


This report has been prepared as input to the 2012 World Water Week and its Special Focus on Water and Food Security.

Feeding a Thirsty World

Challenges and Opportunities for a Water and Food Secure Future

WORLD WATER WEEK in Stockholm

SIWI

REPORT 31

ISBN: 978-91-978846-5-5
ISSN: 1404-2134

How to Cite: Jägerskog, A., Jønch Clausen, T. (eds.) 2012.
Feeding a Thirsty World – Challenges and Opportunities for a
Water and Food Secure Future. Report Nr. 31. SIWI, Stockholm.

Cover photo: iStockphoto
Design by Britt-Louise Andersson and Elin Ingblom, SIWI

Printing by Elanders, Mölnlycke, Sweden. The
printing process has been certified according to
the Nordic Swan label for environmental quality.
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Challenges and Opportunities for a Water and Food Secure Future

Photo: David Brazier /IWMI

Note to the Reader

Today, in 2012, nearly one billion people still suffer from hunger and malnourishment, in spite of the fact that food production has been steadily increasing on a per capita basis for decades. Producing food to feed everyone well, including the 2 billion additional people expected to populate the planet by mid-century, will place greater pressure on available water and land resources.

This report provides input into the discussions at the 2012 World Water Week in Stockholm, which is held under the theme of Water and Food Security, and was edited by Anders Jägerskog, Director, Knowledge Services at SIWI, and Torkil Jønch-Clausen, Chair of the World Water Week Scientific Programming Committee. It features brief overviews of new knowledge and approaches on emerging and persistent challenges to achieve water and food security in the 21st century. Each chapter focuses on critical issues that have received less attention in the literature to date, such as: food waste, land acquisitions, gender aspects of agriculture, and early warning systems for agricultural emergencies. It is our hope that the articles provoke concern and inspire action where needed.

Contributing authors of the chapters are Malin Falkenmark, Ana Cascão, Mats Eriksson, Josephine Gustafsson and Jan Lundqvist of SIWI; Sibyl Nelson, Ilaria Sisto, Eve Crowley and Marcela Villarreal of the Food and Agricultural Organization of the United Nations (FAO), and Mark Giordano, Tushaar Shah, Charlotte de Fraiture, and Meredith Giordano from the International Water Management Institute (IWMI). The production of the report was made possible through the support from the Swedish International Development Cooperation Agency (Sida) and the International Fund for Agricultural Development (IFAD).

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Introduction

By Torkil Jønch Clausen

In 1974, at the first World Food Summit, the then US Secretary of State Henry Kissinger stated that "no child will go to bed hungry within ten years". Many years later, at the turn of millennium when millions of children still woke up hungry, the UN declared a Millennium Development Goal stating that the world would "reduce by half the number of people suffering from hunger by 2015". At the time, they set the target at reducing the number of hungry people from 840 million to 240 million. Today, in 2012, nearly one billion people still suffer from hunger and malnourishment, in spite of the fact that food production has been steadily increasing on a per capita basis for decades, even at the peak of the food price crisis in 2008.

The Food and Agricultural Organization of the United Nations (FAO, 1996) definition of food security states that "food security exists when all people at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". As the number of undernourished people has risen in parallel with an increase of food production per capita, it is clear that production alone is not the answer.

Achieving food security is a complex challenge involving a host of factors. Two of the most critical are water and energy, both essential components to produce food. World Water Day 2012 was devoted to "Water and Food Security", and the 2012 World Water Week in Stockholm is also putting this subject as its primary focus. Both global events place "water" at the centre while recognising the broader overall complexity of food security.

At the Rio+20 Summit that took place in June 2012 "water" was recognised as a key issue in the final text "The Future We Want", including as a critical factor for the Green Economy. In preparation for the Rio Summit, the Bonn 2011 Conference had highlighted the "Water, Energy and Food Security Nexus", stressing the importance of addressing water in this broader context. Although not explicitly stating so, the central role that ecosystems play in this Nexus was implicitly recognised in the Bonn outcomes.

Photo: Mats Lannerstad

The "water" factor

Turning to the water and food security challenge, the statistics speak for themselves. If today we still face the challenges of feeding one billion undernourished people out of a total population of 7 billion people, how do we achieve food security for a world population that is expected to reach 9 billion in 2050? FAO predicts this will require that we increase food production by 70 per cent by mid-century. This will place additional pressure on our already stressed water resources, at a time when we also need to allocate more water to satisfy global energy demand – which is expected to rise 60 per cent over the coming 30 years – and to generate electricity for the 1.3 billion people currently without it.

The answer is not simple and has many facets. We can focus our attention on the production and supply, looking at how we can cope with the increasing stress on our water resources, their variability and the impact of climate change; we can look at the demand to see how good demand management can increase water and energy efficiency in food production, including getting "more crop per drop"; and we can look at the entire chain from "field to fork" and see how to reduce the 30-50 per cent of food that is lost and wasted from harvest to consumption. This is a troubling statistic: with all our efforts to improve efficiency, increase yields and raise production in the field we sacrifice half of it in avoidable losses in the early part of the food chain, and wastage in the latter. The bad news is that we are wasteful; the good news is that means if we reduce waste we can feed everybody without additional resource use.

Addressing the challenges related to "water and food security", through the entire chain from production to beneficial use and waste, calls for focus on a wide range of technical, economic, financial, institutional, governance and political issues, with the "triple bottom line" of economic development, social equity and environmental sustainability guiding us. No single event can accord full justice to all issues, but the World Water Week in Stockholm shall try

Photo: Edelpix

to cover as many aspects as possible and provide a platform for dialogue between all relevant stakeholder groups from academia, government, the private sector and civil society from all parts of the world.

World Water Week in Stockholm – and this publication

We have attempted to do this through the Thematic Scope of the Week (see page 10), which covers the following key issues: increasing water efficiency in all aspects of food production; linking food production to human health and ecosystem services; paying more attention to the food supply chain – from field to fork; securing water and food security in an urbanising world; moving towards a green economy – recognising the water-food-energy nexus; trading food and virtual water; and building new partnerships for knowledge and good governance. These issues will be covered in workshops, seminars and side events during the week, and hopefully leave us all somewhat wiser, and better equipped to help eradicate food insecurity in the world.

This publication provides brief overviews of new knowledge, thinking and approaches on emerging and persistent challenges to achieve food security in the 21st century. It focuses on critical issues that have received less attention in the literature to date, such as: food waste, land acquisitions, gender aspects of agriculture, and early warning systems for agricultural emergencies. It also offers perspectives on how to better manage water and food linkages.

The food challenge as seen from the water perspective is presented by Malin Falkenmark who outlines how the competition for water between food production and other uses will intensify pressure on essential resources. She argues for an integrated approach to identify competing demands and assess trade-offs between different uses.

Mark Giordano, Tushaar Shah, Charlotte de Fraiture, and Meredith Giordano from the International Water Management Institute (IWMI), the 2012 Stockholm Water Prize laureate, discuss water and society from a governance perspective. They suggest that while there may be a scientifically rational way to address certain water and food challenges, in the real world of complex socio-politics the politically feasible "second best" solutions are often the realistic ones.

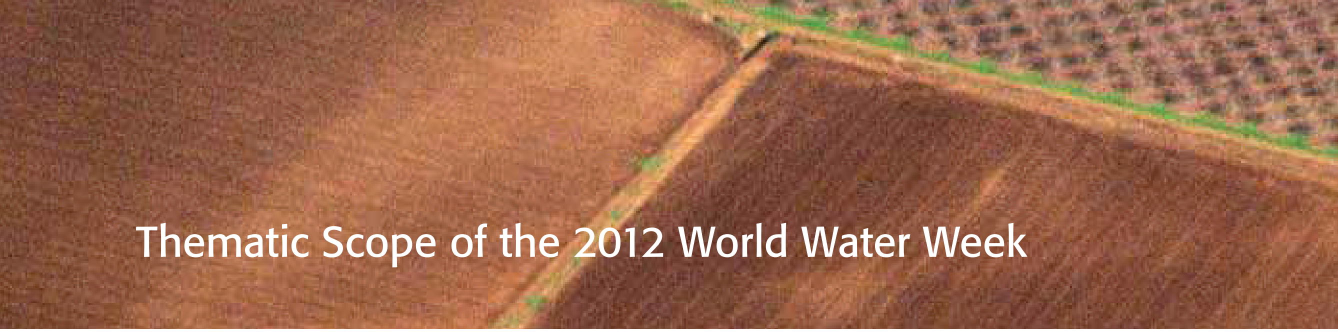
Sibyl Nelson, Ilaria Sisto, Eve Crowley and Marcela Villarreal zoom in on the issue of gender and agriculture and explain that one of the reasons why the agricultural sector underperforms in developing countries is that men and women do not have equal access to resources and opportunities. While the central role of women in water management was highlighted three decades ago in the 1992 Dublin Principles, progress has been slow.

Josephine Gustafsson and Jan Lundqvist explore the food supply chain and highlight how increasing the efficient use of food, by reducing losses and curbing consumer waste, can save water. They also note how prevailing policies and practices encourage a culture of waste and overeating, which places unsustainable pressure on both fertile land and water to produce much more food than is actually needed to sustain a healthy global population.

Mats Eriksson addresses the challenge of adapting food production to water availability in the face of high rainfall variability, which may become more erratic as the climate changes. He discusses how Early Warning Systems (EWS) can identify coming shortages of both water and food in various regions of the world, but stresses that institutional linkages and capacity must be developed in national and international agencies to utilise these warnings to take preemptive action. The chapter shows how the recent famine in the Horn of Africa was foreseen by several alerts before the crisis hit, but did not trigger the required response. This clearly demonstrates that EWS systems need to be accompanied by appropriate governance mechanisms and political will by decision-makers to act before it is too late. Vulnerable populations also must be better prepared and aware of the actions they can take upon receiving information from EWS systems.

In the final chapter, Anders Jägerskog and Ana Cascão investigate the recent increase in the acquisition of land in foreign countries, primarily targeting Africa but also happening in Latin America and Asia. They note that land contracts and agreements rarely include provisions for water. Access to the water needed to grow food or bio-energy on the land seems to be taken for granted. Concluding that land investments will impact local and in some cases regional water resources, they argue that land lease contracts must be more transparent and include explicit regulations for the use and protection of water.

Photo: Thomas Henrikson



Thematic Scope of the 2012 World Water Week

Increasing water efficiency in all aspects of food production

A more productive use of limited, highly demanded and unreliable water resources is necessary. In most debates, an increase in water productivity is associated with a more efficient irrigation. This is important. But it must be complemented with better use of local rains combined with small scale supplemental irrigation. A better coordination between land and water resource management, with strong and early involvement of farmers is vital. This requires financial and policy support to farmers and farmers' organisations from authorities and private actors.

While improved 'green water' management will contribute to meeting the increased food demand, investments in 'blue water' infrastructure, such as dams and irrigation systems, are still needed. These investments need to ensure optimal returns to society at large, including more 'jobs per drop'.

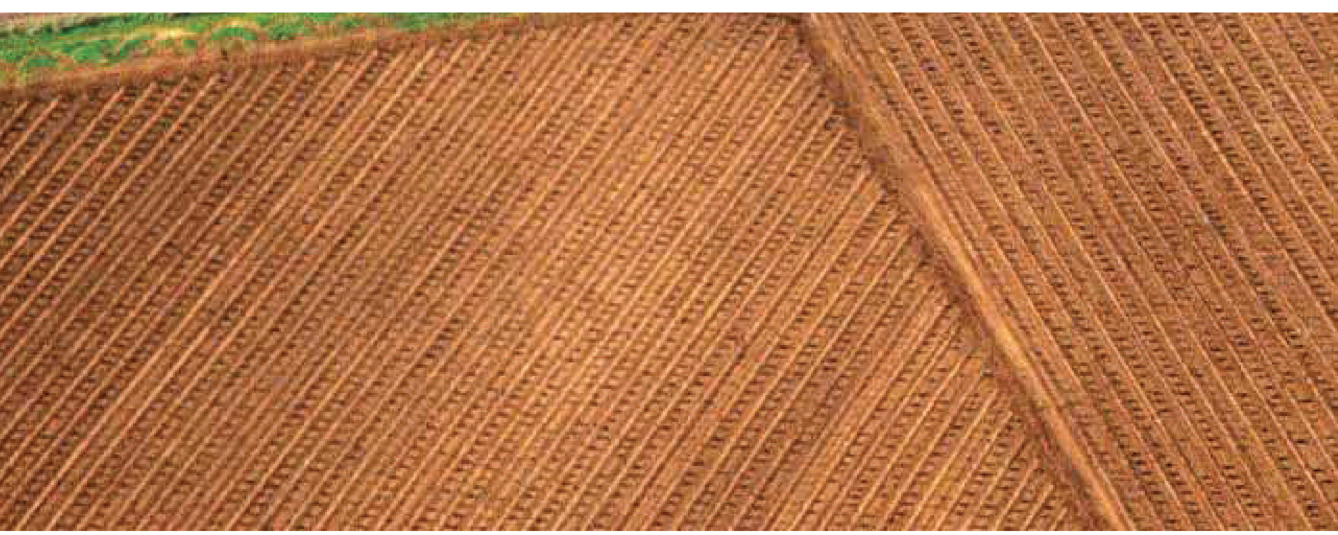
A large proportion of the world's food production is based on un-sustainable exploitation of groundwater that at the same time are threatened by increasing pollution by agro-chemicals.

