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WATER FOR FOOD AND FARMING

Introduction

The demand for water for food production is rising rapidly. Although during the last 50 years food production met and even surpassed population growth, the forecast for the future shows a different picture. The combination of key scientific developments responsible for the green revolution, and large scale investment in water infrastructure such as dams and irrigation systems played a significant role in the success of meeting food demand during that period. However, today's world is witness to an unprecedented demand for food brought on by rising populations and rising incomes in developing countries. We are now aware that many of the successes of the past came at the expense of the environment and equitable food distribution and still for some 800 million people food security is elusive. For many of the world's poor water is not available or not accessible due to the lack of physical or institutional infrastructure. Moreover, a continuation of the current model of agricultural water management will have dire consequences on the environment and may not be appropriate to help alleviate poverty.

The need for a fresh perspective on water and food management is imminent in light of the concerns of rising incomes and changing diets, urbanization, and population growth in developing countries.

Challenges of water resource management for food security

The water cost of food production
The largest demand for water comes from agriculture and human use. The challenge of producing food for the world's population is clearer when understood in terms of the vast quantities of water required to grow crops.

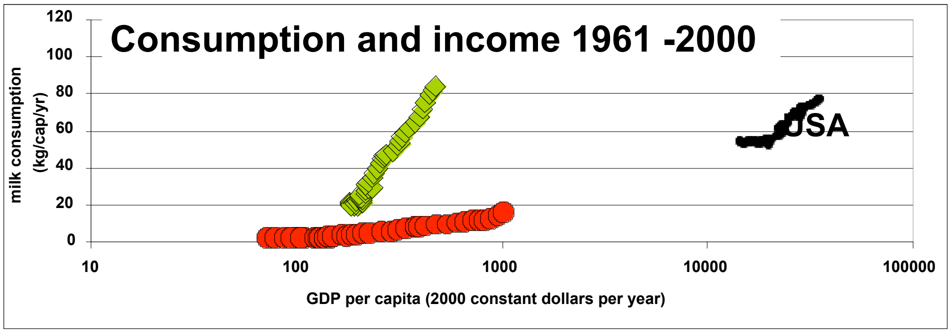
It is estimated that to meet global food and fiber demand crops evaporate between 6,800 km3 and 7,130 km3 of water annually (Postel, 1998; Rockstrom et al., 1999; Molden et al., 2007b). This is equivalent to more than 3,000 liters per person per day, an order of magnitude larger than the quantity needed for drinking (2-5 liters) and for domestic purposes (20-300 liters). Water needed to grow crops comes from rain falling on agricultural lands, supplemented by irrigation where needed. Most of the crop water requirements, some 80%, are met directly by rainfall. For the remaining 20%, some 2,650 km3 of water are withdrawn from rivers and lakes, accounting for 70% of all water diversions for human purposes. This makes agriculture the biggest water user by far. Some regions rely heavily on irrigation (e.g., North Africa, South Asia, North China Plains), while in other regions agriculture is mainly under rain-fed conditions (e.g., Latin America, Europe). With increasing urbanization, domestic and industrial water needs are expected to rise faster than agricultural water demand but, according to most projections in the near future, agriculture will remain the largest user by far. In semiarid and semi-humid areas, where most of the population growth will take place, an increasing part of the crop water requirements is expected to be met by full or supplementary irrigation.

Already there are signs of growing water scarcity, particularly in some important agricultural areas in the world, such as declining water tables in the western USA, North India, Pakistan, North China, Mexico, and the Mediterranean, among others, (Shah et al., 2007) while dried-up rivers, such as the Yellow river in China, the Krishna in India, Syr Darya in Central Asia, the Colorado in western USA and the Murray-Darling in Australia no longer discharge to the sea for extended periods of time (Molle et al., 2007). Climatic change may aggravate water shortages in these and other areas.

Cereal demand projections range from 2,800 to 3,200 million tons by 2050, an increase of 55–80% from now, particularly to feed livestock. Meat demand projections vary between 375 and 570 million tons by 2050, an increase of 70–155% also from today. Sugar, oil, vegetable and fruit demands are also projected to increase substantially (Lundqvist, de Fraiture and Molden, 2008).

