actors are involved? How does water governance take place? And what are possible/anticipated consequences? However, by starting this analysis from a livelihood-informed perspective, the paper will look for the effects of political processes on the lives and their strategies for survival of the people and thus hopes to provide a more nuanced judgement of the complex interrelation between water resources and conflict in South Sudan.

2. *Water governance in South Sudan: A Pandora's box floating on the disputed waters of the Nile basin*

While the international dimension of the disputes in the Nile River Basin (which have been played out in relatively institutionalized ways) has received a lot of international attention, the national policies of the affected riparians have only been insufficiently analysed, regardless of the manifold linkages between domestic and international policies for water management. Taking the international dimension of the dispute as a given setting, the following paragraphs are to look into domestic water issues in South Sudan.

Policies and performance of the Government of South Sudan have to be judged against the background of the civil war that has devastated the county over the past decades: without a thorough "localization and contextualization of how governance systems evolve and how these result from precedent, the environment and local practice" (Franks, Cleaver, 2007, 292), the analysis lacks a solid base. In South Sudan, infrastructure, (human) capacity and governance mechanisms have been eroded and are being (re)built under very unfavourable conditions ever since the signing of the Comprehensive Peace Agreement (CPA) of 2005.

The CPA and the Interim Constitution declare that both the Government of Southern Sudan (GoSS) and the ten states have power over water within their areas of jurisdiction. The Ministry of Water Resources and Irrigation was created in January 2006, and its first water policy document was published in 2007: the proclaimed goal is to promote social development and economic growth by promoting efficient, equitable and sustainable development and use of available water resources and effective delivery of water and sanitation services in Southern Sudan by 2025.[6] But how does this ambitious plan play out in practice?

The main issue creating water stress in Sudan is not the absolute amount available but rather the high regional diversity and low predictability of rainfall (which is likely to increase as a result of climate change) that constitute constant challenges. The White Nile, the Sobat and Bahr el Ghazal with its tributaries descending from the Nile-Congo divide plateau converge in Southern Sudan to create the largest wetland in Africa: the Sudd. The climate is tropical in the south and arid in the north and both droughts and floods pose common threats to the population and their livelihoods. About half of the land is suitable for agriculture, of which about only 170,000 km^2, or some 7 %, is actually cultivated arable land fed by rain water (70% of agriculture in the whole of Sudan is rainfed, compare Sullivan, 2010). The Nile River is virtually the only source of clean water in the country (ESCWA, 2010). Especially the South Sudan has vast untapped, undeveloped water resources (especially groundwater), which could potentially contribute greatly to the development of agriculture, which takes up over 90% of water consumption (Sullivan, 2010). Irrespective of the available resources, much of South Sudan's population suffers from a shortage of both clean water for drinking, and reliable water for agriculture (UNEP, 2007, 220). Food security has improved slightly in 2011, but the post-independence period poses grave challenges in terms of food supply, such as the return of countless refugees from the north.[7]

Livelihood strategies for most rural households have traditionally depended on access to natural resources, especially water and land[8]. According to De Wit (2009), these have been mobile, event driven and opportunistic. Pastoralists, farmers and nomadic tribes have shared these resources, and arising disputes used to be settled by traditional customary mechanisms of conflict resolution (Wassara, 2007). These mechanisms have ceased to work given the growing competition between different groups and the politicization of the resource leading up to and during the civil war. Today, in independent South Sudan, water rights are still highly political. This trend is aggravated by the expected shortage as a result of climate change and continued struggles between different users.

Even though any mono-causal explanation would be a mockery of the complex conflict setting in Sudan, De Wit (2008, 2) argues that "the underlying cause includes beyond any doubt access and management of land and natural resources and the distribution of the benefits derived from their exploitation. Chronic structural conflicts over land and natural resources have persisted for a long time." How did these local struggles feed into the Gordian knot that are the Sudanese Civil wars? And how is this legacy addressed by

[6] For a full version of the policy framework issued by the MWRI, see: www.rwssp-mwrigoss.org
[7] For the full report, see: http://www.wfp.org/news/news-release/south-sudan-food-security-improves-though-prospects-depend-post-referendum-period
[8] About 80% of the people in Sudan depend on agriculture, Compare: FAO, 1998.

the new state of South Sudan? The chapter will sketch in how far water management has been shaped by its political environment and, as a second step, has fed back into the dynamics of the civil conflicts. Fieldwork will eventually be used to enrich and scrutinize these considerations. The Livelihoods Analytical Framework introduced above will provide guidance in presenting the (at this point still anecdotal) evidence in a more systematic way and to critically analyze it.

2.1 Water governance is shaped by its political environment

The United Nations Environment Program (UNEP) describes the environment as the "silent casualty of conflicts". For the present discussion, the institutional impacts that bring about this connection are most important:

> Conflict causes a disruption of state institutions, initiatives, and mechanisms of policy coordination, which in turn creates space for poor management, lack of investment, illegality, and the collapse of positive environmental practices. At the same time, financial resources are diverted away from investments in public infrastructure and essential services towards military objectives (UNEP, 2009, 15).

Developments in the Sudan over the last decades seem like a case in point: the discourse on failed states as a driver of conflict provides a vivid picture in how far inefficient institutions and misguided policies can bring about civil conflict: The decades of civil war have greatly affected government performance, especially in the South, where it is basically non-existent. This has also taken its toll on water management, as there is a complete lack of infrastructure and, until recently, little investment in this sector.

The CPA as well as the Interim Constitution declare that both the GoSS and the ten states have power over water within their areas of jurisdiction. They can use water and regulate disputes that may arise over water utilization for economic and social development. However, there has been a corrosion of traditional conflict resolution mechanisms, which have been undermined during the conflict, and the central government is not (yet) in a position to fill that vacuum. There are no coherent vertical linkages between state and society, between formal and traditional forms of governance. Further, there is confusion about the legal system in place, as a result of the war and subsequent reforms[9], which is further aggravated by a lack of a clear post-conflict governance plan and legal enforcement. "Certain intrastate conflicts are "laboratories" for the redefinition of patterns of access to natural resources" (El Fatih et al., 2007, 3): power structures are shifting, the structure of society may be altered, political changes are likely to take place. Unfortunately, the CPA of 2005 has very clear limits as a blueprint for improved governance of natural resources. A new pattern of water governance has yet to take root as it currently still competes with the remains of the corroded traditional system, creating high levels of uncertainty.
Returning refugees and Internally Displaced Persons (IDPs) are posing an additional challenge: conflicts over land rights of returning refugees have the potential to undermine stability and the legitimacy of the post-conflict legal framework, as there are

[9] The German Development Corporation suggests: "Conflict-specific measures have also proven to be effective in reducing water disputes. One of the means to support peace building is the revivification of traditional arrangements and authorities for conflict management and the negotiation on conflictive issues." (Houdret et al., 2010, 14) In South Sudan, the crucial factor is that a coherent system that can be enforced is introduced to provide for legal security.

no viable conflict resolution mechanisms in place. New settlements are evolving as IDPs group together due to their inability to settle formally. These settlements completely lack infrastructure, which has to be addressed by the Juba Government eventually, creating a further strain on the already scarce funds.

2.2 Water governance shapes the political environment

"Governing water inevitably involves governing conflicting interests" (Ravnborg, 2004, 8) and is thus a political process from the start (Mollinga, 2008). Especially in regions shaped by relative scarcity, competition may arise between agricultural and industrial users, farmers and nomads, rural and urban water users, or the centre and the periphery of a given region. In a politicized environment, any form of water governance, be it "good" or "not so good" governance, implies strategic allocation choices and will have political repercussions. This was evident during the course of the civil war, and remains an issue in the South, constantly undermining stability on the local level.

The political tensions in the country were transmitted the delicate equilibrium between the various users of the precious resource: "In the period leading up to the present crisis, policy interventions of the Government of Sudan (GoS) have […] undermined this access and reduced mobility. […] Rural land users have been cut off from their resource base" (De Wit et al., 2009, 7) and pastoral routes are blocked whereas large scale, mechanized farming in the transitional areas between North and South as well as the oil industry have been attributed a lot of water and arable land. The politicization of water management on behalf of Khartoum contributed to the ongoing marginalization of large segments of the population and gave water management an identity-twist that cemented existing fault lines between tribes in the North and the South, as well as between the centre and the (largely neglected) periphery. [10]

Competition for the benefits accrued from the use of surface water was a crucial aspect contributing to the civil war, as illustrated by the Jonglei canal project, which was a cause as well as a victim of the conflict that flared up in Southern Sudan in 1983 (UNEP, 2007): this Sudanese-Egyptian project would have cut off water from the Sudd-wetlands and threatened the livelihoods of many communities in the South to allow for more efficient commercial farming in the North. This project, which is unlikely to ever be completed, highlights how water projects are an integral part of unequal regional development and competing development agendas.[11] The attack of SPLA/M forces on the construction site in 1983 highlights the attempt of the group to fight for the access to resources for "their" people (de Wit, 2008) and the degree of symbolism attached to water development projects.

Similar misguided politics seem to be implemented on a smaller scale in Southern Sudan today: The planning and the construction of small scale canals by the Ministry for Water

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[10] From this perspective, any RBC can be seen as a variant, or as the result of the transformation of "identity conflicts". See: El Fatih, 2007.
For a historical overview of the politization of water management, see Shepherd, Norris, 1987,
[11] Khartoum invested heavily in large scale farming projects to bring about economic development, which was made possible at the cost of small scale farmers. The marginalization of several rural regions, especially in terms of water infrastructure, has given birth to the phenomenon that class structure has a strong regional dimension in Sudan.

and Irrigation, aiming to alleviate the pressure deriving from erratic rain patterns and to improve water security are running the risk of impacting livelihoods of the southern Sudanese, as they affect cattle camps and migration roots. This is one of the crucial points where the livelihood model as introduced above can provide valuable insights to improve policy choices – and to assess the consequences of their implementation (or the lack thereof).

The issue of resource/water governance cannot be separated from the question of land ownership: if water is predominantly used for rain-fed agriculture, access to land is just as crucial as access to water. Especially in South Sudan, land administration is among the main drivers for local violence and instability: constant clashes between herders and pastoralists over access to water and land constitute a source of instability with great repercussions on the regional or even national level.[12] As in all of Sudan, the question of how to allocate land and water rights to the pastoralists poses a sensitive challenge to the government in Juba, as their nomadic lifestyle clashes with modern conceptions of statehood and territorial administration (Bromwich, 2009): traditionally, pastoralists and farmers managed their different requirements for water and land peacefully, but these mechanisms are now failing due to reallocations of land, increased pressure on existing resources and increased strains on livelihoods. Ultimately, the issue of pastoralists will become a sensitive point for many African states as they represent the clash between traditional (transnational) livelihood strategies and modern, state-centred modes of subsistence and production.

The failure to establish a coherent regime has created uncertainty at the local level and opened up room to exploit this administrative vacuum (Rolandsen, 2009; Schomerus, Allan, 2010).[13] Disputes over communal, or "tribal" boundaries have intensified. These conflicts were exacerbated by the (proclaimed) policy of the SPLM/A to decentralize land administration. Land administration is to function according to the subsidiarity principle. However, lacking legal certainty at the national level and lacking administrative capacity on the regional level have so far inhibited the reaping of the benefits of these reforms: "While government structures are being established, these do not necessarily reflect existing power relationships. As actual power is played out, administrative confusion arises" (ibid. 26) and keeps tensions high.

Ultimately, "natural re-sources may not be immediate game changers, but their use (and misuse) will continue to influence the likelihood of friction among central, regional, and local parties, as well as the economic success of the future Sudanese state(s)." (Sullivan, Nasrallah, 2010, 2) So even if this paper endorses a cautious assessment of the link between water and conflict, it does argue that water issues need to be addressed in order to bring viable peace to South Sudan. More specifically, they need to be addressed taking livelihoods, questions of heterogeneity in power status, and political will and capabilities into account.

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[12] The claims and needs of returning refugees and stakeholders in the conflict who now try to turn their military power into civil power increase the pressure on farmers and pastoralists.