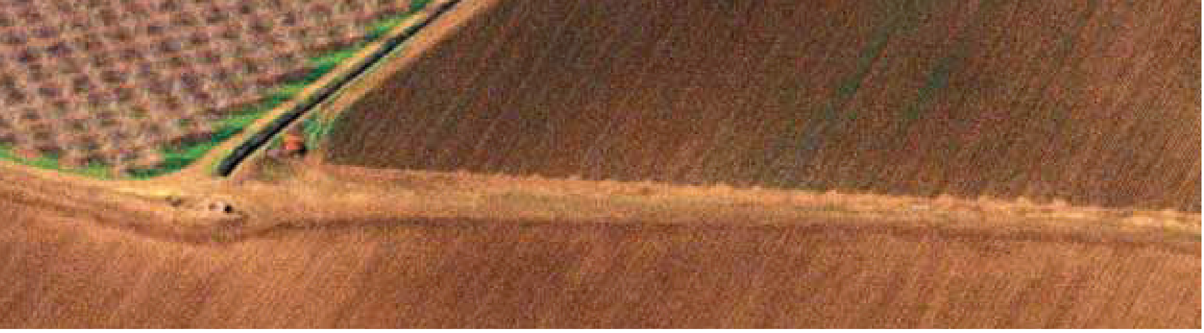
Given the increasing variability of rainfall, farmers need systems for early warning of drought risks, as well as early information on opportunities for promising cultivation seasons. Improvements in modelling and data compilation and dissemination can provide timely guidance to farmers about likely water situations at various time and geographical scales.

Producing more staple crops alone does not increase food security. Diversification is vital for farmers to be able to sell their produce at decent prices. It also offers the possibility to use variable water resources more efficiently, contributing to stronger resilience to climate change.

Linking food production to human health and ecosystem services

Water for food production, as for any other use, needs to be considered and managed in terms of both quantity and quality. An obvious win-win between the two is the safe re-use of wastewater and the recognition of faecal products as resources rather than waste. Effective water and nutrient use in rural and urban agriculture, controlling 'point' and 'non-point' pollution from the





food chain, safe reclamation of wastewater for local food production, and reduced leakage of nutrients are important aspects of agricultural water management. Multi-functional use of land and ecosystems, e.g. through payment for ecosystem services, improves the incentives for food production in tune with nature.

Water interventions for food security, at production and household levels, need to focus on improved nutrition, better health, critical bio-diversity and sustainable livelihoods, achieving co-benefits for environmental as well as human health. The food production in the world is more than enough to feed all its inhabitants properly. Yet, a billion are undernourished, around two billion are overeating, and staggering amounts of food are lost or wasted. In addition, food alone will not eradicate hunger as up to 50 per cent of malnutrition is related to unclean water, inadequate sanitation or poor hygiene.

Paying more attention to the supply chain – from field to fork

There is no such thing as a post-agricultural society. But society outside agriculture is expanding. Perceptions about food, water and life support systems are changing with the growth of the urban population, often disconnected from food production. This context calls for increased attention to supply chain issues. It is in the interest of producers, consumers and society at large to ensure that agricultural produce is optimally used.

Urbanisation and a growing affluence alter the food demand towards more resource intensive diets. Geographical distance between producers and consumers increase the need for better post-harvest operations. Today, a large and growing fraction of the food produced is either lost, converted or wasted. There are enormous imbalances and significant synergies at the water and food nexus.

Securing water and food security in an urbanising world

Urban areas are the engines of economic growth and rely heavily on water, energy and food to sustain this growth. Many cities in developing countries face the challenges of water scarcity and food insecurity, with major impacts on the urban poor, especially women and children. Furthermore, many agricultural practices

Photo: Jupiterimages

have negative environmental effects, particularly on water quality, adding to the urban water challenge.

While the complexity of the relationship between water food and cities may be daunting, there are huge untapped synergies that can be realised through coherent planning and management. By better understanding of the urban water and food nexus innovative ways of closing the water and nutrient loops can turn problems into resources.

Moving towards a green economy – recognising the water-food-energy nexus

Throughout the food chain, water and energy inputs are both crucial and interlinked. On one hand, making water of acceptable quality available for food production carries a heavy energy bill. On the other, energy production is associated with significant water consumption, e.g. when energy and agriculture meet in the production of first generation bio-fuels that can consume up to 20-30 tonnes of water per litre bio-fuel.

As is often said: mitigation is mainly about energy and adaptation mainly about land and water. Improved agro-forestry, 're-carbonising the landscape' and increased consciousness about water and energy linkages will be a cornerstone of future food, water and energy security. The food-energy linkages are also about costs. Higher energy prices affect the cost of agricultural inputs, including water, and consequently food prices. High energy prices also increase the incentive for growing crops for fuel rather than food. The volatility of energy prices is hence transferred to the price of food contributing to food security risks.

Trading food – and virtual water

Food trade is often seen as an opportunity to transfer a surplus to areas of shortage. But there are obstacles that could impede a sound trade for food security. The current rush for land and water outside national territories is modifying international food trade.

Food will be exported silently away from people and from areas where food security is hard to accomplish. Growing swathes of water and land are controlled by interests far from the location of these resources and ordinary trade principles may not apply. The socio-economic implications of trade and overseas land acquisition for national and global food security need to be explored and addressed further. On one hand, land acquisition may stimulate investments in areas that otherwise would be stagnant. On the other, it may be detrimental for the ambitions to reduce poverty and the number of people suffering from malnourishment.

When food is transported substantial volumes of water flows within it. For every kg of food produced, between 5 and 25 tonnes of water is used. Moving food from areas with high water availability, and high water use efficiency, to areas with scarcity or low productivity may result in considerable overall water savings.

Water, food and energy are closely linked in many of the world's trans-boundary river basins where riparian states share water as well as the benefits from its use. Turning competing demands for limited water resources into mutually beneficial benefit sharing is both a major challenge and a major opportunity.

Building new partnerships for knowledge and good governance

Like the circulatory system of the human body ensures the integrity of functions by different organs, a sound water system is critical to sustain practically all sectors of society. Water is critical for food security, energy security, health security and has key democracy, human rights and equality dimensions. The Integrated Water Resources Management approach attempts to address competing demands from different sectors and the sustenance of ecosystem livelihoods and biodiversity by involving all stakeholder groups. Developing new partnerships with civil society and the private sector in all parts of the food chain, from production in the field, through the food industry and transport system to the retail link and the consumers is vital to wise resource management.

Stakeholder interaction is important in both the creation and sharing of values, including getting fair access to the goods and services that are created, and in implementing corporate social responsibility. Only informed stakeholders can make this system work, calling for both generation of knowledge through research, technology development and innovation, and dissemination of knowledge in all parts of the chain.

In a rapidly globalising world, good governance of the water and food security system – securing the institutions, information and investments – call for improvements at all scales, from the local through the national and regional to the global level.

Photo: Alastair Morrison, SIWI

Food Security: Overcoming Water Scarcity Realities

By Malin Falkenmark

The following chapters in this publication will address water and food security in a broad perspective. They will stress its link to both urban growth and virtual water, and highlight the mounting pressure on scarce water and land resources, the considerable food losses, and the need for promotion of a water saving society. This chapter will put focus on the reality we face of a growing water scarcity, and use a back-casting perspective to analyse our prospects and options for ensuring that water scarcity does not constrain our ability to achieve global food security in 2050. It looks into key questions, such as: What will the crop water availability situation look like in 2050? How important will virtual water flows be? How can we balance competing demands from urban and other uses? What essential difficulties will we need to overcome?

Food production consumes water

Food is produced through the photosynthesis process by which plants manufacture carbohydrates. Water constitutes one of the two required raw materials – carbon dioxide being the other.

Water is absorbed by the roots from the store of infiltrated rain in the soil, which is often called the green water resource. Substantive amounts of water are consumed as crops grow; each person requires 50 to 100 times more water to produce the food they eat than they use in their home. One fundamental condition for good yields is that the roots gain access to enough green water to allow for an efficient photosynthesis. This green water is a local resource that is available to the farmer. To avoid crop water deficiency, blue water from rivers or aquifers may be added by irrigation. Farmers will have to compete for that water, since it is the key resource for other societal functions, including water supply, industry and energy production. Continued population growth in large regions with limited rainfall will creates dilemmas in the future as the competition for blue water escalates.

What will the water availability situation look like in 2050?

A country's ability to produce food is limited by the amount of available water on its croplands. In order to compare the availability of cropland water with food water requirements in 2050, a series of model-based studies have been carried out at Stockholm University in cooperation with PIK, Berlin, using the well-established pixel based LPJml dynamic global vegetation and water balance model (Gerten *et al.* 2004). This model assumed climate change will follow the A 2 scenario and population will grow according to UN medium projection (Falkenmark *et al* 2009; Rockström *et al.* 2009, 2010, 2011). Water availability on current croplands was integrated into country-based availability data (green water was calculated as infiltrated cropland rainfall, blue water was calculated as current irrigation, and allowed only a 15 per cent expansion to limit further undermining of aquatic ecosystems). The available water was compared with food water requirements of different diet compositions, with meat requirements in line with country-based balancing of red vs. white meat. It also assumed a 25 per cent yield gap closure. In the analysis, the water rich countries were assumed to produce surplus food to allow water short countries to compensate their carrying capacity overshoot by import, which is now often described as 'virtual water transfer'. Estimations of purchasing power were based on World Bank classification (World Bank, 2009). Three different diet combinations were analysed,

1. Food production in line with current dietary trends (3,000 kcal/p d, 20 per cent animal food);
2. A diet in line with current trends but a reduction of meat consumption (3,000 kcal/p d, 5 per cent animal food)
3. The food intake required asuming that all losses could be avoided (cf Gustafsson & Lundqvist in this volume).

The analysis showed that there will not be enough water available on current croplands to produce food for the expected population in 2050 if we follow current trends and changes towards diets common in Western nations (3,000 kcal produced per capita, including 20 per cent of calories produced coming from animal proteins). There will, however, be just enough water, if the proportion of animal based foods is limited to 5 per cent of total calories and considerable regional water deficits can be met by a well organised and reliable system of food trade.