Changing Diets and the demand for water

As income levels rise, food habits change in favor of more nutritious and more diversified diets. Higher incomes correspond with a change in eating habits towards higher calorific and more nutritious food. Generally, this leads to a shift in consumption patterns among cereal crops and away from cereals towards livestock products and high-value crops such as fruits, vegetables, sugar and edible oils (Rosegrant, Cai and Cline 2002; Pingali 2004). Although there are many factors that point to changes in the demand for food and feed, projections for future demand indicate that by 2050 cereal demand could range from 2800 to 3200 million tons. This is an increase of 55% to 80% from present consumption rates. The demand for meat, which is highly related to rising incomes, is estimated to rise to between 375 and 570 million tonnes by 2050, which is 70% to 155% of consumption rates in 2000. Also the demand for sugar, oil, vegetable and fruit demand is projected to rise substantially. The changes in diet have important implications for agricultural water use. Livestock products and the production of sugar and oil typically require more water per unit output than staple grains. Without improvements in productivity crop water requirements may increase as much as 70 to 110% by 2050 (de Fraiture et al 2007).



India

USA

Milk

China

Climate Change

The effects of climate change is particularly important for agricultural water. Present and future availability of water is increasingly determined by changing precipitation patterns, temperature levels and other climate related changes. These impacts need to be incorporated into plans for water development infrastructure in order for human demand to adapt to the changing availability of water resources. Strategies will also need to be developed in order for communities to adapt to these changes. For poor farmers living in rural areas, investments into construction of water storage and control will need to be made. At the larger policy level, the impacts of laws and regulation to mitigate greenhouse gas emissions will also need to be examined with respect to their impact on water. For instance, the promotion of biofuels under the Clean Development Mechanism and other such solutions although important measures that can help reduce the impact of climate change, can also have a detrimental impact on land and water resources (Zomer et al, 2008).

Volatile food and fuel prices

Advances in agriculture and water development have contributed to a steady decline of food prices in the past two decades, until very recently. The years 2007 and 2008 saw a sharp rise and subsequent fall in the price of major staple grains. Volatile food prices have a serious impact on poor food importing countries and poor families who spend most of their incomes on food. The rising price of food is linked to, among others, fluctuating energy prices and the recent pressure to find alternative energy sources. This has increased the demand for water and is changing the pattern of water allocation. In addition, the cost of pumping groundwater, which is a major source of water for agricultural production, has risen due to spiking energy prices thus making an impact on production. Rising energy prices also limit the use of alternative sources for irrigation, such as desalinated water, as all of these processes are dependent on energy. The cost of fertilizer and oil based inputs to agriculture are also affected by energy price rises which in turn affect the cost of food. Other reasons behind rising food prices relate to the rising demand for food, volatile markets, bad harvests due to climate change and natural disasters and the lack of investment in the agriculture sector. Although there are differing views on how much of a role each of these factors have played in contributing to food price increases, few caused such a heated debate as biofuels.

The water footprint of energy crops

The world's industrial and emerging economies are dependent on diminishing fossil fuels. This has led to an impetus to discover new ways to produce energy and meet fuel needs. Large investments are currently being made in agriculture and water for the production of crops that can be used to produce biofuels. Biofuel production is fast becoming a major trend across the world will have huge implications on water and land resource management.

At present, biofuel crop production constitutes less than 2% of the total amount of land that is being cultivated in the world. Of this amount, only 1% of water is being evaporated by biofuel crops. Although it is unclear as to the extent that biofuel crops will be grown, many countries have set ambitious targets for their production. These have been set amidst fears of depleting energy sources and rising oil prices—in India 20% of fuel for transport is meant to be drawn from biofuels by the year 2017. While in other countries, initial positive reactions to the promise of biofuels was curbed by environmental concerns, rising food prices and food insecurity. The EU placed a ceiling on the amount of transport fuel it would replace with biofuels to 6% (Directive 2003/30/EC).

Energy crops are large consumers of water—the water footprint of biofuel crop production is about 40 to 70 times larger than fossil fuels (Gerbens-Leenes et al, 2008). Hence the evaporation from crops that is required to produce biofuel is much larger. It is estimated that to produce 1 litre of biofuel, between 2500 and 3500 litres of water will be evaporated by the crop (de Fraiture et al 2008). The same quantity of water is required to produce food for one person's daily intake. Although biofuels can be produced by plants that use less water, such as grasses and trees, there is not a lot of research on the water productivity of these crops. i.e. how much can be produced with the least amount of water.

At present, estimates for the amount of water that will be used for biofuel production ranges from conservative estimates of 1000km3, to the highest being around 11,700 km3, both of which incorporate trees and grasses.

Pathways to increased productivity

The rise in food prices has shown us that there is a need to focus greater attention on agricultural productivity. A renewed emphasis on agricultural water management is now imminent following a long period of stagnating investment in agriculture and irrigation infrastructure across Asia, and varied results from investment in Sub Saharan Africa.