[13] "Peace agreements also bring along new land conflicts, especially when military and political forces seek opportunities to transfer their wartime powers into post conflict economic power, mainly by scrambling for land and natural resources. Securing access over the commons corresponds with a strong pro poor development strategy." (De Wit, 2008, 22)

3. What lies ahead

Clearly, water issues, if not managed correctly, can cause frictions in any given society that may have wide repercussions. The case of Sudan during the civil war, as well as Southern Sudan during the phase of reconstruction and state building are powerful examples to highlight how water issues and politics interlink.
The GoSS has, at least on paper, endorsed the principles of Integrated Water Resources Management, good governance and presents its work as part of South Sudan's efforts on the road towards the Millennium Development Goals. As already laid out above, current policies may have improved access for many citizens, but are still anything but inclusive and have so far ignored, or even aggravated the structural problems on the ground. Consequently, both the dedication of the government as well as applicability of these concepts has to be critically assessed. Surely, governance in South Sudan has to be judged against the background of the decades of civil war that have severely eroded institutions, but this does not mean that it should be met with less scrutiny.

This is even more critical given the issue area of international and private investment in the water sector. The attempt to generate funds from private actors through Public Private Partnerships (as proposed by the strategy of the Ministry of Water Resources and Irrigation) is unlikely to address structural problems but instead aims to improve efficiency irrespective of the social geography of the water resources. On the international scale, large projects such as the Multi Donor Trust Fund administered by the World Bank channelling large amounts of money into the water sector in South Sudan. The current "land grabs" or land lease agreements, which amount to roughly 9% (Vidal, Provost, 2011) or the territory of the new state, are to further complicate water and land distribution. If this dimension is taken into account, a thorough understanding of the social consequences of current patterns of water allocation is even more crucial.

A lot more research and time is required to fully assess the consequences of the current developments in South Sudan. This paper was to lie out the issues and challenges at stake and to point out areas and contexts that need further research. By focusing on livelihoods at the local level and their linkage to the bigger political picture the project aims to overcome deterministic and alarmist images of "water wars" in South Sudan, and instead provide an empirically sound assessment of the issues at stake. If the world's 193th state is meant to be a success story, these issues need to be addressed sooner rather than later.

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Chapter 13:

Cultural notions of water and the dilemma of modern management: Evidence from Nigeria

Emmanuel M. Akpabio, PhD

Department of Geography and Regional Planning,
University of Uyo, P. O. Box 4223, Uyo, Akwa Ibom state, Nigeria
E-mail: emakpabio@yahoo.com

Emmanuel Akpabio (AvH Fellow and Senior Researcher),
Zentrum für Entwicklungsforschung,
Universität Bonn, Walter-Flex-Str. 3, 53113, Bonn, Germany
http://www.zef.de/staff/1106.html
akpabio@uni-bonn.de

Abstract

The contexts in which knowledge and representations of natural entities occur differ between places and over time given differences in social, cultural, ecological and historical factors. This paper explores some forms of local beliefs and philosophies about water in Akwa Ibom state, Nigeria. Discussion on these also looks at the management implications of such local beliefs and philosophies as well as their dissonance with modern management approaches. Given the tension identified at the interfaces of the two knowledge domains and the consequent negative impacts on available water resources, the paper argues for an integrated knowledge which has the potential of reconciling and incorporating the best practices often espoused by local ecological knowledge of resource management. Striving for such level of knowledge, the paper observes, could achieve the twin objectives of education (especially on misplaced assumptions) and at the same time learning from the strength of local knowledge resources. The paper recommends more research in this direction.

Introduction

The relationship between society and nature can either be in the form captured in Swyngedouw (1993) or the contrast presented by Smith (1984, 1996). Swyngedouw had argued that 'humans encounter nature with its internal dynamics, principles and laws as a society with its own organizing principles. This encounter inflicts consequences on both. The dialectic between nature and society becomes an external one, i.e., a conflicting relationship between two separate fields, nature and society, mediated by material, ideological and representational practices. The product then, is the thing (object or subject) that is produced out of this dynamic encounter'. On the other hand, the author recorded Smith's (1984; 1996) contrasting argument which insisted that nature is an integral part of a process of production or, in other words, society and nature are integral to each other and produce in their unity permanencies (or thing-like moments). These arguments, as Swyngedouw himself notes shows that both society and nature are produced, hence malleable, transformable and transgressive. How society and nature are produced or reproduced depend on the knowledge system available. Martins' et.al (2010) philosophical comparison of the differences between traditional ecological knowledge and western science is very useful in understanding the various versions of human-nature interaction. In the categorization, three interrelated issues stand out as follows: 1.) the relationship between humans and their environment; 2.) the nature of knowledge-making in space and time, and; 3.) the role of belief systems in knowledge-making. By the yardstick of relationship between humans and nature, several studies have noted the traditional ecological knowledge as symbolizing the unity of nature and culture as opposed to the worldview of the western science[1] which sees humans as typically disembedded, or as existing autonomous from the local system, creating a schism between non-human nature and human culture (Banuri and Apffel-Marglin, 1993; Pierotti and Wildcat, 1997; Bateson, 1972; Berks et.al, 2000). Looking at knowledge making in time and space vis-a-vis the ecosystem, modern western science arose principally in one geographic locale (Europe) and is constructed and disseminated in a fixed manner based on rationality and universal principles. By this, western science assumes that knowledge exists independent of time and space. Citing several authors (such as Walters, 1986; Holling, 1996; Roy et.al, 2010), Martins et.al pointed out that ecosystem scientists have provided numerous examples of cases in which knowledge independent of time is insufficient due to common occurrence of ecological perturbation and surprise. This is in contradistinction to traditional ecological knowledge which has been shown to be context driven, evolutionary and adaptive, situated knowledge (Chambers and Gillespie, 2000) and is flexible over time, evolving with an often unpredictable, uncontrollable environment (Pierotti and Wildcat, 2000; Menzies and Butler, 2006). The last point in this categorization emphasizes the fact that, unlike western science, traditional ecological knowledge depends on beliefs, values, norms and spirituality which has been criticized for its 'anti-rational' philosophy (Howard and Widdowson, 1996). Berkes (2008) observed that the most fundamental lesson from the traditional ecological knowledge perhaps relate to the fact that worldviews and beliefs do not matter in the context of human-nature interaction. Given the reality of unpredictability and uncontrollability of the ecosystem, it is becoming quite clear that science conceptual separation between human culture and non-human nature is becoming increasingly untenable, and this tends to lend credence to the role of belief components in regards to human-environment relations (Costanza, et.al, 1993; Martin et.al, 2010).

[1] Caton and Dunlap (1980 cited in Jacob, 1994), observed that the western knowledge tradition consist of the following beliefs and assumptions: 1.) that people are fundamentally different from all other creatures on earth, over which they have dominion; 2.) that people are masters of their own destiny, they can choose their goals and learn to do whatever is necessary to achieve them; 3.) that the world is vast, and thus provides unlimited opportunities for humans; and 4.) that the history of humanity is one of progress; for every problem there is a solution, and thus progress need never cease.

Using water resources as a point to illustrate the impact of traditional ecological knowledge, a wide array of meanings and world views can be glimpsed from the literature because of its existential significance as well as the various roles it plays (Orlove and Caton, 2010; Gibbs, 2009; Allon & Sofoulis, 2006; Sofoulis, 2005; Strang, 2005, Kibread, 1999). Such meanings and worldviews, according to Linton (2010) are dependent on historical-geographical circumstances: people inhabiting deserts have tended to form ideas (and metaphors) that differ markedly from those formed by people living in humid regions. The author went on to say that all ideas of water are hybrids in the sense that they are at once social and natural, internalizing the emergent-that is, historical and geographical-properties of H_20 along with historical and geographical circumstances of the thinker. Groenfeldt (1991), while looking at the various irrigation practices in Asia, came to the conclusion that the physical properties of water alone do not determine a homogenous social response. According to the author, the solutions to these universal problems are ‘unique to each indigenous system, depending upon the particular social and cultural traditions, the particular physical setting, and the particular individuals concerned’. These imply that water is not only the natural stuff that one sees and uses but a social and cultural substance that forms the locus of interaction between humans and the non-human worlds.

Given the complex, dynamic, mutually constitutive and reciprocal nature of human-water relationship, its management has assumed various discourses over the years. In the word of Linton (2010:58), ‘water management implies a particular kind of hydro social relation, one characterized by deference to a kind of abstract expertise and professionalism. It also implies a particular kind of water, stripped of its complex social relationships such that it may be managed by experts who are not necessarily directly involved in these relationships. John Donahue and Barbara Rose Johnston (cited in Linton 2010: 58) highlighted the need to investigate the links between how water gets defined, how it gets managed, and for whose benefit: ‘what different cultural meanings does water have for the contending parties, and how do these meanings complicate mediation among the various interests? How are some social actors able to impose their definition of water on other social actors with different but equally legitimate definitions? In other words, how is power used in the service of one or another of the cultural definitions of water?’

This paper looks at the importance of acknowledging different worldviews surrounding the management of water resources in the light of emerging evidence pointing to the crisis engulfing modern water management system. Such evidence reflects in the tension and anticipated problems that have triggered unending debates on such issues as privatization, commodification, commercialization and individualization of water resources. In doing this, most examples and cases are drawn from specific cases from Akwa Ibom state, a state in the south-south geopolitical zone in Nigeria.

Akwa Ibom State and Water Resources Management Antecedents

Discussions in this paper draw from cases and examples from rural areas of Akwa Ibom state, one of the 36 states in Nigeria. Akwa Ibom state is located to the south-south of

Nigeria, and has three major ethnic groups (namely, Ibibio, Annang and Oron). Its total population stands at 3,920,208 spread across a landmass of 8,412km^2 (NPC, 2007). In the rural areas, local consciousness of, and attachments to the natural environment are very strong given its role as the largest reservoir of natural resources upon which people depend for livelihoods.

Akwa Ibom state has no fundamental differences in culture beyond slight linguistic variations and differences in environmental behavioral attitudes, which itself is determined by the context of a given environment and other historical factors of relationship with nature. For instance settlement groups closer to a river tend to develop certain behavioral orientation deeply anchored on their social and economic relationship with water, e.g., the Oron, Uruan, Mbo people and others. In terms of development level, the rural areas lack behind in basic physical and social infrastructures compared to their urban counterparts. Linguistically, the people speak diverse languages reflecting the slightly diverse socio-cultural and ethnic background of the State. The common language understandable to all the ethnic groupings is the Ibibio dialect. Indeed, available literature is of the consensus that the people of Akwa Ibom state have a common stock from the main Ibibio (Udo, 1983). Therefore, Ibibio is seen as the central; Annang, the western while Oron remains the sea-born Ibibios (see Ukpong et.al, 2001: 120 & 156). This is buttressed by the almost general mutual linguistic intelligibility of the various ethnic groups-for instance, the Annangs understand and can speak Ibibio and vice versa, the Orons understand and can speak Ibibio but an Ibibio person may understand an Oron man but may not speak the language very well. Beyond the major ethnic groups of Ibibio, Annang and Oron, there are various other sub-groups with slight variations in linguistic circumstance and history, e.g., Ekid, Itu Mbonuso, Iwerre, etc. Over ninety percent of Akwa Ibom indigenes are Christians. In actual fact, Akwa Ibom is a dual religious society given that certain traditional and Christian beliefs co-exist, and the Christians most often respect and are subject to the traditional institutions of governance especially in the rural areas. Currently, Akwa Ibom state has 31 local government areas, each administered by a group of representatives at their respective council headquarters. Uyo is the headquarters of the state and forms the centre, which attracts the rural people from different parts of the state for greener pastures.