Water scarcity problems to overcome

The table shows a correlation between low national income and cropland water deficiency. There is no low income country with cropland water surplus. These countries are therefore dependent on getting access to water or food from elsewhere. The growing

Diet kcal/cap, day	Income	Deficiency km3/yr	Surplus km3/y	Policy Implication
3,000 20% animal protein	Low	-1,086	0	Impossible alternative
	Medium + high	-2,504	1,400	
3000 5 % animal protein	Low	-724	0	Horizontal expansion
	Medium + high	-1,359-	1,954	Import
2,200 5 % animal protein	Low	-381	6	Horizontal expansion
	Medium + high	-469	2,373	Import

Table 1. Accumulated global scale country-based water deficiencies and surpluses on current cropland as foreseen by 2050 (Source: Rockström *et al.*, 2012)

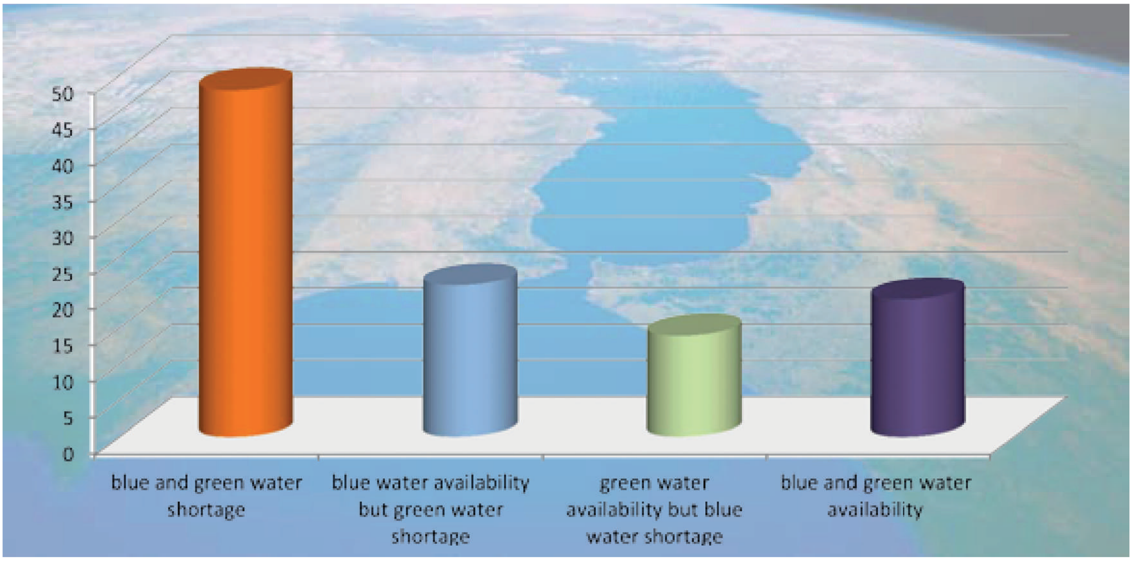


Figure 1. Per cent of global population living in areas with blue and/or green water shortages in 2050 (source Rockström *et al.*, 2011).

predicament of water scarcity is further demonstrated in Figure 1. It shows that only one-third (14+19 per cent) of the world population will have enough available green water to allow for food self-sufficiency from rainfed agriculture and that three-fifths (46+14 per cent) will face difficulties to access to irrigation water (chronic blue water shortage) (Rockström *et al.,* 2011). The numbers suggest that water shortage will develop into a very real challenge for the next generation, with almost half the world population living in chronic water shortage.

Thus water scarcity may be expected to be important to food production for 2050 from two perspectives:

- Where there is green water scarcity, irrigation will be essential (by 2050 67 per cent of the world population) but will face increasing competition for the blue water with other societal sections.
- Where there is both green and blue water scarcity (46 per cent of the world population), competition for blue water may be increasingly critical to cope with.

Water sharing through virtual water transfer

Figure 2 (page 16) compares the outcome of two opposite production alternatives:

1) 3,000 kcal/per capita and day with a reduction of the proportion of animal based foods to 5 per cent;
2) 2,200 kcal/per capita and day with a reduction of the proportion of animal based foods to 5 per cent.

The blue colours indicate the number of people living in water surplus countries with potential possibility to export, the green represents those dependent on import due to water deficiency, and red shows the amount of people foreseen to be living in water short regions that can not afford to import food. The sectors refer to different economic situations according to the World Bank's classification of countries.

Two essential conclusions emerge from this analysis: First, the virtual water transfer component will have to increase considerably in order to compensate foreseeable carrying capacity overshoot. Second, in low income countries (the second bar in Figure 2), horisontal cropland expansion will probably be impossible to avoid. This then poses several fundamental questions that need to be addressed, such as: How can a reliable virtual water transfer system be developed? What rules would be needed? Will the better endowed countries in fact be able (and willing) to produce the necessary food surplus for export? How will foreign land acquisition affect the picture? What further constraints need to be analysed to understand the actual capacity to grow food? Which water and land resources will be unfit for food production from climates that are too cold or other factors? How much cropland area will shrink due to urbanisation and what will be the impact? How will biofuel production affect the situation?

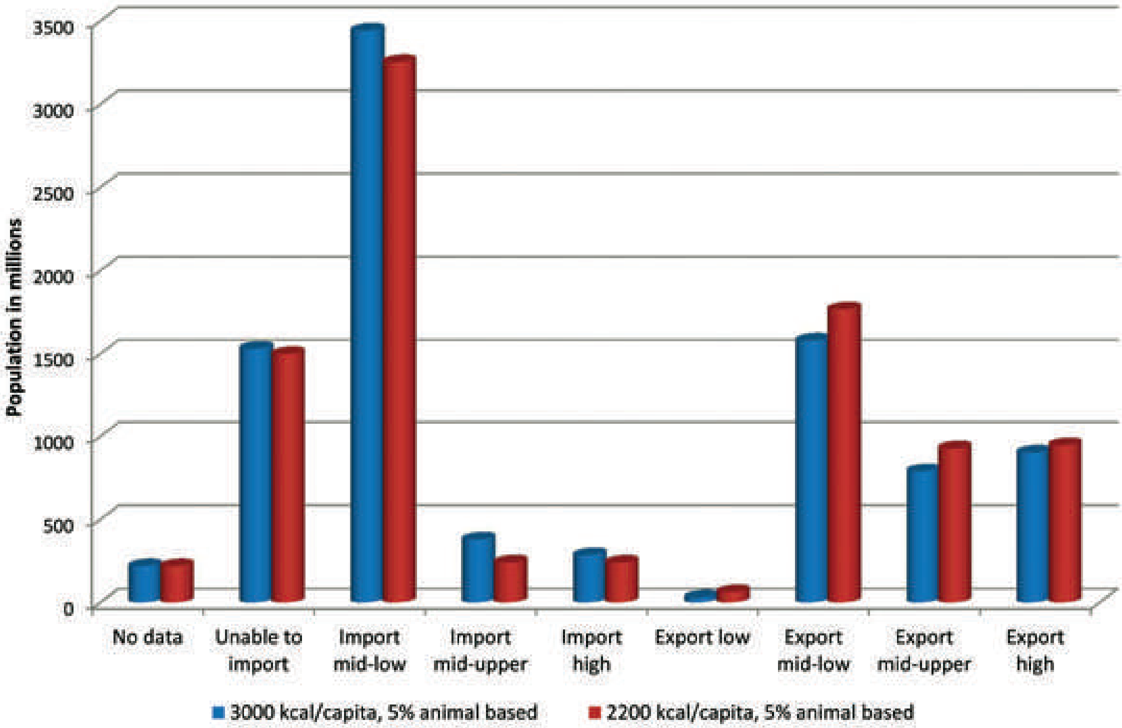


Figure 2. Trade dependence by 2050 for two different per capita food supply scenarios, showing the total population living in areas that have different degrees of dependence on food import, and in areas with different capacities for food export. Blue bars: 3000 kcal/per capita with an assumed proportion of animal based foods of 5 per cent. Red bars: 2200 kcal/per capita with an assumed proportion of animal based foods of 5 per cent (Source: Rockström et al 2012)

A majority of the low income countries (the second bar in Figure 2) are in sub-Saharan Africa, where under nutrition is prevalent and life expectancy low. The availability of water for food production to feed their populations will be a critical issue in coming decades. The estimates show that many of these countries might in fact have enough green water on their croplands to, in principle, be food self-reliant (Figure 1). This means that providing an adequate future food supply in the region would largely require wide-spread upgrading and upscaling of rainfed agriculture.

All these results represent what would be expected given the average level of precipitation as projected for 2050. The increasing variability of rainfall is a large challenge, however, that must be coped with. Different categories of droughts involve different types of disturbances and will have to be countered by diverse policies (Falkenmark & Rockström, 2008). Intra-seasonal dry spells, for example, can be compensated by water harvesting and supplementary irrigation. Inter-annual droughts, however, will result in varying degrees of crop failure and must be compensated by irrigation. Climate-change related situations that result in slow aridification, will require more fundamentally altered water policies (Lundqvist and Falkenmark, 2011).

Increasing competition for blue water between the farm and the city

Blue water is essential for food production to complement green water in areas where green water is scarce. When using blue water for agriculture, however, more attention has to be paid to future river basin realities, in particular the implications that continued economic development and urban growth will have on the demand for local blue water sources. Consumptive water use for food and other biomass production continues to increase, reducing the blue water availability for other uses. Already today river flow depletion is considerable – over 25 per cent of continental land area has river flow been depleted – and is occurring largely in regions where agriculture depends on irrigation (Falkenmark & Molden, 2008).

As more people move to and densely congregate in cities, they place more pressure and demand for water. At high levels of water crowding (low per capita water availability), blue water allocation will become more complicated. Wastewater reuse will be increasingly essential. At a water crowding level that exceeds 2,500 people per flow unit of one million m^3 per year (400 m^3 per capita and year), a municipal/industrial (M/I), supply level of 200 m^3 per year – a level of water use that, as recently as the 1990's was not seen as wasteful (Lundqvist and Gleick, 1997) – would not allow any irrigation at all. Only by reducing the M/I-supply could water for irrigation be afforded. The "three H basins" in China, (Hai, Huai and Yellow river basins) offers an example. In this silt-laden region, blue water for environmental flow is seen as essential to meet the requirements for river based functions and processes, including the flushing of silt. Reserving some 30 per cent of the river flow for this purpose (Falkenmark and Xia, 2012), would involve a limiting of the M/I allocation to around 90 m^3/per year.

Balancing our dependence on irrigation with other water users

Large breadbasket regions in the world are heavily dependent on irrigation. Currently, 80 per cent of global agricultural water use comes directly from green water with the remaining 20 per cent coming from blue water sources (CA, 2007). Altogether 3,830 km^3/year of blue water is used, out of which 1,570 km^3 is consumed. About 1,000 km^3/year originates from groundwater. Two problems complicate future food production there: groundwater overexploitation and river flow depletion.

The expansion and reliance on groundwater has been increasing in agriculture. Large scale non-sustainable groundwater overexploitation exacerbates the existing irrigation problems. In the last 50 years, the groundwater depletion has doubled and is now in the order of 300 km^3 per year – that is enough to provide a subsistence diet to almost 1 billion people! Three large groundwater aquifers have attracted particular interest: the Ogallalla aquifer in USA, the North China Plain and Gujarat in northwest India. The future use of these plains is a question that will impact the livelihoods of millions. Kendy and Scanlon (in Rockström *et al* 2012) report that irrigation of the Ogallalla will have to stop altogether. In the North China plain, they will have to decrease its irrigated area to stabilise the water table, but while doing so they will need to find ways to maintaining social stability by continuing agricultural production by synchronising crop production with rainfall.

Surface water irrigation in some cases is also unsustainable due to river flow depletion and regional climate aridification. The vulnerability of 10 major monsoon river basins in Asia-Pacific region were recently analysed by Varis *et al* (2011), who combined average water stress with five other vulnerability indicators (governance, economy, social, environmental, hazards). They concluded that Ganges and Indus have the highest river basin vulnerability. Demand-driven water stress was high in Yellow river basin and very high in the Indus basin. It is worth noting that all three basins have already reached high levels of (population-driven) water crowding and suffer from severe water shortage. In closed river basins where water crowding is high, economic development is particularly challenging. One example is the Limpopo basin in the SADC-region, which is on track to reach a water crowding rate of almost 5,000 people per flow unit by 2025 (200 m^3 per capita and yea, Turton & Botha, 2012), but is predicted to face more than double the current water demands over the same time period. To achieve water security under extreme cases of water shortages, water governance will critically depend on strong leadership. Otherwise, conflicts and competition over water may trigger social instability and unrest as people lose their source of livelihoods that depend on water resources.

Looking ahead, shifting thinking

In the future, an integrated approach to land and water will be needed to navigate our competing demands for, and shared dependence upon, available green water and blue water provided in the basin. Finding the best path for sustainable food production requires an understanding of the resource requirements from cities, industrial use, energy production and for sufficient environmental flow in the river to maintain healthy habitats for freshwater and coastal aquatic ecosystems. This calls for a shift in thinking that is based upon sequential reuse along a river system.

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Photo: Timothy Syrotya/ IWMI

Innovations in Agricultural Water Management: New Challenges Require New Solutions

By Mark Giordano, Tushaar Shah, Charlotte de Fraiture and Meredith Giordano

In the late 1960s, the prospect of widespread famine threatened many areas of the developing world. In response, donors provided support to develop new crop varieties that produced much higher yields. Fertilisers were made available to support the new seeds, and massive investments in irrigation provided reliable water supplies to nurture the crops and give farmers the confidence to invest in change. Irrigation water was so vital that the Green Revolution which resulted has even been called a "Pump Revolution," because of the tremendous role farmer supplied groundwater had in driving change (Repetto, 1994). With this revolution millions of farmers became food secure, rural livelihoods were transformed and new food supplies drove down prices for urban consumers.

