TREND OBSERVATORY ON WATER

TREND SHEET

Thirsty food systems – How can we feed the world with limited water resources?

#4

The state of food security and nutrition is alarming – and so are food systems' impacts on water security. A number of food system trends are threatening the state of water resources, but there are also some promising advances in reducing water demand.

Read this Trend Sheet to learn about food system trends and their impacts on water and to get insights on more effective use of water for achieving food security.

Content

Why this Trend Sheet?

What trend do we observe?

With population growth and economic development, global demand for food is expected to increase by around 50% between 2010 and 2050. At the same time, a change in preferred diets from largely cereal based diets towards higher consumption of meat and dairy products is observed.

Why is this trend important for water practitioners in development cooperation?

With agriculture accounting for approx. 70% of water withdrawals globally, food systems have major direct impacts on water resources. But they also affect the climate and relevant water-related ecosystems. More sustainable food systems are therefore essential to meet SDG 6.

What is new?

The need to adopt a systems perspective in efforts to ensure water and food security is gaining ground in research and practice. Latest research on water productivity, increased availability of environmental data, and better understanding of the complex interlinkages on various scales provide insights on how water could eventually be used more effectively to ensure food and nutrition security.

Summary

Water is critical for ensuring food security and sustaining food systems. Vice versa, food systems need to become more sustainable if SDG6 is to be achieved in a near future. A number of trends in food systems can be observed that are likely to have negative impacts on water resources, such as trends towards increased consumption of meat, land grabbing, and the enormous amounts of food that are lost or wasted. Nevertheless, there are also some trends towards more sustainability of agriculture and food systems which provide opportunities for reducing water demand of food systems. Positive trends include innovations in soil-less indoor farming that allow for recirculation of resources, increasing consumer awareness of sustainable diets, and resource conserving agricultural practices such as agroecology.

Meeting the growing and changing global demand for food will not be possible by simply using existing resources more efficiently. Moving towards more effective and sustainable use of water resources will be required at all scales, from farm to basin and global level. With increasing demand for food and limited water and other natural resources, the key question will not only be how to produce more food with less water – but also how limited water resources can be used most effectively. This Trend Sheet summarises main food system trends relevant for water and provides insights from recent research related to more effective use of water resources in food systems.

Definition of terms

Food systems – The entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products. Food systems comprise all food products that originate from crop and livestock production, forestry, fisheries and aquaculture, as well as the broader economic, societal and natural environments in which these diverse production systems are embedded.

Food security – A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Based on this definition, four food security dimensions can be identified: food availability, economic and physical access to food, food utilization, and stability over time.

Hunger/ Chronic undernourishment – Undernourishment is defined as the condition in which an individual's habitual food consumption is insufficient to provide the amount of dietary energy required to maintain a normal, active, healthy life. The prevalence of undernourishment, i.e. the proportion of the population that lacks enough dietary energy for a healthy, active life, is the indicator used to monitor hunger at the global and regional level, as well as Sustainable Development Goal Indicator 2.1.1.

Nutrition security – A situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment and adequate health services and care, in order to ensure a healthy and active life for all household members. Nutrition security differs from food security in that it also considers the aspects of adequate caregiving practices, health and hygiene, in addition to dietary adequacy.

Undernutrition – The outcome of poor nutritional intake in terms of quantity and/or quality, and/or poor absorption and/or poor biological use of nutrients consumed as a result of repeated instances of disease. It includes being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (suffering from wasting) and deficient in vitamins and minerals (micronutrient deficiency).

Definitions follow those used in the FAO State of Food Security and Nutrition Report 2020.

The state of food security is alarming

The world is not on track to end hunger and all forms of malnutrition by 2030 (Sustainable Development Goal 2, targets 2.1 and 2.2). The FAO State of Food Security and Nutrition Report 2020, estimated that nearly 690 million people, or 8.9 percent of the world population were hungry in 2019. When considering also moderate levels of food insecurity, the numbers are even higher: an estimated 2 billion people in the world did not have regular access to safe, nutritious and sufficient food in 2019. Women are more often affected than men, and the gender gap even increased from 2018 to 2019.

2 ZERO HUNGER

Total numbers have increased over the past years, and risen rapidly with the COVID pandemic to reach an estimated peak of more than 760 million people in 2020. Projections are that following the pandemic, global hunger will decline slowly to fewer than 660 million in 2030 (FAO State of Food Security and Nutrition Report 2021). Moreover, secure access to an appropriately nutritious diet remains a challenge. **Around 3 billion people cannot afford a healthy diet**, particularly dairy, fruits, vegetables, and protein-rich foods.

Drivers of food and nutrition insecurity include population growth and urbanisation, but also climate variability and extremes, economic slowdowns and downturns, poverty and inequality. Moreover, economic development contributes to increasing demand for food. A recent study estimates that under a business as usual scenario, global food demand will increase by around 50% between 2010 and 2050. At the same time, the environmental effects of the food system could increase by 50–90% if no counter measures are taken (Springmann et al. 2018). **Strategies to eradicate global hunger and malnutrition and to feed the future world population will have to consider social and environmental impacts** as well as all components of the food system, ranging from producing to processing, transporting and consuming food.