Increasing water productivity

Water development or investments in infrastructure to improve delivery and access to water for agriculture from the 1950s onwards played a large role in the improvements in food production that were also seen over that period. Statistics from the FAO indicate that between 1961 and 2003, the total area under irrigation expanded from 139 to 277 million hectares. These developments contributed to a reduction in the cost of food in the 1980s and 1990s. Despite current demands and the new challenges there are significant opportunities to improve the productivity of water and be more efficient in food production while ensuring that enough water is left for the environment (Molden et al., 2007b). Improving the agricultural productivity of rain-fed regions in addition to improving the water productivity of irrigated agriculture can help to balance out the requirement for further development of water resources (Molden et al 2000; Rosegrant et al. 2002, Rockstrom et al. 2003). Research from the Comprehensive Assessment of water management in Agriculture shows that about 50% of the water required for food production can be met by improvements in water productivity (de Fraiture et al, 2007). This would require a change in practices to include more water efficient methods of irrigation such as water harvesting, supplementing irrigation, precision irrigation and methods for soil-water-conservation.

Additionally, improvements in other areas such as soil fertility, better pest and disease control as well as to improve markets and agricultural policies can also improve agricultural productivity.

Different pathways to productivity exist for different regions of the world. Due to the large extent of irrigation being practices in South Asia (over 50% of the area under harvest is irrigated but produce low yields), studies that have analysed different scenarios show that there is great potential to improve the performance of irrigation in these areas. It is estimated that of the additional food required to meet demand in 2050, three quarters can be met by improvements in productivity. All of South Asia's additional demand for cereal can be met purely by improving yield though irrigation performance, although there will be some additional water requirement. However, for other regions such as the Middle East and North Africa and countries belonging to the OECD, the potential for this degree of productivity is much less.

In the regions where crop water productivity is high levels of yield do not necessarily translate to water productivity increases. In arid regions or areas where water reuse and recycling is practiced, the losses and inefficiencies are lower (Seckler et al, 1998). However, in such cases there maybe a negative consequence for water quality as agrochemicals used to improve productivity lower the quality of water (Nangia et al., 2008). Options such as the breeding of new crop varieties have played a significant role in improving harvests and therefore water productivity however these are not seen to make a large impact on water productivity in the future. Importantly, among the promise of second generation genetically-modified crops are those that are capable of resistance to abiotic stress and capable of growing in arid or drought conditions (Nuffield Council on Bioethics, 2003, FAO, 2007). One other important factor that is imperative to improving water productivity is the presence of enabling institutional conditions, in the form of various kinds of support that will help farmers to be better managers of water (Molden et al, 2007a).

Despite being a fairly complex undertaking, improving water productivity and therefore irrigation performance can be achieved with the right set of policies and incentives to encourage and support farmers.

Addressing environmental concerns through rainfed agriculture

Environmental concerns often come into the discussion on ways to increase agricultural productivity. Many problems relating to water can be attributed to large scale mono-cultural production, which is what agricultural production essentially creates. However, this does not mean that other ecosystem services cannot be accommodated within agricultural systems provided that they are multifunctional (Falkenmark et al. 2007). Water management approaches that are ecosystem-based and take into consideration biodiversity and habitat do not necessarily constrict the agricultural production. High yield can be achieved while also limiting environmental degradation through efforts that improve water efficiency, quality, and also assist in carbon sequestration (Pretty et al, 2006). The positive impact of such systems can also improve the livelihoods of farmers downstream who would benefit from better water quality. Examples of these include terraced fields which in climates with monsoons can reduce soil erosion, help to recharge groundwater, provide flood retention land, improve filtration and also serve as a unique biotope for plants and animals. Upgrading rainfed farming through investment in water harvesting techniques also has great potential to increase agricultural production. As these techniques are low-cost and have less environmental impact, many argue that they require much less investment and point to evidence that shows some of the highest yields being recorded from rainfed agriculture in temperate regions (de Fraiture, Karlberg and Rockstrom, 2008). Two issues that have affected the widespread support of water harvesting is the difficulty in its upscaling – mainly due to the amount of labour involved, low returns from agriculture, and lack of access to markets. For an individual farmer, relying solely on rain brings many risks, particularly in the wake of increasing climate variability. However, water harvesting techniques can be used to help farmers in times of drought or even during shorter dry spells. Since most farmers who rely on rainfed agriculture constitute some of poorest small holders, investment in upgrading rainfed agriculture through rainwater harvesting can help preserve livelihoods and improve yields offering one more solution to address food demand in the future.