The early successes of the Green Revolution had many factors in their favour. Those making the changes benefited directly. Farmers saw the benefits of growing improved varieties with higher yields that brought them larger incomes. Feedback was direct and measurable, so adoption increased quickly. Politicians could easily understand the issues and benefits. Thus, there was strong political support for policy changes that led to the construction of large irrigation schemes and energy subsidies to support water access. The technical and engineering solutions were at hand.

The conditions that challenge agriculture today are very different from those of the 1960s. From a water perspective, rivers are drying up, groundwater is being depleted, and 'water crisis' is now a commonly used term. Agriculture now consumes 70-80 per cent of all human water withdrawals, with severe consequences for many ecosystems and the related services on which we all depend. We now know that we can no longer view water as an inexhaustible and free input to a global food production system (Comprehensive Assessment of Water Management in Agriculture, 2007).

Higher incomes, changing diets, and urbanisation will impose new demands on agricultural water. Biofuel production will compete with food production for available resources. Climate change will bring more frequent droughts and floods, and will influence temperature regimes in ways that will increase the challenges faced by farmers in how they manage water. Economic growth will deepen competition between agricultural and non-agricultural water uses.

At the same time, we know we have not yet solved the rural poverty challenge that drove our earlier efforts. Large numbers of the rural poor will continue migrating to cities in search of employment. Increasing urbanisation will place additional pressure on agriculture to produce sufficient food at low cost.

We are thus presented with a dilemma. Water, as put by Kalpanatai Salunkhe, a rural development worker in India, "is the divide between poverty and prosperity". But using that water has a cost. "More rice, at the price of a river," as succinctly articulated by acclaimed Indian author Arundhati Roy in The God of Small Things (1997).

Sometimes there are obvious scientific and technical solutions to the dilemma. Many times though it seems that the problems are insurmountable. We provide in this paper three examples of how the dilemma can be solved, or at least reduced, by approaching water problems from alternative perspectives. We look first at working in concert with the trends individual farmers are pursuing. We then describe how less than "optimal" solutions can generate improved results. Finally, we show why it is important to be cautious when forming perceptions of problems and potential solutions, as some problems require case-specific or localised approaches that might not seem evident upon our initial review.

Small is beautiful… and what farmers are choosing

Much of the public investment in agricultural water management has focused on large scale irrigation systems. Perhaps because of this, national irrigation statistics sometimes do not even attempt to include the areas funded by private sector investments, particularly those of individual farmers. One consequence is that smallholder agricultural water management is often ignored and unrecognised by both investors and policy makers. But, smallholder agricultural water management is a vibrant and growing sector, and in many countries the area under privately managed and owned irrigation is substantially larger than that under public irrigation schemes.

For example, in South Asia most of the irrigated area depends on privately owned and managed wells. Some estimates put the number of privately owned wells in India at around 25 million, providing 70 per cent of all irrigation water (Shah, 2009). In Bangladesh 5.1 million of the 6.2 million irrigated hectares are under privately owned wells and 86 per cent of the area is served by privately owned pumps (BBS, 2010).

The situation is similar in Southeast Asia. In Indonesia the number of privately owned motor pumps used in irrigation increased from 1.17 million to 2.17 million just between 1998 and 2002 (Government of Indonesia cited in Shah 2009). In Vietnam the number of privately owned irrigation pumps quintupled during the 1990s to 800,000 (Barker and Molle, 2004). In Thailand there were 3 million privately owned irrigation pumps in the year 2000, up from 500,000 in 1985 (Molle *et al.*, 2003). While recent data are scarce, it is likely that the trend observed in the 1990s has continued.

Trends are similar in Africa even if the scale is not as extensive. Small private irrigation now represents 15 per cent of irrigated area in Kenya, 55 per cent in Niger and 75 per cent in Nigeria (Abric *et al.*, 2011). In Ghana nearly half a million smallholders irrigate 185,000 hectares using buckets, watering cans and small pumps, compared to 11,000 farmers in the public irrigation schemes (Namara *et al*, forthcoming). The small private irrigation sector employs 45 times more individuals and covers 25 times more land area than the public irrigation schemes. All this is virtually unrecognised in public statistics despite the fact that this small private irrigation has been the only real force in increasing irrigation in much of sub-Saharan Africa in recent decades (Takeshima *et al.*, 2010).

Supporting smallholder agricultural management can leverage an existing, farmer-driven trend largely ignored by investors. Farmers' genuine interest is demonstrated by their willingness to initiate and finance irrigation themselves. Without the need for large infrastructure (dams, canals, distribution devices) upfront investment costs are low. Technologies suitable for smallholders are available. Compared to public or community managed schemes, the organisational aspects are simple and profit margins are high.

However, there are constraints, mostly unrelated to the water sector, for which public action is needed (de Fraiture, forthcoming). These include market inefficiencies such as poorly developed supply chains; high taxes and transaction costs; and access to information and knowledge regarding irrigation, seeds, marketing, and equipment. We must also address the information and power asymmetries in output markets, which limit the returns many farmers receive for their produce.

While we must be mindful of potential negative consequences of uncoordinated private irrigation development, the reach of the sector and its contribution to both poverty reduction and food security in Asia and Africa could expand significantly with appropriate public interventions. As an example of the possibilities, in sub-Saharan Africa there are an estimated 122 million potential rural beneficiaries of motorised pumps. Widespread adoption of such pumps could generate net revenues up to USD 7.5 billion per year (see Xie *et al.*, forthcoming).

Pricing water and energy could help… but so too can creative, non-price solutions

In trying to solve water problems, we often look for "optimal" solutions emanating from our disciplinary or sectoral perspectives. However, holding out for the best often means we miss other opportunities for positive change as the case of Gujarat, India shows (Shah and Verma 2008, Shat *et al.* 2008). There, free groundwater and the free electricity to pump it contributed to severe groundwater overdraft, near bankruptcy of the State Electricity Board, and poor power supply to farmers and other rural residents. The problem had been well known for decades, and the textbook solution was simple: price electricity and groundwater to reflect their value. However, those who tried to implement these solutions did not appreciate the political realities of India. Efforts to rationalise pricing were met with great resistance by farmers. Politicians lost their jobs

Photo: David Brazier/ IWMI

and external funds for modernising the system were withdrawn. The State Electricity Board continued to generate great losses and was unable to meet the needs of the rapidly growing economy. Farmers had to accept poor quality power supply ('free' often has a cost), and the pressure on groundwater was substantial.

An alternative approach, called the Jyotigram Scheme, diverges from the textbook optimum and embraces the electricity subsidies as a strategy. Rather than viewing subsidies as a default component, the Jyotigram Scheme focuses on providing rationally managed subsidies where needed, and pricing where possible. Under the programme, rural Gujarat has been completely rewired. Villages are given 24-hour, three-phase power supply for domestic uses, in schools, hospitals, and village industries, all at metered rates. Farmers operating tube-wells continue to receive free electricity, but for 8 hours, rather than 24 hours and, importantly for the satisfaction of farmers, on a pre-announced schedule designed to meet their peak demands.

The separation of agricultural energy from other uses and the promise of quality supply were sufficient to gain political and social backing for implementation. The Jyotigram scheme has now radically improved the quality of village life, spurred non-farm economic enterprises, and halved the power subsidy to agriculture. The programme has indirectly raised the price of groundwater supplied by tubewell owners in the informal market by 30–50 per cent, thus providing a signal of scarcity, and reducing groundwater overdraft. The solution may not be perfect, but it has proved to be implementable and it has brought substantial improvement in and outside the water sector.

All aquifers are not the same… management regimes should differ also

The problems of groundwater overdraft, such as those described above, are well known around the world, from the Unites States to Saudi Arabia, and to eastern Australia. Most of our research and management efforts rightly concentrate on solutions to the vexing problems of groundwater overuse and abuse (Giordano, 2010). However, our fears of overdraft have at times spilled over to areas where the positive contributions of groundwater to livelihoods and food security have yet to be tapped.

For example, Mukherjee (2005) showed that in India the perception of groundwater overdraft carried over from water-scarce regions, such as the Punjab, where groundwater overdraft problems are immense, to water-rich areas of eastern India. In the state of West Bengal, the government has applied particularly strict regulations on the use of groundwater despite its abundance and high rates of recharge. Rather than needing to control use, it has been argued that additional groundwater use in the region could have further benefits in flood control as part of a Ganges Water Machine (Revelle and Lakshminarayana, 1975). Making matters worse, the policies and regulations implemented in West Bengal were designed for a much more formal system than exists in India and with which farmers have little experience (Shah, 2008). The result is excessive groundwater regulation and

not enough groundwater use, outcomes which ultimately hamper the economic development of one of the world's poorest regions.

Looking forward… with a view toward innovative policy approaches

We face daunting agricultural water management challenges as demand increases and rural poverty and general food insecurity persist. There will be no single solution, but by thinking differently, we can craft case-specific solutions that are appropriate for given locations and points in time.

We have highlighted three examples of innovative approaches toward solving water management problems. While we might be perplexed at how to better manage existing large scale irrigation schemes, we can observe the irrigation successes of small private farmers and work with them to increase their production and expand their livelihood activities. While problems such as groundwater overdraft may seem impossible to resolve, we can look for alternative approaches outside the water sector and craft packages of change that are politically palatable and move us in the right direction. When "toolbox" approaches do not seem to deliver, we can re-examine our perception of the problems and make sure that our solutions truly fit the problems of a particular time and place.

Good science will continue to enhance our understanding and provide the technology needed to improve the way we work. We will also need new insights and innovative thinking to help us put science and technology into use within the many political economies in which we live.

Photo: David Brazier/IWMI

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Photo: A. Fleuret, USAID

Women in Agriculture: Closing the Gender Gap for Development[1]

By Sibyl Nelson, Ilaria Sisto, Eve Crowley and Marcela Villarreal

"Gender" refers not to male and female, but to masculine and feminine – that is, to qualities or characteristics that society ascribes to each sex. People are born female or male, but learn to be women and men. Perceptions of gender are deeply rooted, vary widely both within and between cultures, and change over time. But in all cultures, gender determines power and resources for females and males.

In traditional rural societies, commercial agricultural production is mainly a male responsibility. Men prepare land, irrigate crops, and harvest and transport produce to market. They own and trade large animals such as cattle, and are responsible for cutting, hauling and selling timber from forests. In fishing communities, capturing fish in coastal and deep-sea waters is almost always a male domain.

In many societies, rural women have primary responsibility for maintaining the household. They raise children, grow and prepare food, manage family poultry, and collect fuel wood and water. In addition to these unremunerated tasks, women and girls also play an important, largely unpaid, role in generating family income, by providing labour for planting, weeding, harvesting and threshing crops, and processing produce for sale. Women may also earn some income for themselves by selling vegetables from home gardens, poultry or milk products, grains or forest products. They spend that income mainly on meeting family food needs and educating children.

Although women make substantial contributions to household well-being and agricultural production, in many households men control the sale of crops and animals and the use of the income. The failure to value their work reduces women's status in economic transactions, the allocation of household resources, and wider community decision-making (FAO, 2012). A recent study on the progress against key Millennium Development Goal (MDG) indicators shows that,

[1] This chapter is largely based on FAO's *The State of Food and Agriculture - Women in Agriculture: Closing the gender gap for development (2011).*

globally and with few exceptions, rural women fare worse than rural men and urban women and men for every indicator for which data are available, with very few exceptions (Inter-Agency Task Force on Rural Women, 2012). This is why, addressing the differences between men and women and in particular the inequalities women tend to face in relation to men is a critical component of rural agricultural development.

The gender gap in agriculture

The agriculture sector is underperforming in many developing countries, in part because women do not have equal access to the resources and opportunities they need to be more productive. While tremendous progress has been made in supporting women's legal rights, educational achievements and participation in public life and the economy, no country can claim to be entirely free from gender-based discrimination.

The "gender gap", which is the difference between men and women in access to productive resources, imposes real costs on society in terms of lost agricultural output, food security and economic growth.

Promoting gender equality is not only good for women; it is also good for agricultural development and for poverty and hunger reduction.

Women make essential contributions to the rural economy of all developing country regions as farmers, labourers and entrepreneurs. Women comprise, on average, 43 per cent of the agricultural labour force in developing countries. This average share ranges from 20 per cent in Latin America to 50 per cent in Eastern Asia and sub-Saharan Africa. Their contribution to agricultural work varies even more widely depending on the specific crop and activity. In many countries women are involved in rainfed agriculture, backyard or irrigated home gardening, while men are often responsible for rainfed commodities and land management aspects of irrigation. Women play a key role in fisheries and aquaculture (see box 1).