Ekong (2003) recognized seven types of land holdings in Akwa Ibom state, some of which have relationship and implication for water knowledge, utilization and management. This includes the community or communal land *(Ikot Idung)*; lineage land (*Ikot Ekpuk or Ikot Ufok)*; individual holdings (*Okpokpo Ikot or Ndedep Ikot)*; borrowed land (*Nno Nkama or Nto Nwo Ikot)*; pledged land (*Ubiong Ikot)*; secret society land (*Owok Ekpe or Owok Nka)*; sacred groves (*piece of land dedicated either to deities or for the disposal of those who did not die in the proper manner)*. In relation to water use and management, individual holdings, imply right of ownership of all available groundwater within the land area (Land use Act, 1978) while surface water, notwithstanding the types of land holding system, belongs to the community. Water bodies found in sacred groves or secret society lands carry the same meaning and treatment as the land itself namely restricted entry, ocassional sacrifices, among others. In urban areas most of these types of land holdings have given way to individual ownership for development and settlement expansion purposes as distinct from the traditional forms of ownership still very much common in rural areas.

Local Notions, Beliefs and Practices around Water

In most rural areas of Akwa Ibom state, local meanings, beliefs and practices about water are largely built around invisible and supernatural powers and located in taboos, values, and spirit deities, among others (Table 1).

Table 1. Traditional Observances/Practices about Water

Themes	Manifestations	Rationale for practice	Remarks
Taboos	1.forbidden days (*ebet idim*)	privacy to the water deities	The strength of this belief depends on the level of modern development
	2.farming not allowed around a watershed	To protect the water deities	The strength of this belief depends on the level of modern development. Some have suffered encroachments by individuals
	3.some water bodies do not welcome 'mothers of twin children' or women in their 'menstrual cycle'	The water deities do not accept them (for uncleanness) and will be angry if violated-leading to the dry-up of such water body	The influence of the Christian religion has weakened such beliefs in most areas. However, most people still attribute the problem of most water bodies to such violations
	4.fishes in some streams are not eatable	They are believed to be spirit deities	In spite of the waves of Christianization, this belief still hold in some remote rural areas
Spirit Deities	1.mami wata (*ndem mmọọṇ*).	Popularly believed to influence humans by spiritual possession either for good or for bad.	The belief is still dominant across religions and ethnic groups.
	2.water gods/goddesses	Believed as the spirit of the land (or a community) and fertility	Still referenced in some communities. Such spirit agencies offer unifying platform for ceremonies, festivals and rituals
	3.souls/spirits of humans (*Ukpong owo*)	Most water bodies are believed to harbor human souls and spirits or the souls of the entire members of a community. Any community linked with such stream often strives to protect it.	Where an individual is known to have his or her spirit in a particular water body, rites of protection and renewal of such spirits are often secretly conducted especially when such an individual is ill
	4.spirit avenger (*mbiam*)	Such water bodies are believed to have the power of avenging wrongdoings especially when sworn falsely.	Most communities resort to this medium of arbitration and justice especially when the modern legal system fails in justice and arbitration. Some of those water bodies are still notable and often patronized when serious cases arise

Values	1.peace-making	Water is believed to represent peace and has often been used in peace making.	Still widely practiced in cases of individual or group disagreements
	2.free and perfect nature	This is anchored in the belief that 'water comes from God' (*Abasi anie mmọọŋ*). Any gift from God is considered perfect and cannot harm (*mmọọŋ-mmọọŋ eyet idioknkpo, idioknkpo iyetke mmọọŋ*)	Here water is seen as free to all manners of people irrespective of socio-economic status and background. This does not give room for commoditization, commercialization or privatization
Religious Functions	1.rituals	Most traditional rites have to be performed in the water bodies, e.g., rites for spiritually possessed persons, women circumcision and fattening rites etc	Still widely practiced both at individual and group levels. The new Pentecostal movements occasionally get involved during spiritual deliverance exercise
	2.baptism	Most immersion (baptism) rites are conducted in water bodies	The Christians are mostly involved in this
	3.holy water	Water that has been spiritually sanctified	The Christians are mostly involved
	4.special bathes	Some traditional and spiritual healing homes often prescribe special bathes as a measure of solving some spiritual problems	Still very common and mostly conducted in secrecy. Some streams are remarkable for this function
Others	1.offers powers for malevolent and benevolent acts	1.In riverine areas, fishermen are still believed to worship the gods of fish to improve their fishing fortunes 2.the powers of manipulating water bodies for evil ends still attract beliefs. 3. rain-making by traditional rituals is still a strong belief	These beliefs are still popular.
	2.offers medium for social activities	Some local festivals (*Usoro Ndem*, *mbre Ekpo*) have final link with water bodies	Traditional institutions and individual families hitherto known for these are still practicing them but in low-keyed
	3.security functions	Some communities believe their waters protect them by neutralizing foreign charms	Not all water bodies are believed to perform this function

N/B: this compilation is a work-in-progress

The gods and goddesses, spirits of the land and fertility (of both human and material resources) are the most notable spirit deities in the 'water world' that are capable of effecting the fortunes or misfortunes of individuals and the society. Clues to some beliefs in the water world echo in such phrases and wise sayings as '*Abasi anie mmọọŋ'*, i.e., 'water comes from God' or 'water is the dwelling place of the spirit and souls of humans (*mmọọŋ edi idung ndem ye ukpọŋ owo*). Attributing water to supernatural powers is common irrespective of religious inclinations. Commonality in such beliefs manifest in the common terms often used to capture the ambivalent capabilities of the water world as the 'marine powers', 'marine world', 'mermaid spirits', 'mami wata' agency, etc. While the Christians tend to demonize such powers and most often make it the locus of prayers and miraculous deliverance (especially by the new Pentecostal prayer houses), such powers are believed to find favorable utilizations either for benevolent or malevolent ends by an individual or an entire community (e.g., sacrifices to the goddesses of fertility and abundance or the role of water in peace and for the administration of justice in a community). For instance, the '*Atakpo Ndem Uruan'* is believed to dwell in *Iboko Inyang Itiaba*-a river, and is perceived as the symbol of strength and fertility of the Uruan people. Most other local streams were (some are still) renowned for their role as the justice arm of most communities, and consequently contribute in curbing social vices and crime. Mami wata, of course, is a very much-talked about marine spirit that has attracted wider belief across traditional societies in Nigeria (Bastian, 1997; Drewal, 1988; Gore and Nevadomsky, 1997).

The notion and belief that water bodies harbor spiritual powers facilitates their occasional enlistment for arbitration, avengement for wrongdoings as well as other forms of local traditional acts of governance. Such roles have been utilized, in some cases, to strengthen the moral foundation of indigenous communities. Swearing, open baths and invocations often feature any occasion of traditional arbitration processes. The waters of such streams, in most cases, constitute elements of traditional spiritual concoctions such as '*mbiam*[2]'. Most indigenous communities use these medium to settle disputes, enforce compliance to rules, curb social crimes and other vices as well as healing strange sicknesses among community members. '*Etok idim'* in Ibesikpo Asutan (as captured in a song by a local Musician-*Udo-Abiana*) is a familiar and clearly documented metaphorical example which arbitrated in a family where two housewives were accusing each other of stealing a goat meat in the house. In Ikono, the services of some water bodies (*Idim mbat*) or *Ika itiaba* are always engaged for vengeance against offenders in the community. People swear to such water bodies as a basis for establishing truth and credibility of information. The fact that the outcomes of such arbitration process are not normally contested perhaps gives some levels of credence to the potency and credibility of such agencies.

Sustaining the spiritual strength of such water bodies imply constant sacrifices and sacred observances. In some instances, rites involve the use of soft drinks, biscuits, eggs, white linens, white plates and groundnuts thrown inside such a water body. It is also an important practice that water bodies of special religious and spiritual significance enjoy some free days of non-visitation (e.g., *Idim Urua Ituen* in Oruk Anam, *Idim mbat* in Ikono). Such

[2] Mbiam is an avenger of broken vows sworn upon its name, or of wrong done to any. A person who swears falsely by mbiam or steals where mbiam had been invoked is bound to be sick and die (Ukpong et.al, 2001).

free and forbidden days, '*ebet idim'* is believed to be one of the ways of according privacy to the gods and goddesses of such streams. Stories of snakes of different species and 'mami water' in human manifestation are familiar narratives of individuals who accidentally or deliberately violate or disobey such special traditional privacy days for the water spirits. Violation normally attracts negative sanctions, and the depth of sanctions remains sensitive to whether it was accidental or deliberate. Such sanctions could range from minor 'on the spot consequences', strange encounters to outright disappearance or death of the erring individual. In some cases, the consequence is believed to result in the dry-up of such a water body. A story is told of a certain stream (*idim etok*, which harbors a certain spirit-*Iso-abasi etok*) when around 1907, a preacher (foreigner) went to the stream and caught a fish (was forbidden to catch a fish in the said stream) and eat, and in less than 3 days, the stream dried up…..the preacher (being a foreigner) survived. The indication was that the offending preacher would have died were he to be a native of the village….since, according to the story, the water does not hate a foreigner.

Water has traditionally been associated with perfection among indigenous societies. This is encapsulated in the common philosophical saying that *mmọọŋ-mmọọŋ eyet idioknkpo, idioknkpo iyetke mmọọŋ* (it is only water that can wash away dirt-i.e. cleans or purify-dirt cannot clean or purify water. Or the idea that 'water comes from God' (already discussed in a different version). These all capture water as a perfect 'nature', of course perfectness is traditionally associated with the supernatural which implies higher sense of spiritual responsibility and relationship. The senses here are that water is perfectly designed for man and cannot be considered harmful; and as a divine gift, free access is already guaranteed for everyone irrespective of social and economic affiliation or stratification. This notion of perfectness forms the basis for which the utilization of water has no serious concern for its quality in indigenous societies. Although Akpabio (2011) has questioned such notion of 'uncritical use of water (especially drinking water)', other notable best prescriptions about these philosophies revolve around the anti-commodification, anti-privatization, anti-individualization and anti-commercialization stance which are the hallmarks of modern water policies. Associating water with the 'divine' has also been instrumental in peace and reconciliation deals for warring factions from time immemorial. This act of 'making peace with the use of water' is still widely practiced, in cases of individual and group disagreements, in local communities. It is simply achieved when a glass of water mixed with local clay (*ndom*) is given to warring parties to drink. It is traditional and morally binding on the factional parties.

Traditional philosophies and beliefs are foundations for the evolution of various traditional ethical, charismatic and institutional channels to regulate human relationship with water. In Akwa Ibom state there is a specific proverb '*ọtọọŋọ uduan iso mmọọŋ, afo mmunwono, eyen uso ayaanwon/otok ikim inyan iduokke duok, edem ete mminwono, edem eka aya awon (translated as you who defecate at the mouth of the spring, if you don't drink from it, your relative will drink from it*). Such proverb thoroughly reflects deeply ethical perspectives that regulate and encourage responsible human relationship with water in the fact that it sees water as an integral part of human existence and consequently prescribes some 'dos and don'ts' norms to mediate relationship. More so, there are various power arrangements distributed across many networks and groups as well as individuals to regulate relationship with water. For instance, there exists the earth priests (who are the various link agents between the physical and marine world; the age grades who perform various physical sanitation and activities as well as enforcement of some traditional norms; the Chief and Council of Elders who take decisions and perform sacrifices and rituals). Other non-human and invisible agencies include taboos such as *'ebet idim'* (forbidden days) etc. Water bodies in secret society lands (*owok ekpe or owok nka*) and sacred groves are of very high spiritual and religious importance such that in some communities, people rarely use for drinking and other domestic purposes except for ritualistic purposes. Although outright restriction of entries is not common these days, in most cases a day or two is reserved against utilization, the idea being to allow some measure of privacy to the goddesses and the spirits as well as give room for regular sacrifices and rituals as forms of obeisance to the spirit kingdom. One traditional ruler affirmed this when he stated thus: *'where the sources of water are found in these lands [i.e, secret society land and sacred groves], it is customary to set aside some portions in some days for the purposes of sacrifice and worship.*' Indeed, such practice has been interpreted as conservational and protective. Akpabio (2011) recorded a 28 year old respondent as confirming this when he said the idea of forbidden days is to *'protect the water and allow aquatic animals to rejuvenate'*. It is also traditionally forbidden in indigenous societies to farm in lands surrounding water bodies, and no property right is assigned to any individual to such areas. The belief is that farming around a water body will destabilize the spirits and will consequently lead to the dry-up of such water body. Incidence of stream dry-up is most often attributed to such acts.