International trade

Due to the large quantities of water required for agricultural production international trade in food crops can impact how individual nations manage water demand. The phrase 'virtual water' refers to the quantity of water used to produce agricultural products that are traded between countries. When a water scarce country imports agricultural commodities from a country that does not suffer from scarcity, it is able to 'save' the water it has not used to produce those same crops. A good example of a virtual water trade is the importing of grains from the United States, by Egypt which suffers from water scarcity—in 2000, Egypt imported 8 million tonnes. Had it produced this grain itself, about 8.5 million m3 of water would have to be used for irrigation, which constitutes about a sixth of the annual volume released from Lake Nasser. Some of the largest producers and exporters of grain, USA, Canada, France, Australia and Argentina are able to produce large quantities of the crop under rainfed conditions, therefore relying less on irrigation. On the other hand, the biggest importers of grain, Egypt, Mexico, Iran, Saudi Arabia and Algeria, rely solely on irrigation for their production. Figures for 1995 show that without the trade in cereals the demand for irrigation water would have risen by 11% (de Fraiture et al 2004, Oki et al 2003).

International trade is thus seen as a policy tool to address water scarcity and global productivity. An 'ideal virtual water trade' would occur between a country where there is an abundance of water resources which leads to a high production ability and a country where there is water scarcity. This would mean that North America, Latin America (particularly Brazil and Argentina), Northwest Europe and Eastern Europe (particularly Russia and Ukraine) would export to North Africa, the Middle East, Indian, Pakistan and China. In such a scenario, the importing countries would aim to improve crop yields by 25%, and maintain their irrigated and rainfed regions. For Sub Saharan Africa, the focus would be on improving their rainfed cultivation and import of food crops would be small to improve the self-sufficiency of the region. Areas with serious water shortages within the importing countries would reduce their production of cereals and shift towards producing higher value crops such as vegetables which may also be more labour intensive. The exporters would aim to improve rainfed production of cereals such as soybeans, roots and tubers by an average of 60%. Where there is potential, the exporters would also expand their total area of rainfed cultivation.

Although international trade in agricultural products and commodities is in part driven by water scarcity and the amount of land and labour available, water is unlikely to be a main driver of trade in the future. One of the critical determinants of the amount of trade a country can engage in is foreign exchange, which is needed to pay for imports and can only be earned by selling exports or acquired through loans and grants. Many low income countries are not in the position to import large quantities of food from other countries due their lack of foreign exchange—this is the case for many sub-Saharan countries. The recent food crisis and price fluctuations have exacerbated the terms of trade for many importing countries. As trade also requires the added environmental and financial cost of transporting goods, poor countries that are dependent on a few export goods often find themselves in a weak position. Early in 2008 when prices of rice, wheat and maize rose sharply the main exporters such as Viet Nam, Thailand and India responded by restricting export amidst fears of meeting national food demand. In view of these market uncertainties many developing countries opt for a certain level of self sufficiency in food production and for that, development of water resources can play a critical role.

International trade can operate as a short term solution to address water scarcity and meet food demand however its viability as an option for poor countries is contingent on the terms of trade, the costs involved, in addition to national priorities.

Reducing food wastage

The increasing consumption of meat and shift to diets based on meat from grain-fed cattle has increased the demand for water significantly. A vegetarian diet requires 2000 litres of water a day to produce, whereas a non-vegetarian diet requires 5000 litres, more than twice the amount (Renault and Wallender 2000). The potential to reduce the demand for water through policies that affect food consumption patterns exists, however it is very difficult to influence or change food habits. At present, most efforts to reduce water use are focussed on food producers rather than food consumers.

One other option to reduce water use in food production is to limit the wastage of food. It is estimated that about 40 to 50% of agricultural produce is lost at different stages during the chain from cultivation of the crop to its consumption. At the field scale, pathogens and pests can result in between 20 and 40% of the harvest being lost. Transportation of the produce and processing can result in about 10 and 15% of loss, although at this stage the losses could reduce the economic value of the food product between 25 and 50%. At the retail and consumption stage, considerable losses also occur as perishable, unused food is discarded. The quantities of food lost at this stage vary greatly between countries—in the US about 25% of fresh food and vegetables is not consumed, while in developing countries it is about 10%. Although the estimates for the quantity of food wasted vary, there is still great potential to reduce wastage and thus save water.

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