Women's roles are diverse and changing rapidly, so generalisations should be made carefully. Yet one fact is strikingly consistent across countries and contexts:

Photo: Derek Sciba, USAID

Box 1:
Women in fisheries and aquaculture

Information provided to FAO from 86 countries indicates that in 2008, 5.4 million women worked as fishers and fish farmers in the primary sector. This represents 12 per cent of the total. In two major producing countries, China and India, women represented a share of 21 per cent and 24 per cent, respectively, of all fishers and fish farmers.

Studies of women in aquaculture indicate that the contribution of women in labour is often greater than men's. Women are reported to constitute 42 per cent of the rural aquaculture workforce in Indonesia and 80 per cent in Viet Nam.

The most significant role played by women in both artisanal and industrial fisheries is at the processing and marketing stages. Most fish processing is performed by women, either in their own household-level industries or as wage labourers.

women have less access than men to agricultural assets, inputs and services and to rural employment opportunities, including land, water, fertiliser, livestock, mechanical equipment, improved seed varieties, credit, extension services and agricultural education, among others. Women and their concerns remain still mostly invisible in decision-making in governance structures, planning, policy-making, infrastructure and technology development, as well as in rural institutions. Women are often excluded from decision-making processes in new agricultural water management approaches and resource allocation, with no choice in the kind or location of services they receive. It is important to develop policies and programs that address the needs, interests and constraints of women and men in the agriculture sector. This includes to strengthen extension systems to be more responsive to women, address structural barriers to their access to productive resources and improve the financial systems to support rural women producers and entrepreneurs to move out of less productive segments of the rural economy. Compared with their male counterparts, women:

- are much less likely to own land then men and, when they do, operate smaller farms, on average only half to two-thirds as large;
- keep fewer livestock, typically of smaller breeds, and earn less from the livestock they do own;
- have a greater overall workload that includes a heavy burden of reproductive and care activities like fetching water, firewood, child care and domestic food preparation with low or no economic returns;
- have less education and less access to agricultural information and extension services;
- use less credit and other financial services;
- are much less likely to purchase inputs such as fertilisers, improved seeds and mechanical equipment;
- if employed, are more likely to be in part-time, seasonal and low-paying jobs; and
- receive lower wages for the same work, even when they have the same or better experience and qualifications.

The impacts of this gap are significant. Female farmers produce less than male farmers, but not because they are less-efficient farmers – extensive empirical evidence shows that the productivity gap between male and female farmers is caused by differences in input use. If women had the same access to productive resources as men, they could increase yields on their farms by 20–30 per cent. It is important to highlight that, in some specific contexts, rural men can also be disadvantaged with no role in decision making or limited access to resources and services (i.e. domestic water, local markets or credit) or exposed to more dangerous jobs than women. Traditional stereotypes may not allow men to dedicate enough time to reproductive activities, like child care, with consequent impacts on their life quality.

Closing the gender gap in agriculture would generate significant gains for the agriculture sector and for society. By bringing the yields on the land farmed by women up to the levels achieved by men would increase the total agricultural output in developing countries by 2.5–4 per cent. Increasing the production by this amount could reduce the number

Photo: Neil Palmer, CIAT

of hungry people in the world by 12–17 per cent[2]. According to FAO's recent estimates, 925 million people are currently undernourished. Closing the gender gap in agricultural yields could bring that number down by as much as 100-150 million people. The potential gains would vary by region depending on how many women are currently engaged in agriculture, how much production or land they control, and how wide a gender inequality they face.

Rural women and agriculture water management

There are numerous gender issues in agriculture water management, many of which relate to the existing inequality between women and men in agriculture. Women's lack of ownership and weaker tenure of land, in comparison to men, impacts their ability to make decisions about water use on the land. Lack of ownership of land can also bar women from participating in water user associations, which can result in poor technical outcomes in water management (World Bank *et al*, 2009).

Women's role in managing domestic water, and the impact this has on their livelihoods, has been documented in numerous countries. Studies from Kenya, Uganda and the United Republic of Tanzania, for example, show that children and women in rural areas fetch water from the main water source on average four times per day and require about 25 minutes for each trip. "In rural areas of Guinea, for example, women spend more than twice as much time fetching wood and water per week than men, while in Malawi they spend over eight times more than men on the same tasks. Girls in rural Malawi also spend over three times more time than boys fetching wood and water. Collectively, women from Sub-Saharan Africa spend about 40 billion hours a year collecting water" (Inter-Agency Task Force on Rural Women, 2012).

Many of these tasks could be made much less onerous and time consuming through the adoption of simple technologies. In addition, the introduction of water sources in villages can significantly reduce the time spent by women and girls fetching water. For example, the construction and rehabilitation

[2] Inserting the potential output gains calculated above into the formula for estimating the number of undernourished provides a rough quantitative estimate of how closing the gender gap in agriculture could contribute to reducing hunger. If yield gaps of 20–30 per cent were closed and domestic production increased by 2.5– 4 per cent, the number of undernourished people in the countries for which data are available could decline by 12–17 per cent.

of water sources in six rural provinces of Morocco reduced the time that women and young girls spent fetching water by 50–90 per cent. Primary school attendance for girls in these provinces rose by 20 per cent over a period of four years, which was partly attributed to the fact that girls spent less time fetching water. When women's and girls' time is freed from these burdensome tasks, they can engage in other activities to strengthen livelihood resilience, including productive activities such as crop production. On one side this fosters social and group cohesion and provides women with an opportunity to communicate with other women and people outside their homes. On the other hand, it exposes them to threats of violence and health hazards.

New agricultural projects are becoming more multi-purpose, multi-use and multi-user, with more involvement of communities, both men and women, in the selection of and planning for such interventions. Neither recognising nor addressing the multiple uses of water is one of the causes of women's lower participation in water users' associations. In many societies, ensuring that there is water for household use is a task assigned to women. However, in some places both men and women are getting involved in water issues at various levels and capacities to solve water problems, taking into account their knowledge and skills regarding the local water situation, and their different use and control of water (World Bank *et al.*, 2009).

The Dublin Principles (adopted at the International Conference on Water and the Environment, 1992) recognise the central role of women in water management and policymakers have subsequently made attempts to incorporate gender issues in water development projects. "However, these policies have not been adequately translated into practice and attempts to involve women in water management have met with only modest success. Inequality remains a serious problem among various groups (socio-economic, religious, ethnic and caste) and between men and

Photo: Mats Lannerstad

women within these groups. This is mainly due to a series of factors, including the lack of understanding of gender issues by policymakers and project staff, the lack of will and commitment during the project design and implementation, the limited capacity and use of relevant tools, and the limited sex-disaggregated data, in addition to the local cultural norms" (World Bank, *et al.*, 2009).

Policy interventions can help close the gender gap in agriculture and rural labour markets. Priority areas for reform include:

- Eliminating discrimination against women in access to agricultural resources, education, extension and financial services, and labour markets;
- Investing in labour saving and productivity enhancing technologies and infrastructure to free women's time for more productive activities; and
- Facilitating the participation of women in flexible, efficient and fair rural labour markets.

Water sector reforms in several countries have created many new institutions, some of which may include a gender unit, even though these often have not affected the way the institutions work. Some positive examples of affirmative action policies have incorporated into regulations of water ministries (i.e. Lesotho, Uganda and South Africa) targets for involving women at all levels of water management, specifying per centages of staff who should be women. The African Ministers' Council on Water (AMCOW) has also launched a Policy and strategy for mainstreaming gender in the water sector in Africa to ensure that gender concerns are taken into account in the formulation and implementation of policies and laws to create equity and equality.

Building on these positive developments, additional efforts are needed to close the gap between women and men in the agriculture sector. Making women's voices heard at all levels in decision-making and ensuring that they have the same access to resources and opportunities as men is crucial to making them better farmers, more productive workers, better mothers and stronger citizens.

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Photo: Susanna Westman Todorovic, SIWI

Food Supply Chain Efficiency "From Field to Fork": Finding a New Formula for a Water and Food Secure World

By Josephine Gustafsson and Jan Lundqvist

Demand for food will increase dramatically this century. With increasing competition for limited water, land and other natural resources, a fundamental task ahead is to make the best possible use of these resources and to facilitate that the goods and services produced, including food, will be accessible across social groups and properly used by a burgeoning population. This raises questions as to whether continuing conventional propositions that focus almost exclusively on increasing production to meet demand is the only, and the smartest, way forward in feeding a growing world population.

There is reason to question the prevailing and conventional approach to achieve food security. Between one-third and one-half of the produced food is being lost early on in the supply chain segments or wasted at the consumer-end, amounting to about 1.3 billion tonnes per year globally (Gustafsson *et al*. 2011; Lundqvist, 2010; WRAP, 2011; Parfitt and Barthel, 2010). Significant variation characterise the situation and reliable statistical information is limited (Parfitt and Barthel, 2011). For the US, it is argued that the level of absolute losses and waste increases in pace with increased food supply (Hall *et al*. 2009) which in essence means that the more we produce, the more we waste.

'Good old thinking' is not good enough

The analytical disconnect between production and beneficial use of the produce is striking although it is not a new phenomenon. As aptly formulated in an FAO report (1981:2): "It is distressing to note that so much time is being devoted to the culture of the plant, so much money spent on irrigation, fertilisation and crop protection measures, only to be wasted about a week after harvest". In the 30 years that have passed since this conclusion was drawn, the resource situation has become more precarious. The future is loaded with uncertainties but competition for resources will undoubtedly increase. The fact remains that all food produced, regardless if it is eaten, lost or wasted, has consumed water, energy, occupied land and contributed to GHG emissions.

Stage	Example of food waste/loss characteristic
Harvesting	• Edible crops left in field, ploughed into soil, eaten by birds, rodents, timing of harvest not optimal, loss in food quality • Crop damaged during harvesting/ poor harvesting technique • Out-grades at farm to improve quality of produce
Threshing	• Loss through poor technique
Drying – transport and distribution	• Poor transport infrastructure, loss due to spoiling, bruising
Storage	• Pests, disease, spillage, contamination, natural drying out of food
Primary processing – cleaning, classification, de-hulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, milling	• Process losses • Contamination in process causing loss in quality
Secondary processing – mixing, cooking, frying, moulding, cutting, extrusion	• Process losses
Product evaluation – quality control, standard recipes	• Product discarded/out-grades in supply chain
Packaging – weighing, labelling, sealing	• Inappropriate packaging damages produce, grain spillage from sacks, attack by rodents
Marketing – publicity, selling, distribution	• Damage during transport: spoilage • Poor handling in wet market • Losses caused by lack of cooling/cold storage
Post-consumer – recipes elaboration, traditional dishes, new dishes, proper evaluation, consumer education, discards	• Plate scrapings • Poor storage/stock management at home: food discarded before serving • Poor food preparation technique: edible food discarded together with inedible • Food discarded in packaging: Confusion of 'best before' or 'use by' dates
End of life – disposal of food waste/loss at different stages of supply chain	• Food waste discarded may be separately treated, feed to livestock/poultry, mixed with other wastes and landfilled

Table 1: Generic FSC and examples of food waste (Parfitt and Barthel, 2010).


Photo: Felix Antonio/IWMI

The high rates of losses and waste of food make our resource efficiency very low, and this inefficiency comes at substantial economic and environmental costs (Lundqvist, *et al.* 2008; Björklund, *et al.*, 2008). It is important to note that estimates on the level of losses depend on what is included in the definition. Higher figures include the conversion of grain to feed and to biofuels into the calculations. Some even take overeating into account as a form of "waste", as this arguably is a non-beneficial use of food, which is also on the increase. The level of losses also varies significantly between seasons, years and between commodities and regions. A 'logical paradox' is that losses tend to be larger during "good years" i.e. when yields are high, due to insufficient transport, storage and market access (Enfors, 2009; Adesina, 2009; Lundqvist, 2010).

Apart from the need to pay attention to quantitative aspects in the supply chain, more attention should in parallel be paid to consumer diets and habits. Dietary trends on the whole are moving towards an increased overall demand for, and a larger share of, more water intensive food items. This will have wide implications for resource use, though it is difficult to predict precisely how these patterns will affect resource consumption in the future (WWAP, 2012). Thus, balancing health-related preferences such as high meat intake diets (which require more water) with sound natural resource use principles will be increasingly important in efforts to meet future food demand in a sustainable manner.