Water Resources: the Traditional Worldviews vs. Modern Management Approach

Water resources management in Nigeria, over the past three decades, has undergone immense modernization (in line with structural and democratic modernization of cultural and political institutions of authorities) but in a way that does not receive voice and partnership from the locals. Consequently, various strands and diversities of management interest have been observed (fig 1).

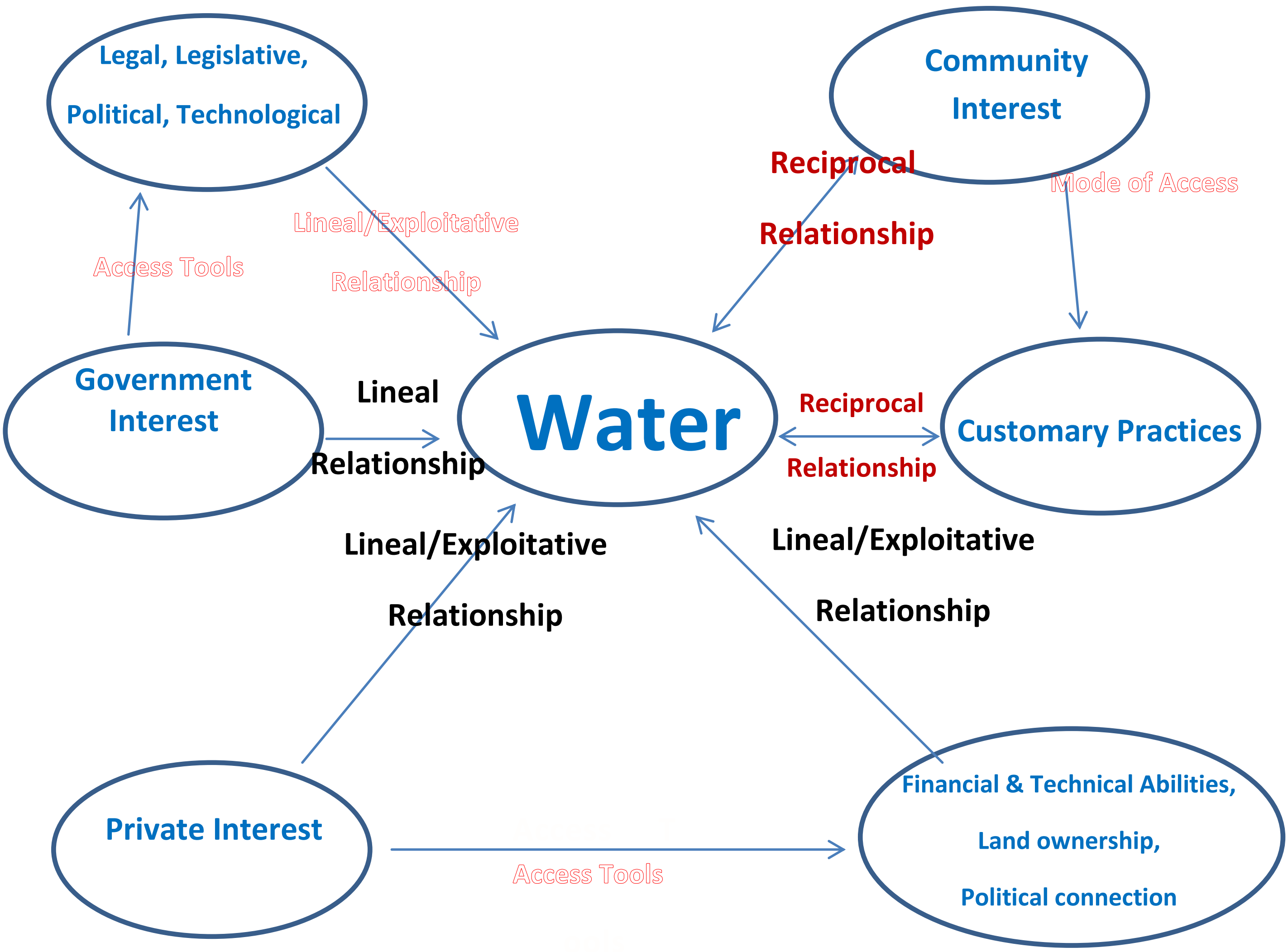

Fig 1. Levels of Interest in Water Resources Utilization in Akwa Ibom State

From Fig 1, it is seen that each of the interested parties uses various management means, including customary practices, technical and technological abilities, economic, legal, legislative and political powers as management, access or utilization tools. Project communities are more at home with the usual customary and spiritual view of water and so would want its management correspond with taboos, sacrifices, custom-defined access with no cost attached. Private individuals' access to water is legally and legislatively enhanced by the Land use Act, which opens opportunity for those with economic power, land ownership, and political connection to have unlimited access to water resources especially at urban areas. Governments (represented at federal, state and local levels), on the other hand, adopt direct legal, legislative and political instruments to access water for public development and use purposes in a lineal, and most often exploitative manner through endless 'politically motivated' supplies. These instruments, however, mostly do not fit with the peoples' spiritual and symbolic attachments to water resources especially where such government services are not relevant, leading to friction in management claims. For instance, it looks strange to pay for government owned water projects. In a country with very poor and highly erratic character of public service as well as deep distrust about government, communities often harbor misgivings about public offer primarily because of the fear of discontinuity and abandonment.

Such contexts do not normally lend full cooperation of community members to any public water related projects especially if it has to encroach on the historically stable traditional sources of supplies and customs. Such dilemma is one of the sources of frequent confrontation often encountered (as in Nkari dam project in Ini LGA) between host communities and the State over projects that seem to engender a sense of loss of power and identity, in addition to placing members at the mercy of irregular public service culture. Given the scenarios of non-cooperation from the contending communities and rigid imposition by government project developers, the consequence is always negative on the available water resources; as in when governments developed water projects do not encourage conservational use by the host communities. Such externally initiated projects (as in Itu and Abak) automatically confers some form of rights of free, reckless and 'revenge' use – 'revenge' in the sense of taking their portion of the national cake. Since there has not been any customary notion attached to such project, its usage is even more reckless and cannot attract best management practices as it would have been with a typical community owned resource project. In an era of politically motivated project imposition in Nigeria, such negative perception and attitudes become even stronger given that such a project was not a product of genuine community need.

These characteristics behaviors are compounded by ecological, religious, customary, economic and institutional factors. Ecologically, there is water abundance making it impossible for most communities to realize its value (Akpabio, 2010). There is also the attitude of seeing water as 'a gift from nature' which implies free use to members of the communities (see Genesis 1:28). Looking at the economic perspectives, it could be argued that the impracticability of achieving cost recovery among the people is related to the massive poverty that has been the recurring nightmares of the rural populace in Nigeria. Often times, State's attempts to divest control of public water schemes to be community-managed are not always successful especially when cost recovery is built into it. This is so because price tags are not always so friendly in communities whose livelihoods are built around social relations characterized by mutual trusts and exchanges.

Given the difficulties often encountered in adopting modern ways of natural resource management (by the less exposed, less educated and socially disadvantaged rural inhabitants in Africa) trading off traditional worldviews with the modern worldviews places a given resource (water in this case) at a greater risk of 'bungling'. As they are not thoroughly educated and enlightened about the modern ways of resource utilization and at the same time have lost grip of their traditional resource management norms, it amounts to a case of two elephant fighting while the grass suffers-the grass in this case being available water resources. This is the nature of complexity often discounted by development interventions and policies to the extent that the dynamics of local interests are not thoroughly understood and vigorously engaged**.** It is even confounding that a clear case for public intervention in rural water resources management, in most cases, has not been established beyond the wrongly held notion of 'providing dividends of democracy even when there is no need for it. Indeed, current condition of water resources in the rural areas of Akwa Ibom state shows relative abundance and should not need much intervention except in areas of clear constraints as in the northern Akwa Ibom state. However, public water projects seem not driven by such reality beyond politics and the misguided attitude of diverting public funds into private pockets. The argument here is that public water interventions in rural areas, with all its modern appurtenances, are unnecessary at least for now. As the reality of tension between local norms and modern system of water management becomes inevitable, the implication poses additional problems for sustainability of the water resources system.

The idea that water is the major gateway to the spirit world still remains heavily internalized at least in the psyche of the older generation and, by extension, the upcoming ones who have not yet been linked up in the modern arena. In Nigeria, the division between the rural and urban areas remains distinctly yawning. While the rural areas are often characterized as highly disadvantaged in terms of public infrastructures and development, the fact remains that its people are very much more stable and predictable in values and behaviors as well as the ways they relate with the natural environment. This is in sharp contradistinction with the urban areas characterized with uncertainties and value instabilities given that what should constitute 'modern values' have been further distorted by the cankerworms of corruption leading to what I would like to call 'modernity in reverse gear'. Extended family and kinship relationship in Nigeria implies that urban migrants still retain substantial connections with their kith and kins in the rural areas. Consequently, there is intercommunication of values, with the former (the urban migrants) being in a much more vantage position to effect attitudinal modifications over the later (the rural kith and kins). Such interrelationship has the potential of distorting hitherto long held traditional views about nature thereby generating a greater number of converts especially among the younger generations in the rural areas.

Apparently, discourses and development initiatives about water often originate from the urban elites, who dominate public services, policies and public institutions, and flows to the rural areas carrying with them all the 'distorted packages' of modernity. This naturally raises the question of whose understanding of water, and in whose mode of relating and gaining access or whose values and terms. As Vandana Shiva (2002) has rightly argued, the way water is conceptualized and represented is instrumental in determining who gains access to it and on what terms. This spontaneously could catalyze tension and conflicts over contestations of meanings and values given that the social power equations often weight significantly to the advantages and privileges of a select group bent on foisting a certain attitudes and orientation on the socially disadvantaged. Modern representation of water as a substance devoid of social contents-that is, as a part of nature, a natural resource, or commodity-allows water to be used in the sense of a resource-a reservoir to draw at any time to satisfy human needs (Akpabio, 2006) beyond which it has no other value. This typically 'western attitudes' and framework of relationship with nature hardly find recognition in the traditional values of reciprocity. In traditional societies, individuals are embedded in a wider structure of traditional system which configures their preferences, aims, strategies, behaviors (Giddens, 1984). All behaviors seem to be situated in the context of wider structures within the constraints and opportunities of existing structures. In modern understanding, nature and societies are held as being separate and unconnected entities. The increasing difficulty of maintaining water as a conceptual attraction is now manifest in a host of problems of complications to the extent that any effort or attempt to integrate water development projects into the user embrace and acceptance do not go without struggles and uncertainties.

Religion has equally had a marked influence on traditional attitudes to water resources. In fact, one of the effects of the spread of Christianity and Islam with their dualistic worldviews according to Ellis and Ter Haar (2004: 65 & 94) has been to demonize the traditional spirit world. Such gradual demonization dates back to the nineteenth century evangelization of Africa by foreign missionaries, and its consequent impact of eroding the original and morally neutral character of the traditional spirit world. Second, the traditional religious specialists who used to have the authority to regulate relations between human and the spirit worlds have seen their influence dwindling during the twentieth century as a result of factors such as the institution of a secular state apparatus; social changes that undermine the standing of the village elders and notables who officiate in traditional religious cults; and western education, secular or Christian. These wide-ranging changes have led to a situation today that traditional experts are often ridiculed by younger generation and demonized by adherents of new religious movements, especially the Pentecostal Christians. Ellis and Ter Haar (2004: 94) have observed that there are raging debates between advocates of a return to tradition and those, including the more radical Pentecostals, who maintain that indigenous practices, or indeed any religious actions not based on explicit Scriptural authority, are evil.