The challenges are daunting. Prevailing natural resource use already exceeds the Earth system's carrying capacity, as noted in the Millennium Ecosystem Assessment report (2005) and planetary boundaries are not respected (Rockström *et al.*, 2009). New modes of thinking and governance are required in an era when needs and wants of a growing population expand and where segments of the population are rapidly becoming wealthier. Reduction of poverty is essential, however, increasing wealth and prudence in resource use unfortunately does not seem to be a common combination. Primary challenges are more deeply rooted in socio-economic and political dynamics than policies and management of natural resources. Of course, efficiency in resource use is essential, but expectations and pledges for a better life constitute quite strong social and political forces that may, or may not, abide to the laws and limitation of natural resource systems.

Modifying human behaviour is an essential challenge

Designing a practical formula to modify human behaviour is one of the most delicate and multifaceted tasks for the 21st century. This challenge requires a combination of tailored measures for different actors, including producers, market operators and consumers. To be effective, many of the measures need to be designed with reference to the local social and environmental context. The notion of 'more crop per drop', which is widely accepted, needs to be combined with a strategy that promotes an intended and beneficial use of the goods and services produced. Waste does not have a place in such a vision. In an urbanising world with new relations between producers and consumers, a better understanding of consumer preferences and behaviour becomes essential, as elaborated in Table 1 below (Parfitt, *et al.* 2010). Sound incentive-structures lie at the core of any institutional approach aiming to influence consumer behaviour, be it through information campaigns, taxation of water-intensive food items or waste fees.

Snapshot case: Water saving society in China

China serves as an illustrative example of the challenge of feeding a huge and still growing population under environmental constraints. Rapid economic progress and urbanisation in the nation has increased food supply and demand. By any comparison, increases in food supply have been remarkable, as illustrated in Figure 1.

As a result of economic progress, food security and quality of life have improved for hundreds of millions. Economic growth has, however, intensified pressure on scarce water and land resources (as shown in Figure 2) and brought serious environmental threats along with it. River basins in north- and northwestern China will constitute hotspots of extreme water scarcity within the coming years (Rosegrant *et. al.*, 2002). With much of its production located in the dry North, China is an interesting case to discuss in terms of the need for improved virtual water management even within its own borders. If trends continue, the prospects for sound rural development, food security and the environment will be negatively impacted by water shortages and environmental degradation. Political leadership in China has recognised that sustainable stewardship of natural resources is needed to ensure continuous socio-economic progress. The promotion of a “water saving society” is one of the pillars in official policy (FYP, Ministry of Water Resources, 2010). China’s combination of a precarious water situation, rapid socio-economic development, postharvest losses and determination to promote stable progress for society and the environment, make it an interesting case to examine what can be achieved by improving supply chain efficiency in a nation that must provide food to a vast population with limited natural resources. Unfortunately, few studies have looked into the level of food losses and waste in China today, but figures indicate that between 20-30 per cent of the food produced is lost or wasted (these figures are however uncertain and differ between food items). Smil has argued that by lowering China’s post-harvest losses to around 10 per cent the country could gain 30 Mt of grain a year, which is enough to provide 75 million people with adequate diet (Smil, 2000). This is just one example that highlights the potential gain of reducing food losses and waste in the Chinese context.

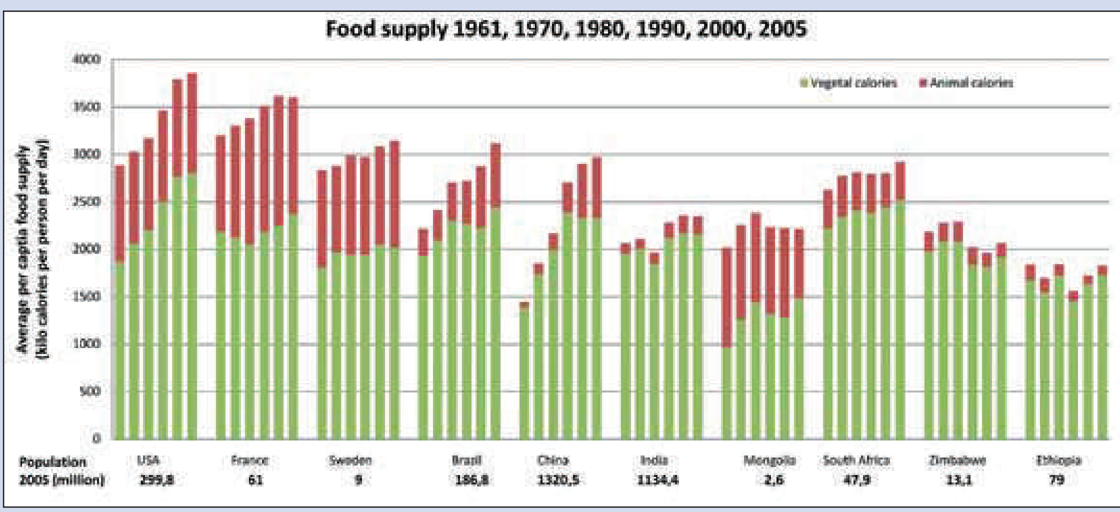

Figure 1. Average per capita food supply in kcal per day, for selected countries and years (Lundqvist 2010, based on Food Balance Sheet statistics, FAO).

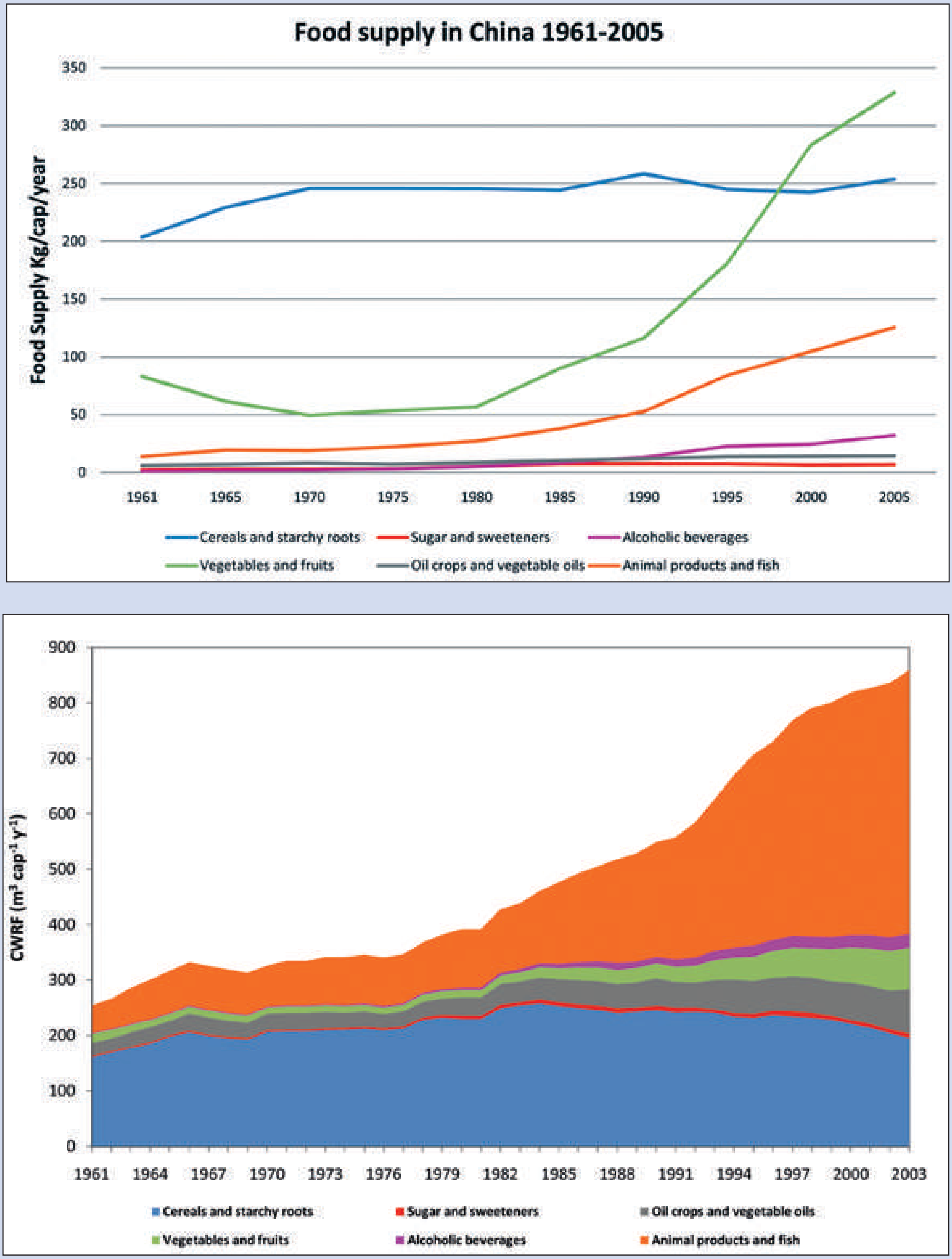

Figure 2. Food supply in China and the associated per capita water requirement 1961-2005 (Lundqvist 2010, updated from Liu, J. *et al.*, 2008)

Opportunities to improve supply chain efficiency

For farmers and consumers alike, there are no real benefits associated with food losses and waste. Although there are costs associated with the reduction of losses (e.g. investments in improved storage and transport), it is a potential win-win option. Reducing losses and waste of food not only saves water (as well as energy and other resources), it also enables farmers to receive income from a larger fraction of their production (Lundqvist *et al.*, 2008). Solutions to reduce losses and waste are relevant from a corporate perspective, from a natural resources use perspective and for society at large. Yet, there is little debate on how different actors could contribute to achieve a more efficient and sustainable food supply chain and the benefits that would be gained by their action. Currently, there is not sufficient analysis on potential water savings gained through improvements in the supply chain. Expanded research in this area would be valuable to guide cost-effective interventions to save water.

It is interesting to note that today businesses are taking a more active role in developing strategies to improve future supply- and value chain efficiency. This is highly relevant particularly for actors with activities located in water scarce regions and in areas where water predicaments constitute a potential business risk. Some actors see for instance improved packaging that can decrease the risk of food waste as an integral part of their corporate social responsibility (Segré and Gaiani, 2012).

Food supply chain collaboration – A way forward?

The underlying factors that cause food losses and waste are significantly different when comparing industrialised countries (where food waste and overeating is the bigger problem) and developing countries (where food losses and undernourishment are more extensive). There is consensus among scholars and decision-makers that these require different approaches. In developing countries and tropical regions, investments in improved storage, transport and cooling infrastructure are important as is increasing producers' access to food processing, packaging and markets, i.e. beyond the local ones. Agricultural commodity producers should be supported to diversify and scale up their production. Both public and private actors have a role to play to ensure that this is achieved. Food waste also needs to be reduced through a combination of

Photo: Digital Vision

policy interventions. In industrialised countries and economies in transition, awareness-raising activities should target consumers, retailers and the food industry (Gustavsson, *et al.*, 2011).

What is required is essentially a comprehensive assessment of the cultural perceptions of food and habits and their impact on natural resources. In rich and affluent societies, people are living in a "culture of abundance" (Stuart, 2009) and in "comfort zones" (Eliasson, 2010). With an abundance of food, consumers are accustomed to choose from shelves burgeoning with subsidised food items, accessible around the clock. This makes it easier and less costly to waste and overeat, and provides less incentive to cut down on waste and to enjoy a sustainable diet. Few realise that the price on the tag of the items in the shop is only part of the real price. Another part is paid by taxes (to cover subsidies), and the environmental costs are left invisible to the consumer.

Moving beyond what is already known, there is a need to strengthen empirical knowledge on the magnitude and the trends of losses and waste of food. Unfortunately, official statistics leave much to be desired (Smil, 2000; Parfitt and Barthel, 2011). Many actors need to contribute to remedy the situation. Businesses, for instance, could provide data and information for part of the supply chain. They are in a strategic position between the producers and the consumers that demand a variety of food items. To the extent possible, information and figures on food losses, waste and potential savings respectively need to be analysed to also understand the impact of waste in water and socio-economic terms. Similarly, attempts need to be made to identify holistic food supply chain arrangements that contribute to water and energy savings. A dialogue with actors in the supply chain on strategies and arrangements that will improve supply chain efficiency therefore needs to be initiated.