While traditional notions of water have, historically, contributed to framing and structuring individual/collective values and behaviors in indigenous communities, the impacts of Christianity and modern ways of governance have tended to gradually delegitimize and marginalize the traditional political and religious authorities, to the extent that the hitherto long-held historical values now exist in individuals' minds and continue to be practiced in secrecy. Given that the management of water resources is now more in the public realm which has tended to alienate or marginalize the traditional institutional authorities, it is not out of point to guess the consequences such 'cultural confrontation' could manifest, some of which have been earlier discussed. When a particular local natural resource that had long enjoyed the emotions of the people as well as providing platforms for cultural and social activities are interfered upon, it is possible spontaneous local negative reaction, resistance or attitudes would be triggered. Bonaiuto et.al (2002) in a 'local identity processes and environmental attitudes in land use changes of protected areas' observed that local resistance to such public encroachments could be due to the strict regulative and normative aspects related to such projects. In the case under consideration, it is more appropriate to explain spontaneous reaction to public resource management projects in cultural communities as engendered by the anticipated fear and feelings or marginalization and alienation from their long held attachments with nature. While modernization and policy reforms about water management initiatives have tended to assume a one-way imposed state development options, the danger however remains that achieving resource sustainability will be practically impossible as local voices and inputs keeps being sidelined. Where traditional values about resource management is no more effectively used a situation of 'no man's island', which imply irresponsible utilization, tends to prevail. Akpabio (2009) clearly elaborated on that when he likened a public water projects whose host communities had no inputs in its design as equivalent to a 'national cake' syndrome whereby everybody struggle to have a share of it in a very reckless manner, which eventually tend to lead to the breakdown of such project in a very short period of time.

Concluding Remark

The gradual modernization of traditional societies as expressed in urbanization, improved communication avenues, migration, among several others, have had significant impact on traditionally held notions of natural resources management most especially in Africa. What is of greatest concern, as highlighted in this paper, is that the introduction of modern values with its lineal view of human-resource relationship often discounts or stigmatizes the locally internalized values of reciprocity. The result is not always pleasant. As Mango (2002) rightly argues: 'a model that assumes linear knowledge production (outside locality), dissemination (to locality) and utilization (in locality) is misplaced' (cited in Gerke and Ehlert, 2009). In Nigeria, conventional approaches of viewing development and well-being often ignore the intangible issues bordering on socio-cultural values of human-resource relationship. This normally does not lead to the expected developmental outcome, but rather a harvest of negative setbacks. Given the level of development, modernity and education of indigenous people, a tinge of traditional practices and understanding still remain relevant in preserving the resources of nature e.g., water. Scientifically, it is known that destroying an ecosystem (in the form of a watershed) would spark off a feedback mechanism that tends to affect such a system negatively (in the case of a stream, such reaction would lead to its siltation). However, traditional explanation for this draws from the spiritual and metaphysical. There is nothing entirely odd about that if it has served to regulate the relationship of a group of people with the natural ecosystem. The paper believes that working with local cultures, as opposed to working outside, in the management of water resources could achieve the twin objectives of education (especially on misplaced assumptions) as well as learning from their strength with the possibility of building an integrated knowledge.

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Chapter 14: The Australian water trade

Doreen Burdack

Humboldt University of Berlin
Chair for International Agricultural Trade and Development
Faculty of Agriculture and Horticulture

Australia is a country with immense water problems. Severe droughts followed by devastating floods are recurring weather phenomena. An appropriate solution for coping with such variability of water availability is the Australian water market. This paper discusses whether the Australian water trade is a sustainable water management tool. It illustrates the dimensions of changing weather conditions and fluctuating water supply in Australia followed by information about the institutional framework and the Australian water market. Additionally, the functioning of water trade, the involvement of market participants, and aspects of pricing are described. Even though the Australian water market is one of the most sophisticated water markets in the world, there are still substantial barriers which need to be overcome in the future.

Australia: extreme weather and fluctuating water supply

Australia is one of the most vulnerable countries in the world in terms of severe droughts and disastrous water scarcity. Central Australia is a very dry area with only a few days of rain per year. The coastal areas of North, East and South Australia receive the biggest share of precipitation. Whereas precipitation is highest in the northern part of the country during the summer months due to the monsoon; the southern part gets most rain during the winter months (Bureau of Meteorology 2011a). Therefore, water availability is regional and seasonal dependent. In addition, extreme weather conditions are difficult to predict. For example, the long-lasting drought from 2003-2009 was followed by horrifying floods in summer 2010 resulting in Australia's third wettest year on record (Bureau of Meteorology, Commonwealth of Australia 2011b). Reasons for this weather condition is a recurring air pressure shift between the east Pacific region and Asia called the Southern Oscillation or El Niño (Bureau of Meteorology, Commonwealth of Australia 2011c).

Floods and droughts are typical for Australia and make the continuous allocation of water difficult. In the short term, the fluctuating availability of water faces an inelastic demand for water and, thus, generates a mismatch on the water market.

In drought periods, water demand is higher than the actual consumption. This is because water availability is smaller than the need for water. Consequently, supply shortages, over-allocation of existing water resources, and an unsatisfied demand arise.

Within the abovementioned drought period, water consumption decreased by 25 per cent from 18,767 gigalitres (GL) (2004-05[1]) to 14,101 GL (2008-09). Agriculture held the lion's share, accounting for 65 per cent or 12,200 GL of total water consumption in 2004-05 (Australian Bureau of Statistics 2006a) and 54 per cent or 7,600 GL of total water consumption in 2008-09 (Australian Bureau of Statistics 2010). Agricultural water consumption decreased by more than 10 per cent in relation to total water consumption between 2004-05 and 2008-09. Hence, especially irrigating farmers are affected by water shortage and variability of the Australian weather conditions.

Given such variability, allocation of water is difficult and must be handled as flexibly as possible. Beyond creating a flexible allocation mechanism, it is indispensible to allocate water in a sustainable manner. In the long-term, intensive water usage is only acceptable if the environment and natural water resources are not excessively exploited.

Economists and governments consider tradable, transparent, secure and actionable water rights as an opportunity to improve the allocation of water between different suppliers such as irrigators, households and industries (Freebairn & Quiggin 2006).

The Australian water market must take over the coordination of available and demanded water without causing any damage to the environment. In comparison to other countries with similar conditions, Australia developed an unique process. What exactly distinguishes it from other water markets? This question will be answered below.

Institutional framework

Water trading has been enabled by the separation of water rights from land in 1994 by the Council of Australian Government's (CoAG) agreement (ACIL Tasman, 2004; National Water Commission 2010a). With this step, a reallocation from low valued water uses to higher valued water uses has become possible (Heaney et al. 2006) and scarcity of water can be better reflected by its price.

Initially, water trading was limited to trades within one irrigation system. In the course of time, trading rules permitted an inter-valley-trade and more recently also trade across state boundaries (Murray-Darling Basin Commission 2008). In the National Water Initiative[2] the Australian states and territories and the Commonwealth agreed to an expansion of water markets across regional boundaries and states in 2004 (National Water Commission 2010b).

Each state provided water rights for users of their own district without acknowledging the holistic character of river morphology and hydrologic processes. Especially during drought periods, this self-management of water without considering additional

[1] The water year runs from July 1st to June 30th.

[2] The National Water Initiative (NWI) is an inter-governmental agreement signed in 2004 by the NWI parties (Australian territories and states and the Commonwealth) to harmonise national water reform efforts.

demand for water of neighbouring states resulted in tremendous over-allocation and unhealthy conditions of rivers, wetlands, and floodplains. This was especially observed in the Murray-Darling Basin which connects four states in South East Australia. In order to prevent unsustainable water management, the independent and inter-governmental Murray Darling Basin Authority (MDBA)[3] was established under the Water Act 2007 to coordinate water management in the Murray-Darling Basin. All states in the basin conferred their water planning powers to the MDBA.

The MDBA is required to prepare a strategic plan called *The Basin Plan*. Supplementary to this Basin Plan, basin states prepare water resource plans (Australian Government Department of Sustainability, Environment, Water, Population and Communites 2011) which set quantitative limits for water usage from ground and surface water resources to account for sustainable water allocation (National Water Commission 2009). These water plans last for 10 to 15 years and are very difficult to change after the State Minister approved this plan. This is for security reasons for consumers who invested into water rights (Young 2010).

The Australian Water Market

The Australian water market consists of many single water markets. Each water market is defined by administrative boundaries and water systems (National Water Commission 2009). On each market, water rights define a right to take water for a particular period of time, at a particular location, or as an "allocation of a particular quantity of water per unit of time" (ACIL Tasman 2004).

Water rights are differentiated between water access entitlements and water allocations and are defined by the National Water Commission as follows:
Water access entitlements are permanent rights to exclusive access to a fraction of water from a specified consumptive pool as defined in a water plan.
Water allocations are seasonal water rights specifying a volume of water allocated to water access entitlements (National Water Commission 2010b). These withdrawal rights depend on the available volume of water in the common-pool resources of storages or rivers each season (ACIL Tasman, 2004). Within this pooling arrangement, every water access entitlement holder has the same status and allocations are made in proportion to the number of water access entitlements held[4] (Young 2010).

However, denotations for water rights vary from state to state. For instance, water access entitlements are called allocations in South Australia, while in New South Wales (NSW) and Victoria an allocation is the annual amount of water an entitlement holder receives. In NSW water access entitlements are called water access licences while in Victoria they are called water rights or diversion licences (Shi 2006).

Additionally, the degree of supply reliability and tenure periods vary across states and even within a single state. Protection given to registered interests and restrictions on trade are also not consistently arranged (Shi 2005).

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[3] Functions of the Murray-Darling Basin Commission were transferred to the MDBA with the *Water Amendment Act* which amended the *Water Act 2007* in December 2008 (Australian Government Department of Sustainability, Environment, Water, Population and Communites 2011).
[4] Assuming there is just one reliability class.

The delivery of water depends on the situation of water availability. In situations of severe drought, not all water allocations and water access entitlements can be provided with water. For this reason, a differentiation of reliability classes was established in Australia. Three classes 'high security', 'general security', and 'supplementary security'[5] are delivered differently with water if water availability is lower than the volume held by water access entitlement holder. 'High security' water access entitlements pay high dividend in water scarce years because risk is lower for these water access entitlement holders. 'High security' perpetuity water access entitlements are likely to be fully met between 91 per cent and 100 per cent respectively. 'General security' water access entitlements are likely to be met between 61 per cent and 90 per cent, but only after high security water access entitlements have been met completely. The third class of 'supplementary security' water access entitlements are likely to be met between zero per cent and 60 per cent, after high and general security water access entitlements were met completely (Shi 2006; Peterson et al. 2004; Grafton et al. 2009). For example, in 2007, only between 30 per cent and 55 per cent of the volume of water access entitlements could be delivered to high security water access entitlements in NSW, Victoria and South Australia. Because of the drought, low reliability classes of water access entitlements were (almost) not allocated for most of the year 2007 (National Water Commission 2008). As a result, water access entitlements are officially defined as a certain maximum of volume, in practice they are more seen as a share of available water and the according volume (Young 2010).

The biggest problem of water allocation regimes is that they were developed in times without water scarcity. For this reason, allocation intensities do not reflect water scarcity during dry periods and end up in unsustainability and overconsumption of water. This was recognised in Australia as well: the solution could be the establishment of tradable water rights.

Water allocation and water access entitlement trade

The term water trade in Australia does not mean that water is traded itself but instead this term relates to the trade of licenses which entitles the water user to use water that is made available by the states (Young 2010) and the Murray-Darling Basin Authority. Water rights can be traded between sellers and buyers within one region or in different regions or states. Water plans, trading rules, and legislation constitute the framework in which the trade of water rights takes place.

In Australia, temporary water rights started to be traded between individual water users in the mid-1990s. At the beginning, most of these rights were the ones which have not been activated and were unused. Therefore they were called 'sleeper entitlements'. After these unused rights were exhausted, trade within agricultural producers increased from low water value users to high water value users (ACIL Tasman 2003; Tisdell, Ward & Grudzinski 2002). A significant part of traded water is distributed through irrigation infrastructure operators; most tradeable water access entitlements occur in the area of the Murray-Darling Basin (National Water Commission 2008).

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[5] These three entitlement categories are definitions from New South Wales and denoted differently in other Australian states.

Water access entitlements and water allocation rights can be traded between entities such as irrigators, water infrastructure operators (authorities), and environmental water managers (National Water Commission 2010a). Next to these market participants, the Australian government contributes the market to buy water access entitlements from willing sellers within the *Water for the Future* program. This program comprises strategies to buy water from irrigators in the Murray-Darling Basin and give it back to the environment by spending $3.1 billion within a 10 year period (National Water Commission 2008). Between the water years 2008-09 and 2010-11, the Australian Government planned to purchase water access entitlements for $1.5 billion (Hone et al. 2010). For instance, in the water year 2009-10 (2008-09) the Australian Government acquired 415 GL (426 GL) of water access entitlements. This is one reason for the 8 per cent increase of water access entitlement trade from 1,800 GL (2008-09) to 1,949 GL (2009-10). However, without market participation of the Australian government, trades of water access entitlements would have fallen from 2008-09 to 2009-10 (National Water Commission 2010c).

Trading water rights is just possible if basic rights in the current season can be met and if basic rights could be fulfilled in the next season under the assumption that there will be minimum inflows (Brooks & Harris 2008).

To simplify the administrative procedure of the trade, trading zones were established by “setting out the supply source or management arrangements and the physical realities of relevant supply systems within a zone” (Commonwealth of Australia 2011, Schedule 3, Clause 1). For instance, the southern connected Murray-Darling Basin has 13 trading zones with each trading zone comprising its own trading rules. Reports must be treated separately for each trading zone.
In July 2007 a system called ‘tagged trading’ was introduced to facilitate water access entitlement trade across state borders and to record the primary resource of traded water (National Water Commission 2009). In the ‘tagged trading’ system, water access entitlements are issued by the water selling state whereby water gets delivered to the water buying state (Murray Darling Basin Commission 2006). While water is extracted in the destination-state, the ‘tagged’ water access entitlement retains its source characteristics and allocations (National Water Commission 2010c). There is no limit on tradable water rights within or into a region. But trades can be limited for water access entitlement exports or trades out of an irrigation district. For inter-regional trades, there is often a volumetric limit for tradeable water access entitlements. For instance, in New South Wales and Victoria a 4 per cent limit on traded volume of water access entitlements that may be exported or traded annually outwith an irrigation region is given. Once this 4 per cent limit is reached, trade out of this region will be rejected and is not possible until the end of the water year. In Victoria, this 4 per cent limit applies to small irrigation districts within water authorities. In New South Wales trades out of the entire region, which is controlled by irrigation corporations or cooperatives, are volumetric limited (Frontier Economics 2009; Sanders, Goesch & Hughes 2010). During 2008-09, the 4 per cent limit was triggered in six districts of Victoria with the consequence that no exports of water access entitlements outwith these districts were permitted after reaching the limit. But the Commonwealth of Australia and the Governement of Victoria agreed to phase out of the limitation from July 2011 for the regions of irrigation districts in Victoria. The limit should be entirely removed by 2014 (National Water Commission 2009).

In addition to the 4 per cent limit, in some states trade is only permitted if the net effect of trade is zero. In most cases it will not be possible to trade upstream if the equivalent amount was not traded downstream beforehand. This ‘bottlenecks’ system (Murray-Darling Basin Commission 2006) should prevent that too much water is available upstream and that trade causes environmental problems in downstream areas.

Trading transactions occur mostly in the Australian summer between October and March and are therefore not constant throughout the year. In peak times, hundreds of transactions may be handled within only some days (National Water Commission 2008). Hence, water trading is most active during summer months when water is rather scarce in Eastern and Southern Australia and farmers need additional water to keep their cultivation. Trade gets more active when the price for water increases and it is more attractive for market participants to sell their water rights.

In total Australia, 32,501 trades of water access entitlements and water allocations with a traded volume of 3,958 GL took place in 2008-09 (Australian Government Department of the Environment, Water, Heritage and the Arts 2010).

The National Water Commission reported that 5,766 water access entitlements were traded in 2008-09 with a total volume of 1,800 GL. By volume, around 7 per cent of total existing water access entitlements were traded in this period of time in total Australia. The major part of these water access entitlements was traded in the southern connected Murray-Darling Basin with 1,080 GL. On account of this, the southern connected Murray-Darling Basin is the main connected water market in Australia. Although it is legally possible, the Northern Territory had no trading activities (National Water Commission 2009). In 2008-09 there was no inter-state water access entitlement trade; in 2007-08 only one transaction of 200 ML was performed between systems in the Murray-Darling Basin. In the water year 2009-10 a total volume of 662 ML of water access entitlements was traded across state boundaries with only a few transactions from New South Wales to South Australia (312 ML) and from New South Wales to Victoria (350 ML).

In contrast, water allocation trade between states accounted for 28 per cent (2008-09) or 19 per cent (2009-10) of total traded water allocations. In 2009-10, national water allocation trade declined to a total volume of 2,495 GL which is a decrease of about 37 per cent compared to the previous year (National Water Commission 2010c). Most inter-state trade was downstream. For instance, New South Wales was a net exporter of water allocation, whereas South Australia was a net importer of water allocations in 2008-09 (National Water Commission 2009 and National Water Commission 2010c).

Strong demand and higher water resource valuation resulted in a total value of turnover of water access entitlements of approximately $2.2 billion and total sales of water allocations with the value of $606 million nationally during 2008-09 (National Water Commission 2009).

The average price for traded water access entitlements depends on the reliablility of traded products. Water access entitlements with high reliability were traded on an average of $2,100 per ML in 2009-10, which is $100 per ML higher than in 2008-09 and $350 per ML higher than in 2007-08. Water access entitlements with low reliablity were traded on an average of $225 per ML in 2009-10.

Price differences are highest in regions which are not able to trade water access entitlements with other regions (National Water Commission 2010c). When permanent water access entitlements are sold to a water user outside of an irrigation district, infrastructure operators[6] charge an exit fee between $32 and $870 per ML[7] depending on infrastructure operators and the reliability class of traded water access entitlements. Some exit fees are approximately as high as 80 per cent of the value of the traded water access entitlements. This might be one reason, why inter-state trade is relatively rare (Australian Competition and Consumer Commission (ACCC) 2006).
For trade with seasonal water allocations, no exit fees apply and transaction costs are much lower than for traded water access entitlements with a market value of approximately 2 – 3 per cent (Grafton et al. 2009). In the Murray-Darling Basin, where most transactions took place, the market price for water allocation rights decreased since 2007-08 from an average of $650 per ML to an average of $150 per ML in 2009-10 (National Water Commission 2010c). This was a price reduction of about 77 per cent on average and is the contrary development of prices compared to water access entitlements where the price increased during this period of time. This is because the water year 2009-10 was wetter than the previous years and more water users entered the market to sell temporary water rights. Caused by more supply on the temorary market, prices for water allocation fell.

However, Australian water users seem to prepare for the next drought by holding or increasing their permanent water rights to ensure that they are able to buy seasonal water allocations during dry periods. Hence, the price for permanent water rights increased as shown above. As a result, trade of water access entitlements do not reflect seasonal fluctuations of water availability but long-term behaviour of water users. The price-increase of water access entitlements might be an indicator for the climate change expectancies of water users and a signal for adaptation. Additionally, prices for water access entitlements might be higher as a result of governmental intervention by the *Water for the Future* program or artificial trade barriers for inter-state transactions, for instance.

Concluding remarks

The Australian water market has many superior features compared to other water markets. One typical aspect is that the delivery of water is only possible, when the water user holds appropriate permanent water access entitlements. These water access entitlements are allocated from a consumptive pool according to each person's share. Additionally, it is dependent on the reliability class of the permanent water access entitlement and the seasonal water allocation rights, which are assigned to the water access entitlement each year. By applying such a system, it is possible to trade water rights on the market.

Trading water rights provide water users with incentives to improve both, their water use efficiency and water savings. Unused water can be sold and no 'use or lose it' strategy needs to be pursued as it happens in other countries (Grafton et al. 2009).

[6] Victorian infrastructure operators did not charge exit fees in 2006.
[7] Data from 2006.

As a result, the Australian water right trade helps prevent water usage in a low-valued way by reallocating it to its highest value uses. As an example, farmers who cultivate water intensive annual crops[8] sell their seasonal water rights in very dry years for a high price and generate higher profits than they would achieve with crop cultivation. Farmers could use this money to invest in new technologies. Investments in efficient technologies improve the farmers' competitiveness and reduce the risk of losses in times of water scarcity. In the period between 1990 and 2001, Australia's water consumption per hectare was cut in half and productivity per invested unit of water increased enormous as a result of major investments in new technologies and new forms of water use (Young 2010).
The price for water allocations gives information about seasonal water availability as well as the ratio of supply and demand on the water market. As illustrated, prices of seasonal water rights decreased as a result of increasing precipitation after the long-lasting drought from 2003-2009.
Water trade enables water users to better adapt to seasonal weather conditions. It is especially helpful for irrigating farmers to cope with water shortages and precipitation variability.

However, regulatory and trade barriers impede the development of a free trade and an exploitation of trade benefits. On the one hand, barriers for a free and working market are the lack of uniformity in terms of water right designation, trading rules as well as a lack of cooperation between states and water system districts. In this way, water market transparency is limited and transaction costs are high. Heaney et al. (2006) acknowledge that the Australian water trade causes third party effects which are responsible for an incomplete market. These effects can be categorised in "reliability of supply, timeliness of delivery, storage and delivery charges, and water quality and examines policy responses" (Heaney et al. 2006). As a result, water prices do not mirror social costs which would include negative external effects. Out of this reason, a gap between social and private costs exists which is one reason for market failure.
On the other hand, trade can be counteracted for sustainability when originally unused water rights are used by new water users. Then, water savings from increased water efficiency cannot compensate the additional usage of water and scarce resources get even more used than it would be the case without trade. However, over-allocation is primarily caused by too many available water rights on the market. The reason for this situation is that each state provided water rights for users of their own district without acknowledging river morphology and hydrologic processes. Therefore, the Australian government has been gradually reducing the number of available water rights in order to achieve sustainable water allocation schemes and established an independent institution (the MDBA) to coordinate water management inter-governmentally.

When a sustainable size of available water rights is achieved given that it does not lead to over-allocation during drought periods anymore and most trade barriers are removed water trade can be a good solution for Australian water users. They are able to better adapt to climate change which might come along with longer water shortages and even more weather variability. This challenge can be mastered

[8] Water low value crops such as rice and cotton with reference to the gross value of production to applied water during production ($/ML).

through more flexibility and transparency on the water market while guaranteeing sustainable water use.

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Chapter 15:
Environmental sanitation planning in Mongolia: First results of a case study

Katja Sigel

Keywords: Sanitation planning, peri-urban, community-led, participation, case study

Contact:

Dr. Katja Sigel
Helmholtz Centre for Environmental Research – UFZ
Department of Economics
Permoserstrasse 15
D-04318 Leipzig, Germany
Phone ++49 341 235 1640
Fax ++49 341235 1836
katja.sigel@ufz.de

Introduction

The lack of adequate water supply and sanitation services is a major issue related to sustainable development in many parts of the developing world. This is also reflected in the Millennium Development Goals (MDGs), an integrated set of time-bound targets set at the United Nations Summit in September 2000 with the aim of ending extreme poverty worldwide by 2015. Among these goals is Millennium Development Goal 7, target 7c: to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. Mongolia is one of the countries committed to reaching this target. However, current data suggest that the MDGs for both water supply and sanitation may not be met, particularly in peri-urban and rural areas (UNICEF & UNDP 2008).