Finally, by adopting sustainable diets we can address the paradox of the opposite trends with undernourishment and malnutrition, including obesity (SIWI, IFPRI, IUCN, IWMI, 2005). With a more efficient food supply chain and fairer distribution of the food produced, a water and food secure world is still possible. To achieve this, it is essential to enable a vivid dialogue and promote collaboration between supply chain actors now that "the business of business" no longer is merely "business" (Friedman, 1970).

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Photo: Anne Wangalachi/CIMMYT

Early Warning Systems for Water in Agriculture

By Mats Eriksson

The mounting demand on agricultural systems requires improved knowledge on how to respond to changes in water availability for food production, particularly in semi-arid, sub-humid and monsoonal systems. More land is being taken into production and increasingly in marginal climate zones (Jägerskog *et al.*, 2012), which are often vulnerable to climate variability and change, particularly delayed, reduced or absent rainfall. In addition, some areas in vulnerable climate zones that are used for farming today may suffer from a warmer and drier climate, and not be suitable for agriculture at all times. As a result, the amount of productive farmland per capita is decreasing rapidly (Funk, 2011).

The shrinking availability of land, growing demand for food, and increasingly variable and uncertain climate together limit the buffer margin for failure in food production (Gerten & Rost, 2009). This makes effective Early Warning Systems (EWS) crucial to prevent catastrophic disruptions of agricultural production from occurring when unfavorable changes in rainfall arise, or when irrigation water supplies are unavailable or insufficient. In this chapter, we discuss how EWS can bolster food security by reducing damages caused to agriculture by water scarcity and drought.

A drought EWS is designed to detect the emergence, or probability of occurrence, and the likely severity of drought (WMO, 2006) and then provide warnings on potential threats posed by such weather and climate forecasts. Any EWS, and particularly those for drought, is dependent on long term reliable monitoring of meteorological and hydrological parameters. The ability to use the obtained data for forecasts is fundamental for the EWS to be effective. By providing warnings at an early stage, EWS can enable farmers to adapt and plan to the projected situation in advance and prevent sudden crisis of food insecurity. EWS designed with the purpose to alert farming communities on climate related shortages in water availability, linked to shorter or longer periods of dry spells or drought, are especially important for this purpose and particularly for non-irrigated agriculture. But they are challenging to establish and make functional. These weather phenomena progress slowly, and it is difficult to know if, and when, a warning for water shortages should be announced.

Photo: R. Rossi Marshland, USAID

From warning to response: Establishing an effective end-to-end EWS

The recent drought and consequent famine in the Horn of Africa is a tragic example that powerfully demonstrates why EWS are needed, as well as the challenges faced to make them functional and effective. In fact, several institutes issued warnings on the predicted shortcoming of rains at an early stage. For instance, the Famine Early Warning Systems Network (FEWS NET), set up by the US Agency for International Development to help policy makers prevent humanitarian disasters, issued alerts several months ahead of the actual drought based on analysis of global scale climate systems (El Niño/La Niña and Indian Ocean temperatures) and the food security situation at the time (Funk, 2011). The warnings did not trigger much action. Even when the absence of rains proved the warnings to be correct, governments and the international community still did not react. It was not until the crisis hit the media and news channels ran stories showing desperately malnourished children that they took action. One reason for the slow response was political fear of financial and reputational risks if the warnings proved to be wrong (Hillier & Dempsey, 2012). Another reason may have been that international actors were apprehensive about being perceived as overly interventionist and, in the process, undermining the capacity of local communities to cope with the drought. In addition, in some regions such as the Horn of Africa, there is a "drought fatigue", which slows the response time.

The 2011 crisis in the Horn of Africa highlights the fact that any EWS has to be an "end-to-end system". This means that it should encompass a chain of activities involving data gathering, compilation, analysis, forecast, decisions, communication, and finally enable a response. Although both are essential, perhaps the largest challenge to creating a functional EWS pertains more to creating communication channels rather than technical matters. Both the climate service providers and the climate service users need to reach out and learn from each other how to transmit and use knowledge more effectively in order to prevent crisis and save lives (UN/ISDR, 2006). Thus, the early warnings, or other related information such as forecasts, need to be tailor-made to the recipient and as such will look different if it is targeting the science community, politicians and decision makers, or farmers. In addition, good governance of the system and political will to take action under uncertainty are crucial factors to avoid climate related disasters and food insecurity.

Current status of climate services and EWS

The collection, storage and dissemination of meteorological and hydrological data are a major task that involves many institutions and centres operating on global, regional and national levels, often under the supervision of the World Meteorological Organization (WMO). Climate information on the global and regional level is based on large scale atmospheric models and remote sensing technology. National level institutions strongly rely on ground-based meteorological observation networks. These have been deteriorating in the last decades, particularly in the tropics, in remote areas, and in least developed countries. Unfortunately, these are places where this kind of information is probably needed the most. Finding stable financing to build and maintain these networks is often a great challenge as governments must be convinced of the importance of this data, its potential service and the value of preemptive action. Nonetheless, themes like food security, water availability and health are the primary targets of policies and are greatly dependent upon effective and efficient climate services in order to deliver results. Demonstrating the benefits of using climate services in these prime target policy areas is essential to enhancing the financial security of National Meteorological and Hydrological Services (NMHS) as well as of global atmospheric and spatial programmes.

Global meteorological climate information systems have also developed considerably during the last decades. The Global Climate Observation System (GCOS), a joint undertaking of WMO, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, UNEP and the International Council for Science (ICSU), is now able to provide comprehensive information on the total climate system. It includes both on the ground and remote sensing components and is intended to meet the full range of national and international requirements for climate and climate-related observations. It constitutes the climate observing section of the Global Earth Observation System of Systems (GEOSS).

Few systems exist worldwide to provide early warnings of droughts (Grasso and Singh, 2011). FAO's Global Information and Early Warning System on Food and Agriculture (GIEWS) (FAO, 2009), the Humanitarian Early Warning Service (HEWS) (established with the help of the World Food Programme) and the Benfield Hazard Research Center of the University College London are the main global programmes that provide early warnings on natural hazards, including drought. The GIEWS provides information on countries facing food insecurity through monthly briefing reports, which includes drought information. The HEWS collects drought status information from several sources, and the Benfield Hazard Research Center produces monthly maps of drought conditions. However, the ways and means to use these information sources on the national level determines whether early warnings become successful or not.

On a regional scale, the US based Famine Early Warning System (FEWS NET) provides monthly reports on droughts and famine conditions for Eastern Africa, Central America and Afghanistan. Similar services are available for North America (the North American Drought Monitor, including US, Canada and Mexico) and China (Beijing Climate Center of the China Meteorological Administration).

WMO, in collaboration with the UNCCD, is implementing two initiatives addressing drought. A High Level Meeting on National Drought Policy (HMNDP), planned for March 2013, will address the need to develop national drought policies. The Integrated Drought Management Program (IDMP) will contribute to the global coordination of drought-related efforts of existing organisations and agencies.

On the national level, National Meteorological and Hydrological Services (NMHS) provide platforms for weather and climate information. The capacities of each NMHS is pivotal for the ability of a country to assess information, and to issue warning and alerts when needed. It provides one of the most crucial links in the end-to-end chain between climate information producers and users (Srinivasan *et al.*, 2010). The NMHS also has to tailor the information to fit the need and understanding of the end-users. WMO has also established Regional Climate Centers (RCCs) that gather and distribute relevant climate information to the global centers and to the NMHS. In most regions of the world Regional Climate Outlook Fora (RCOF) are held on a regular basis to bring climate information providers and users together. At all levels, targeted capacity building to actors in each part of the end-to-end EWS is essential to enhance the gathering, production and distribution of climate information as well as for the understanding and efficient and effective use of the information.

Priorities for the future

Recent advances in information and communication technologies, improved space-based technologies for monitoring weather and climate, and stronger skills in providing weather forecasts and climate scenarios have greatly enhanced the possibilities to establish well functional EWS for water in agriculture. There are still, however, major challenges to overcome in most regions of the world.

Photo: ILRI/Dorine Adhoch

Monitoring of rainfall, soil moisture and other hydro-meteorological parameters provides the basis for the development of water availability scenarios and forecasting of droughts. A combination of field based and remote sensing techniques can be used to provide the information that forms the cornerstone for the assessment of potential upcoming droughts upon which any warnings to the farming and other communities will be based. Changes in climate and its variability are long term processes which also demand long data series. Therefore, it is crucial to continue measuring meteorological parameters and ensure that there are no interruptions in data series. A gap in data cannot be repaired in aftermath, and the cost to maintain data series is small compared to the value of this information when society needs to prepare for climate-induced hazards.

In addition, existing approaches to provide early warning on drought must be improved. Due to their complex nature, several indicators are required for drought monitoring and early warnings. Although all types of drought are originally due to a shortage of rain, monitoring only this parameter is insufficient to assess the severity and impacts of a drought (WMO, 2006). Precipitation must be integrated with other climatic parameters.

For large parts of the world suffering from droughts, EWS are often inadequate, non-functional or non-existent. The most critical component for a EWS is its ability to ensure effective communication of information throughout the end-to-end chain. Here, the importance for decision makers on different levels to take action on early warnings is crucial. Decision makers on higher levels must understand the costs and potential consequences to not responding early and committing resources on the basis of forecasts, and they must be informed on the risks posed by waiting for certainty (Hillier and Dempsey, 2012). Early action generally involves taking a modest financial cost, while acting late risks the loss of lives and livelihoods and ultimately spending more money on response. Waiting until the emergency is fully established means that the risks and consequences of inaction are borne by vulnerable people themselves.

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Photo: John MacRobert/CIMMYT

Land Deals: A ‘Green Revolution’ in Global Food and Energy Markets?[1]

By Anders Jägerskog and Ana Cascão

The Global Sustainability Panel (GSP, 2012) states that “While investment in the agricultural sectors of low-income countries is urgently needed, the new trend of land access deals often compounds local, well-established and persistent constraints faced by the poor in obtaining access to land and water.” The GSP report is one of the first to explicitly point out the link between investment in land and access to water on a global scale. Beyond the issues of access to water and land, politics and global market dynamics further drive the intensity of this nexus and often override local priorities and rights (Jägerskog *et al*., 2012). Land deals in Africa, Latin America and Southeast Asia for the production of food, cash-crops and biofuels has increased in recent years, and quickly escalated after the rise of food prices in 2007-2008. That crisis, coupled by water scarcity in countries in the Middle East and North Africa region as well as in parts of Asia, caused countries relying on food imports (and the ‘virtual water’ embedded within them) to diversify risks to mitigate the impacts that future food price hikes may have on their populations. The strategy pursued by these food-scarce countries has been to invest in land for the production of food crops in countries well-endowed with land and water resources (Von Braun, J. and Meinzen-Dick R, 2009). Can this mean that the world might be experiencing a new ‘green revolution’ (dramatic increase on agricultural production) similar to the one of the 1960/1970s, and for the first time in sub-Saharan Africa’? It is too early to draw conclusions, but what is already possible to observe is an increased international and domestic interest in farmland by governments and private companies, primarily in Africa and Latin America (World Bank, 2011). The proliferation of land investments have raised concerns over their impact on domestic food security

[1] This article partly builds on the SIWI report: Jägerskog, A., Cascao, A., Hårsmar, M. and Kim. K., (2012), ”Land Acquisitions: How Will They Impact Transboundary Waters?”. Report Nr. 30, SIWI, Stockholm

Photo: Erik Forhammar

in host countries (Matondi *et al.*, 2011) and on the implications they have on customary land uses and the rights of local populations, which in some cases are feared to be ignored during large scale agricultural and hydropower developments without appropriate dialogue and agreement (Deininger, 2011).

To date, research of land acquisitions has largely focused on the terms and conditions of the contracts for investment and leasing of land, which are often ot made public or are unclear (Cotula, 2012). The potentially significant effect that these investments will have on water resources, at the local, national and transboundary level has not yet been adequately analysed. This chapter outlines some of the key questions as they relate to the land-water nexus and also discusses potential repercussions for food security.

Land, food and water

As outlined in the introductory chapter to this publication (Jønch Clausen, this volume) and also underscored by the International Food Policy Research Institute (Von Braun, J. & Meinzen-Dick R, 2009) food security is an increasingly global problem. It also is becoming a more important political priority of increasing complexity as the prospects for supplying food are strongly impacted by population growth, the effects of climate change, new technologies, sharply increasing energy demands and shifts in consumption patterns. Thus, the increasing land acquisitions seem logical, at least from the investors' perspective. If you cannot obtain food security through supplies at home – due to scarcity of fertile land or water resources – and do not trust a volatile international food market then the investments in overseas farmland appear as a natural step. However, critical questions on their impacts on land rights, water allocation and food market mechanisms need to be investigated. An important issue is also the costs, benefits and trade-offs that arise when arable land is used for energy production (to create biofuels) rather than food production. Another key concern is the potential negative impacts land investments may have on the food security and customary rights of local farmers and pastoralists.

In addition to potential conflicts around land and water occurring in the countries where investments are being made, transboundary water issues will also come to the fore. The investors will need reliable access to water for irrigation of its crops on the purchased or leased land. This directs attention to the management and allocation of internal water resources of the countries as well as their shared transboundary waters (Jägerskog *et al.*, 2012).

A land investment is a water investment

Few of the contracts on agricultural investment and land acquisition are made available to the public. Lack of transparency and non-disclosure of agreements between parties have been obstacles to investigate land deals on water. Cotula (2011) reviewed 12 land investment contracts in Cameroon, Ethiopia, Liberia, Madagascar, Mali, Senegal and Sudan. The only consistent trend the contracts show on how they address water is inconsistency. In some cases water is taken into account and the terms of access is specified. According to a contract between the government of Mali and the Libyan government, for example, the investors are granted water without restriction during the wet season (June-December), but they are obliged to grow crops which require less water during the dry season (January-April). Another contract signed between the governments of Sudan and Syria allows the investors to access water resources from the White Nile, as well as groundwater resources. Water is not, however, mentioned in other contracts. It seems to be taken for granted that water comes along with the land.

Some investors clearly view land investments as a water investment, in particular those experiencing shortages at home. The new investors including India, China, South Korea, Jordan, Saudi Arabia, UAE, Kuwait and Qatar are either experiencing water shortages or are under severe water stress, at least in parts of the countries. India and China are experiencing water shortages because of the rapidly increasing utilisation of their water resources for agricultural, industrial and domestic uses, and related environmental degradation. Increased prosperity and population growth in both nations, and elsewhere in fast growing economies, have required them to fill its freshwater needs through virtual water trade. Investing in farmland overseas is the other or complementary alternative to meet food demand at home.

What water will be used? Blue, green, transboundary?

Approximately 40 per cent of the world's population lives in transboundary river basins, and 263 international water basins account for about 50 per cent of global land area and 40 per cent of freshwater resources (Wolf, 2002). The hotspot countries for land deals are mostly located in transboundary water basins such as the Mekong, Nile, Niger and Zambezi. The governments of Sudan, South Sudan and Ethiopia have attracted foreign investors to their respective countries because of the 'abundant' land and water resources available. Though the arrival of these investors and the utilisation of the transboundary water from the Nile Basin has not been a source of conflict yet, their implications after they are fully implemented may spark future diplomatic conflicts with the downstream neighbours. In the Mekong River basin, China, the upstream riparian state, has been involved with the Economic Land Concession of Cambodia, the downstream riparian state as well as the country most reliant on the basin. Unlike the case of the Xayaburi dam in Laos, which is under negotiations by a Thai developer and put on hold (Hookway, 2011), the water use in foreign land concessions in Cambodia and Laos has not been a topic in intergovernmental dialogues in MRC (Baird, 2011; Saracini, 2011).

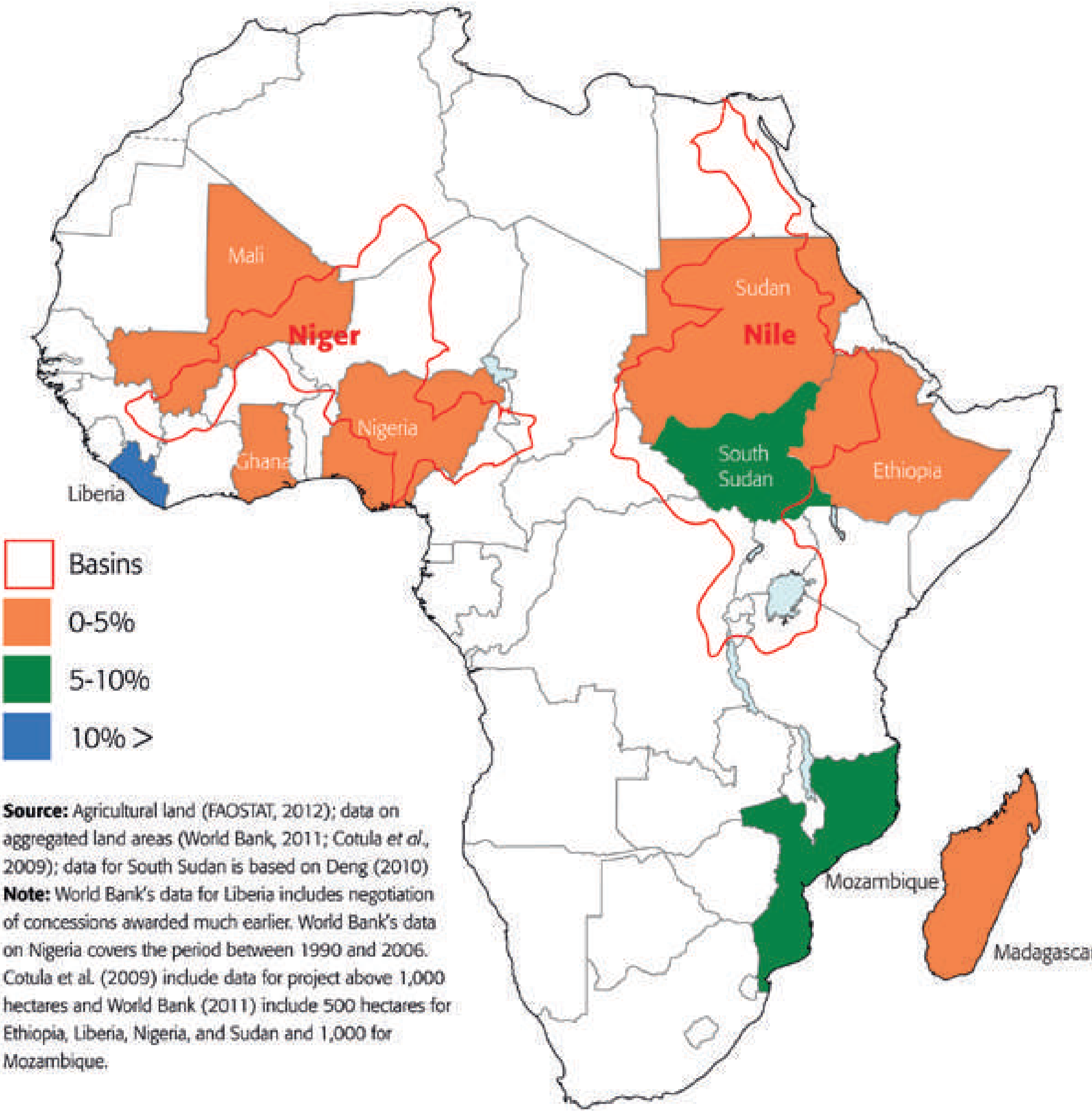
In sub-Saharan Africa, 96 per cent of the cultivated land is currently rainfed (FAO AQUASTAT, 2012). Rainfed agriculture utilises 'green water', i. e. the water that is in the soil moisture. 'Blue water' refers to the water available in rivers and in aquifers. Globally, rainfed agriculture is the most common practice for food production, especially in developing countries. In many developing regions, a lack of irrigation facilities and hydraulic engineering structures limits the use of blue water. If the investors are allowed to construct irrigation facilities and other infrastructure in the leased farm land, blue water use would increase. This would increase agricultural production in the region, and likely will increase the use of transboundary water resources (Jägerskog *et al.*, 2012).

Regulations and institutions: Can they help overcome the grey area?

It is too early to judge if the current land deals will contribute to increased food productivity, food security and trade at the global scale. It is also difficult to assess at this time whether the positive impacts (infrastructure development, jobs, technology transfer, etc) will outweigh the negatives impacts at the national and local levels in the countries where farmland is being leased.

The regulatory environment that oversees land deals is currently filled with several grey areas. There is a lack of both clear regulations and institutions that could deal with potential conflicts of interests between the different users of land and water resources. The adoption of principles at the global, regional and national levels could help ensure that land deals provide

Large-scale land areas acquired in selected countries as percent of total agricultural land areas, 2004-2009



Source: Agricultural land (FAOSTAT, 2012); data on aggregated land areas (World Bank, 2011; Cotula *et al.*, 2009); data for South Sudan is based on Deng (2010)
Note: World Bank's data for Liberia includes negotiation of concessions awarded much earlier. World Bank's data on Nigeria covers the period between 1990 and 2006. Cotula et al. (2009) include data for project above 1,000 hectares and World Bank (2011) include 500 hectares for Ethiopia, Liberia, Nigeria, and Sudan and 1,000 for Mozambique.

a development opportunity with benefits for all the parties involved.

A number of international initiatives have emerged to develop policies aimed at making large scale agricultural investments environmentally, socially and economically sustainable. FAO, IFAD, UNCTAD and the World Bank have agreed upon seven principles for "responsible agro-investments" (RAI, 2010) (See box 1).

In addition, the "Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security" adopted by FAO in May 2012 barely mentioned water. While water is not explicitly mentioned in the RAI principles it is inherent in almost all them. It would be useful if water was also recognised in the international principles for responsible agro-investments as well as more clearly spelt out in the voluntary guidelines. Otherwise, there is great risk that water rights, and impacts on water quality, may be forgotten or ignored.

The adoption of legal principles and mechanisms could also help increase transparency. Regulations related to the current and future land deals could mitigate the negative impacts the deals can have on the local populations and the environment. Regional institutions, such as Regional Economic Commissions (RECs) and River Basin Organisations (RBOs, could also play an important role, in particular when the water resources that are used on the lands come from transboundary sources. However, the development of the national land and water resources for the national socio-economic development of the countries is still in the domain of sovereign states, and it is not expected that this will change. Taking the potential transboundary effects of the land deals into account could provide an opening for riparian states to delegate some advisory and coordination functions to the RECs and RBOs to promote integrated management approach to land and water resources, without countries relinquishing their sovereign rights. Agricultural development, namely through the expansion of irrigation, had been often excluded from the agenda of these institutions due to its politically sensitive character.

Box 1:
Seven principles for "responsible agro-investments" (RAI, 2010)

Principle 1: Existing rights to land and associated natural resources are recognised and respected.

Principle 2: Investments do not jeopardise food security but rather strengthen it.

Principle 3: Processes for accessing land and other resources and then making associated investments are transparent, monitored, and ensure accountability by all stakeholders, within a proper business, legal, and regulatory environment.

Principle 4: All those materially affected are consulted, and agreements from consultations are recorded and enforced.

Principle 5: Investors ensure that projects respect the rule of law, reflect industry best practice, are viable economically, and result in durable shared value.

Principle 6: Investments generate desirable social and distributional impacts and do not increase vulnerability.

Principle 7: Environmental impacts due to a project are quantified and measures taken to encourage sustainable resource use while minimising the risk/magnitude of negative impacts and mitigating them. (RAI, 2010).

Forming a fair land market

The market for farmland and water will become an increasingly large part of the global political economy and the global food and energy markets. Current and future 'land deals' can potentially contribute to an increase in agricultural production and help grow more food, cash-crops and biofuels. The question is: who is going to benefit from this 'green revolution'? Asymmetric power relations between regions, countries, and economic sectors are expected to play a role in determining the benefits and costs that land and water deals will bring for the different parties. Regulations are crucial to ensure that all parties gain a fair deal and that the land and water resources are used efficiently. Through the adoption of international and regional principles and delegation of powers to regional institutions, it is possible to better protect the customary rights of local populations, decrease the negative impacts of the deals on the environment and endorse basin-wide integrated land and water management. This would promote fairer terms of trade between the countries and corporations investing in land and the host countries and local populations. It would also help ensure that those investments enhance regional and national food security in Africa, Southeast Asia, Latin America and globally.

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Feeding a Thirsty World

Challenges and Opportunities for a Water and Food Secure Future

This report presents the latest thinking and new approaches to emerging and persistent challenges to achieve food security in the 21st century. It focuses on critical issues that have received less attention in the literature to date, such as: food waste, land acquisitions, gender aspects of agriculture, and early warning systems for agricultural emergencies. It also offers perspectives on how to better manage water and food linkages.

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