Peri-urban areas in Mongolia normally are referred to as “ger areas”. Here, people live in gers – the traditional Mongolian portable felt tent, also known as the yurt – and/or in simple, detached houses. Basic infrastructure services such as piped water, sanitation, proper roads, public transportation, etc. are poor or non-existent. The unplanned growth of ger areas along with the unprecedented pace of urbanisation brings with it many challenges, such as unemployment, traffic congestion, air pollution and adverse environmental impacts (World Bank 2010). In Ulaanbaatar, the capital of Mongolia, today, more than 60 percent of the population lives in peri-urban ger areas. However, the percentage of ger residents is also very high (about 50%) in secondary cities such as Darkhan, Erdenet and Khovd.

New paradigms and approaches to strategic planning have proved to be a crucial step towards improving water supply and sanitation in urban, peri-urban and rural environments in developing countries (Kvarnström & McConville 2007; Mara & Alabaster 2008; Schertenleib 2005; SuSanA 2008). Key elements of these approaches include (i) responding directly to users' needs and demand, (ii) placing the households and communities at the centre of the planning process, and (iii) ensuring the participation of all stakeholders. One example of such a strategic sanitation planning approach is the *Household-Centred Environmental Sanitation*[1] approach HCES (Eawag 2005) and its revised version, the *Community-Led Urban Environmental Sanitation* approach CLUES (Lüthi *et al.* 2011) respectively. CLUES is a top-down/bottom-up step-by-step procedure for the planning and implementation of environmental sanitation infrastructure and services in urban and peri-urban communities. Within the framework of the German research project "MoMo"[2] a case study is currently being conducted which aims to implement and test the HCES/CLUES approach in a selected peri-urban ger district in the city of Darkhan, Mongolia. The results shall be compared with the results of 7 HCES case studies which already have been conducted across Africa, Asia and Latin America (Lüthi *et al.* 2009).

This draft paper describes (i) the geography, topography and climate of the city of Darkhan (ii) the current situation of environmental health and sanitation, (iii) the project site Bag 7 (a selected ger area district in Darkhan city), and (iv) the methods underlying this paper, i.e. the HCES/CLUES planning approach and its adaptation to the special conditions in Darkhan. The results of the stepwise implementation of this planning approach and the conclusions are not subject of this draft paper but are presented at the workshop.

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[1] Environmental sanitation consists of water supply, sanitation, storm drainage and solid waste management.

[2] "MoMo" is the acronym for the project *Integrated Water Resources Management in Central Asia: Model Region Mongolia*. It is funded by the Federal Ministry for Education and Research (BMBF). For more information see www.iwrm-momo.de.

Geography, topography, climate

Darkhan is located in the north of Mongolia, on the banks of the river Kharaa at an altitude of between 700 and 750 metres. The climate in the Kharaa basin can be characterised as semi-arid and dry winter continental with mean annual temperatures oscillating around -1,5°C. Thus the winters are typically very long, cold and dry and the summers short and warm to hot. The average annual precipitation is very low (around 282mm), and with a large spatial and temporal variability. The second-largest city in Mongolia, Darkhan has a population of about 74,454 (Darkhan-Uul aimag 2009). Roughly half of the city's residents live in ger areas. The main factors driving expansion in the ger areas are population growth and migration into cities. Darkhan has an area of 103 km^2 and is divided in two main parts, Old-Darkhan in the north and New-Darkhan in the south. There is no official information about city planning in Darkhan. In the course of interviews and workshops Mongolian experts and decision-makers stated that in future the peri-urban ger areas shall be converted into apartment areas. But until now there are no concrete plans.

The current situation of environmental health and sanitation

There is no reliable data on environmental health in ger areas in Darkhan, although the prevalence of water-borne diseases is considered very high by municipal health officials.[3] In Darkhan water supply and sewage are operated by a single local, state-owned entity – USAG. About 50% of the inhabitants, mainly apartment dwellers, are provided with a central water supply and sewage services by USAG. In the ger areas water is generally distributed via water kiosks. Ger areas to the west of the city are located within the flood plain. Here many families have private wells on their khashaa as an additional source of water. Moreover, they take surface water out of the Kharaa river. Both water sources are unsafe and not controlled (Sigel 2010; Sigel *et al.* 2011 forthcoming). In Darkhan the ger residents generally use self-built, unsealed pit latrines without cleanouts on their plot of land. This means that faecal matter can pollute soil and groundwater. This is associated with high risks to health and hygiene, particularly when people use water from private wells: the likelihood of contamination with human faeces is considerable. In the ger areas of Darkhan solid waste management only works rudimentary. Solid waste is collected irregularly from once every three months up to three times per month. Households dispose of at least some of their solid waste themselves. Here, waste burning is the most common practice, mainly during winter time. This leads to an enormous amount of air pollution and potential health hazards. Furthermore, a lot of waste ends up in the drains, under buildings and on open ground. The ger areas are drained by open channels. Basic maintenance such as removal of solid waste is usually not done at all. Stormwater flooding sometimes occurs during the rainy season.

The Project site Bag 7

The project site, Bag 7, is the largest ger area district in Darkhan.[4] It is located in east of Old-Darkhan next to the market. Bag 7 has been selected as project site because of the following reasons (Sigel 2010):

- The governor of Bag 7 showed considerable interest in the case study and assured his support
- Bag 7 has a well organised community that is willing to improve the situation. Some of the residents are organised in self-help groups and community-based organisations (e.g. money saving groups)
- Bag 7 has a public bathhouse that is operated by a local NGO. This NGO showed considerable interest in the case study

In the following table the most important baseline conditions of Bag 7 are summarised.

Table: Baseline conditions of the project site Bag 7 (Sigel 2010):

Population:	About 5700 inhabitants
Household income:	Mean: 252,016 MNT/month[5] Minimum: 26,000 MNT/month Maximum: 1,000,000 MNT/month
Average household size:	4,5 persons
Number of households officially registered:	76%

[3] Interview statement May 2009.

[4] Darkhan city includes 16 subdistricts, called Bags.

[5] 252,000 Mongolian Tugrik (MNT) corresponds to about 143 Euro or 205 USD. The poverty line, i.e. minimum income is about 100.000 Mongolian Tugrik (MNT) per month. This equates approximately 82 USD.

Methods

Methodically the case study Darkhan is based on the HCES planning approach how it was described in the 2005 publication *Household-Centred Environmental Sanitation – Implementing the Bellagio Principles in Urban Environmental Sanitation: Provisional Guidelines for Decision-Makers* (Eawag 2005). From 2006 to 2010 the HCES guidelines were tested in seven sites around the world (Lüthi *et al.* 2009). The experiences and lessons learnt from these pilot projects were used to develop a revised set of planning guidelines called *Community-Led Urban Environmental Sanitation. Complete Guidelines for Decision-Makers with 30 Tools* (CLUES) (Lüthi et al. 2011). In the course of implementation of the Darkhan case study the new concepts and ideas of CLUES have been taken up currently. Thus, the Darkhan case study is based on both guidelines, HCES and CLUES. For easier reference in the following it is only referred to CLUES.

The goal of the CLUES guidelines is to enable urban communities and municipalities in low-income countries to plan and implement cost effective environmental sanitation services that employ appropriate technologies suited to user needs. The CLUES guidelines are geared towards the community level, emphasizing the special role that communities play in improving their habitat. CLUES is a multi-sector and multi-actor approach focussing on informal and unplanned urban or peri-urban settlements. It is flexible and neutral with regard to technology choice and it is taking into account economic factors and social benefits (Ulrich 2011). CLUES consists of a 7-step planning approach and a set of 30 practical tools. Beyond that it points out why an “enabling environment” is needed as a precondition for the success of every planning process and how it can be nurtured. This includes political, legal, institutional, financial and economic, educational, technical and social conditions which encourage and support certain activities.

In the Darkhan case study the CLUES 7-step process has been taken and adapted to the special conditions in Darkhan and the determining factors of the project (e.g. timeline, preliminary work). The following figure shows the adapted approach of the Darkhan case study consisting of 6 steps. Also the timeline and the step-related cross-cutting tasks are included.

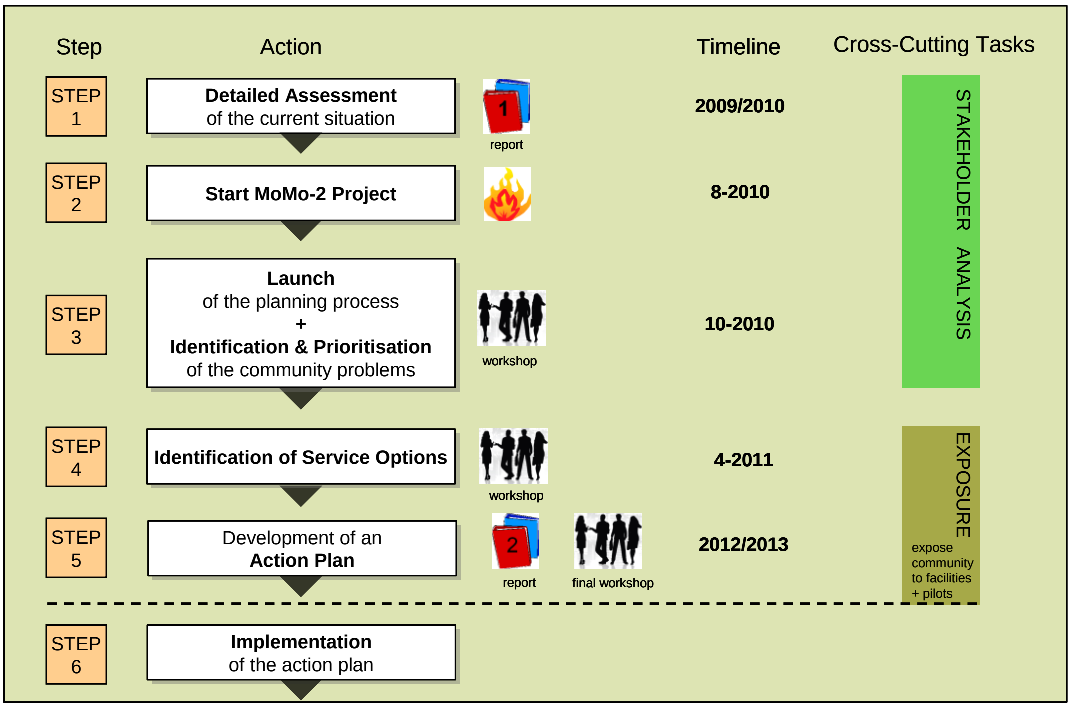

Figure: Planning steps, timeline and cross-cutting tasks of the Darkhan case study

At present step 4 of the case study has been implemented. Step 5 is going to be implemented by the end of the project (April 2013). Step 6 is aimed to be part of a follow-up project. The two workshops were bilingually in German and Mongolian and have been facilitated by professional moderators and interpreters.

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APPENDIX

Further information about the workshop:

Institute for Social and Development Studies at the Munich School of Philosophy

LASSALLE-HAUS BAD SCHÖNBRUNN
Zentrum für Spiritualität, Dialog und Verantwortung

Water management options in a globalised world

Promoting a dialogue between economics, ethics and other disciplines

Scientific Workshop, 20-23 June 2011

Lassalle House, Switzerland

In charge of programme:

Martin Kowarsch, Institute for Social and Development Studies (IGP) Munich, e-mail: m.kowarsch@hfph.mwn.de, website: www.hfph.de/igp

Local organizer:

Tobias Karcher SJ, head of Lassalle House (Bad Schönbrunn, CH-6313 Edlibach, Switzerland), e-mail: tobias.karcher@lassalle-haus.org, website: www.lassalle-haus.org

Sponsors:

We thank the foundation "Forum fuer Verantwortung" (www.forum-fuer-verantwortung.de) and "Wasserwerke Zug" (www.wwz.ch) for their support.

Background and expected outcome

While in the Western world the water issue was discussed in terms of water pollution in the 70s and 80s, in the last decade the focus shifted towards the problem of quantitative global water availability, also in regard to ecosystem resilience. In some countries, especially in subtropical regions, severe water stress can already be observed. Water scarcity is supposed to increase during the next decades due to further population growth, climate change, increasing per-capita use of blue and green water, current non-sustainable use of water and other factors.

Our scientific workshop – with the main but not exclusive target group of junior scientists from very different disciplines with previous experience in the water issue – tries to identify the most important and most promising general freshwater management strategies, that tackle drivers of water scarcity and pollution. Based on state-of-the-art of science and technology, natural and social scientists, economists, ethicists and water management practitioners are brought together. Identifying such management strategies requires a thorough analysis of the underlying problem structure and diverse interactions. This can only be achieved as a result of transdisciplinary research. However, the main focus of the workshop will not primarily be on IA modelling or methodological issues or on the water problem itself, but on general solution strategies, with main emphasis on economic and furthermore on political-ethical aspects.

The main outcome of the three-day workshop should be an evaluation of some central direct or indirect water management options, based on increased understanding of the multilayered freshwater problem. This will strengthen inter- and transdisciplinary research and exchange on one of the most pressing issues of the 21st century and bring together about people from all over the world, who are interested in water management. This workshop, located in the gorgeous scenery of the Swiss Alps, can also be seen as a starting point for further cooperation between the participating institutions.

Programme (overview):

***MONDAY**, 20 June 2011*

14.15-18.30 Grasping the water problem and methodology

- (1) Water availability and scarcity: now and future trends (14.15-15.15)
- (2) Human water use, conflicts and sustainability (15.15-16.15)
- (3) Drivers of scarcity and pollution (16.30-17.30)
- (4) Reflection on methodology, scenario building and scientific policy advice (17.30-18.30)

***TUESDAY**, 21 June 2011*

09.00-13.00 Water management options part I

- (5) Global Blue Water Scarcity and Effectiveness of different Policy Options (09.00-10.00)
- (6) Good governance (10.00-11.00)
- (7) Pricing water? (11.15-12.15)
- (8) Climate change mitigation can reduce water stress (12.15-13.00)

15.00-18.15 Water management options part II

- (9) Virtual water trade in a globalised world, PART I (15.00-16.00)
- (10) Virtual water trade in a globalised world, PART II (16.00-17.00)
- (11) Managing land and water resources (17.15-18.15)

20.00-21.00 Public lecture (Prof W. Mauser, LMU Munich; lecture in German)

***WEDNESDAY**, 22 June 2011*

09.00-12.45 Parallel workshops in small groups on water management options

- (A) Reflections on the governance link between water resources and conflict in Sudan
- (B) Pricing water? How to?
- (C) Virtual water trade
- (D) Cultural ecological perspective of water management – evidence from Nigeria

14.45-18.45 Case studies and implementation barriers

- (12) The Australian water trade (14.45-15.45)
- (13) Water management in Mongolia (15.45-16.45)
- (14) Wasserwerke Zug: Swiss water management (excursion, 16.45-19.00)

***THURSDAY**, 23 June 2011*

09.00-11.00 Water rights and water ethics

- (15) The right to water: an economic perspective (09.00-10.00)
- (16) Water ethics: From human rights to water management (10.00-11.00)

11.00-13.00 Final discussion and synthesis document

Programme in detail:

Monday, 20 June 2011:

12.00 Lunch

13.00-14.15 Introduction; getting to know each other; organisational issues

14.15-18.30 Grasping the water problem and methodology

- (1) **Water availability and scarcity: now and future trends** (14.15-15.15)
  - Speaker: Dieter Gerten (PIK Potsdam)
  - *This talk (30 min.) should explain the current global and regional availability of water and some future scenarios, particularly in regard to climate change impacts, population growth, urbanization, economic development, lifestyle changes and other major factors. Different concepts of "water scarcity" should be mentioned. The main focus should be on future availability and scarcity, but not on drivers of and reasons for water scarcity.*
- (2) **Human water use, conflicts and sustainability** (15.15-16.15)
  - Speaker: Karl Tilman Rost (FU Berlin)
  - *This talk (30 min.) aims at identifying the relationship of human water use with the natural water cycle, and thereby at clarifying the concept of sustainability. Drawing on the case of Central Asia, the talk also deals with water management issues, in particular transboundary water management.*
- (3) **Drivers of scarcity and pollution** (16.30-17.30)
  - Speaker: Joe Hill (ZEF Bonn)
  - *This talk (30 min.) will begin by discussing how the idea of a 'global water crisis' came about, from Gleich's 1993 publication Water in Crisis, and how it is sustained, by for example the World Water Council's formation and publications, and the UN World Water Development Reports of the 2000s. It will highlight the drivers of water scarcity and water pollution pinpointed by this international discourse. The talk will then present an alternative view, to show how such a crisis is formed when water (and population) is conceptualised as a scientific abstraction, devoid of environmental, social and cultural contexts etc. This talk argues that attention needs to be paid to political economic (and other) factors that affect access to water, for not doing so is tantamount to turning a blind eye to the injustices central to the production of affluence for a few (modernist economic development) at the expense of the majority (who rely on water's ecological and social roles).*
- (4) **Reflection on methodology, scenario building and scientific policy advice** (17.30-18.30)
  - Speaker: Wolfram Mauser (LMU Munich)

18.30 Dinner

Tuesday, 21 June 2011:

08.00-09.00 Breakfast

09.00-13.00 Water management options part I

Discussions always with particular regard to ethical aspects, uncertainties, (political) implementation issues and cross-cutting issues (interconnections) like adaptation to climate change.

- (5) **Global Blue Water Scarcity and Effectiveness of different Policy Options** (09.00-10.00)
  - Speaker: Christoph Schmitz (PIK Potsdam)
  - *This talk (30 min.) is about investments in technology (or cultivation methods in agriculture) and infrastructure (e.g. in order to avoid disasters in the case of droughts and floods). It should give an answer to the question about the potential of technological improvements to tackle the water crisis and the economic and political question where the money for necessary investments could come from.*
- (6) **Good governance** (10.00-11.00)
  - Speaker: Nadine Reis (IGP Munich)
  - *This talk (30 min.) discusses the large field of political aspects surrounding the water crisis, that is the role of good (or bad) governance, corruption, markets, participation of local people in decision-making processes, perspective of game theory, political or institutional economics, etc. The potential of international cooperations should be discussed, too.*
- (7) **Pricing water?** (11.15-12.15)
  - Speaker: Kristina Bernsen (Univ. of Leipzig)
  - *This talk (30 min.) introduces to the heated dispute about pricing water, role of private sector (water supply and waste water) and water productivity from an economic perspective.*
- (8) **Climate change mitigation can reduce water stress** (12.15-13.00)
  - Speaker: Monika Prasch (LMU Munich)
  - *This talk (20-25 min. only, because we cannot discuss this issue to a satisfying extent in any event and we do not want to focus on climate mitigation in this workshop, though it is of course an important and interesting issue) should discuss potentials, but also trade-offs (especially use of biomass for energy production) concerning climate mitigation options in regard to the water crisis.*

13.00-15.00 Lunch (break)

15.00-18.15 Water management options part II

- (9) **Virtual water trade in a globalised world, PART I** (15.00-16.00)
  - Speaker: Maite Aldaya (UNEP)
- (10) **Virtual water trade in a globalised world, PART II** (16.00-17.00)
  - Speaker: Nico Grove (Univ. of Weimar)
- (11) **Managing land and water resources** (17.15-18.15)
  - Speaker: Katharina Waha (PIK Potsdam)
  - *This talk (30 min.) is about land use conflicts in regard to the water issue.*

18.30 Dinner

20.00-21.00 Public lecture (Prof W. Mauser, LMU Munich; lecture in German)

Wednesday, 22 June 2011:

08.00-09.00 Breakfast

09.00-12.45 Parallel workshops in small groups on water management options

The focus of the respective workshop (and, eventually, regional focus) highly depends on the moderator´s preference. Each workshop should prepare a little contribution for the final synthesis document on Thursday. An input at the beginning (about 20 min) might be helpful.

(09.00-10.45)

- (A) **Reflections on the governance link between water resources and conflict in Sudan**
  - Input & Moderator: Julia Ismar (IGP Munich)
- (B) **Pricing water? How to?**
  - Input & Moderator: Wolfgang Bretschneider (Univ. of Leipzig)

(11.00-12.45)

- (C) **Virtual water trade: Water-Food-Trade-Energy Nexus**
  - Input & Moderator: Martin Keulertz (King´s College London)
- (D) **Cultural ecological perspective of water management – evidence from Nigeria**
  - Input & Moderator: Emmanuel Akpabio (ZEF Bonn)
  - *This workshop will discuss the cultural and ethno-ecological sense of water. Examples are drawn from Nigeria to highlight core values of water as espoused by indigenous tradition and the dissonance with modern water management approaches. It is argued that narrowing the oppositional gap requires new water norms or integrated knowledge that gives recognition to the role of local values. Useful ways of achieving this are to be discussed.*

12.45-14.45 Lunch (break)

14.45-18.45 Case studies and implementation barriers

- (12) **The Australian Water Trade** (14.45-15.45)
  - Speaker: Doreen Burdack (HU Berlin)
- (13) **Water management in Mongolia** (15.45-16.45)
  - Speaker: Katja Sigel (UFZ Leipzig)
  - *Participative water infrastructure planning in peri-urban settlements in the city of Darkhan, Mongolia.*
- (14) **Wasserwerke Zug: Swiss water management** (excursion, 16.45-19.00)

19.00 Dinner

Thursday, 23 June 2011:

08.00-09.00 Breakfast

09.00-11.00 Water rights and water ethics

- (15) **The right to water: an economic perspective** (09.00-10.00)
  - Speaker: Wolfgang Bretschneider (Univ. of Leipzig)
  - *This talk (30 min.) discusses an economic perspective on the right to drinking water, intending to deliver a framework for its implementation.*

- (16) **Water ethics: From human rights to water management** (10.00-11.00)
  - Speaker: Martin Kowarsch (IGP Munich)
  - *This 30 min. talk should explain, what decisive ethical aspects of the water management problem are and how they can be solved. Ethical reflection on what was said about management options during the workshop so far.*

11.00-13.00 Final discussion and synthesis document

- Discussion of results of small group workshops by discussing a final synthesis document (composed of contributions from each workshop (A-F), from the talks and from the discussants), identifying also relevant uncertainties.
- Optionally: discussion about further steps and cooperations beyond this meeting

13.00 Lunch. Workshop ends after lunch

List of speakers and participants

Emmanuel **Akpabio** (ZEF Bonn; geography)

Dr Maite M. **Aldaya** (UNEP, Univ. of Twente; biology, environmental policy)

Kristina **Bernsen** (Univ. of Leipzig; economics)

Wolfgang **Bretschneider** (Univ. of Leipzig; economics)

Doreen **Burdack** (HU Berlin; economics)

Dr Dieter **Gerten** (PIK Potsdam; geography, hydrology)

Prof Dr Nico **Grove** (Univ. of Weimar; infrastructure economics and management)

Dr Joe **Hill** (ZEF Bonn; political sociology of water resources management)

Julia **Ismar** (IGP Munich; political science)

Tobias **Karcher** SJ (head of Lassalle House; organizer of the workshop)

Martin **Keulertz** (King's College London; middle east politics)

Martin **Kowarsch** (IGP Munich; philosophy, economics; in charge of programme)

Prof Dr Wolfram **Mauser** (LMU Munich; geography, hydrology)

Dr Monika **Prasch** (LMU Munich; geography)

Nadine **Reis** (IGP Munich; geography, development studies; co-organizer of programme)

Prof Dr Karl Tilman **Rost** (FU Berlin; geography)

Christoph **Schmitz** (PIK Potsdam; economics)

Dr Katja **Sigel** (UFZ Leipzig; geoecology, water management)

Katharina **Waha** (PIK Potsdam; geography)

Cancelled at short notice

Ursula **Hein** (Univ. of Basel, studies in sustainable development; audience member)

Dr Owen **McIntyre** (University College Cork; environmental law)

Scott **Moore** (University of Oxford; political science, environmental sciences)

Prof Dr Claudia **Pahl-Wostl** (Univ. of Osnabrück; interdisciplinary resources management, IA)