UNITED NATIONS FOOD SYSTEMS SUMMIT 2021

Against this backdrop, the UN, under the leadership of UN Secretary-General António Guterres, organised the UN Food Systems Summit on 23 September 2021. The aim of the Summit was to "launch bold new actions, solutions and strategies to deliver progress on all 17 Sustainable Development Goals (SDGs), each of which relies on healthier, more sustainable and more equitable food systems"; and to **"awaken the world to the fact that we all must work together to transform the way the world produces, consumes and thinks about food".**

Water is integral to food systems

Water is a critical component in food systems, for irrigation, in food processing and food preparation, but also for hygiene to prevent diseases, such as diarrhoea, impacting on nutrition security. Likewise, food systems have major impacts on water resources and relevant water-related ecosystems. **Improved food systems are therefore essential to meet Sustainable Development Goal (SDG) 6** on water and sanitation. Nevertheless, food security strategies commonly pay little attention to water resources sustainability (cf. Food Systems Summit Brief "Water for Food Systems and Nutrition").

Agriculture accounts for 70% of global freshwater withdrawals and substantial amounts of water are used in food processing. Besides consuming water, food systems contribute to deterioration of water quality.

The global food system is responsible for about 30% of global greenhouse gas emissions (GHG), it is the main driver of deforestation, biodiversity loss, land-use change, and soil degradation. It therefore also affects critical components of sustainable water systems, such as precipitation, wetlands, catchment forests, or soil moisture. Still, many attempts to assess food systems' environmental impact focus on GHG emission only (FAO 2020). Recent advancements in more comprehensive water footprinting methodologies could complement existing assessments (see below on water footprints of meat and other food items as well as of food loss and waste).

Food system impacts on water quality

While often invisible for the human eye, food systems have considerable impacts on water quality, mainly relating to nutrient content and salinisation. Other water quality impacts caused by food systems result from insufficiently treated effluents from food processing, or waste pollution of water bodies from food packaging.

Nutrient pollution of water resources and related ecosystems results from nitrogen and phosphorus run-off caused by excess fertilizer and manure application on agricultural land. It is estimated that the global food system uses around 200 million tonnes of fertilisers annually; and that on average 20% of nitrogen and phosphorous fertiliser is lost through runoff or leaching into groundwater. Moreover, intensified livestock systems and their local concentration increasingly contribute to nutrient pollution in particular regions. High nutrient loads can impact ecosystems through eutrophication. Moreover, as nitrogen transforms into nitrates, it may have considerable health effects, among other it can contribute to stunting of infants. A World Bank report identifies a critical trade-off between using nitrogen to boost food production and reducing its use to protect children's health. It estimates that "while an additional kilogram of nitrogen fertilizer per hectare increases agricultural yields by as much as 5%, the accompanying run-off and releases into water can increase childhood stunting by as much as 19% and decrease adult earnings by as much as 2% (Damiana et al. 2019).

Salinity While urbanisation is the main driver of high salinity levels, agriculture also contributes to salinisation of water resources through leachate from saline soils. High salt concentrations can have impacts on human health, but more importantly they impact agricultural productivity, as saline irrigation water may further contribute to the vicious circle of soil salinisation. Soil salinisation is caused by multiple factors, including inappropriate irrigation practices on naturally dry land, when water evaporation leaves behind salts in the soil.

Salinisation reduces agricultural yield and may ultimately turn soil inappropriate for agricultural production. It thus has repercussions on food security and the world is losing a sizable portion of its food production every year to saline waters. (Damiana et al. 2019)

For more information on water pollution from agriculture and potential management responses, see the FAO report More people, more food, worse water? A global review of water pollution from agriculture.

Food System Trends and their impact on water

Mega trends, such as climate change, urbanisation, demographic change, digitalisation, or globalisation of economies drive developments and changes in food systems. Trends in food systems relate to changes in agricultural production, food processing, consumer behaviour, or packaging and waste. Current trends range from developments in crop varieties, farming practices and digital technologies to highly processed foods, alternative protein sources, and changes in diets (see e.g. FAO 2017, WWF/Metabolic 2017, FAO 2019, fit4food2030). Some of the observed trends have largely negative impacts on water systems, others provide opportunities for more sustainable use of water in food systems.

negative impacts

Trends with largely negative impacts on water systems include, for example:

- **Land grabbing**
- **Increasing meat consumption**
- **Food loss and waste**

positive trends

Some positive trends include, for example:

- **Soil-less indoor cultivation**
- **Agroecology**

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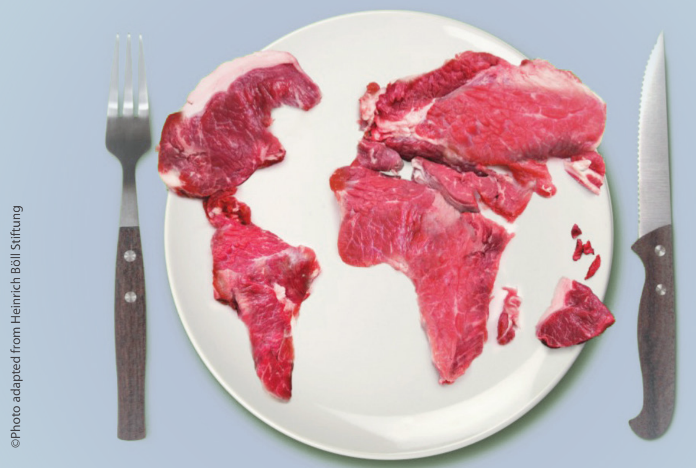
Land grabbing

Since the food-price crisis in 2007-2008, the world has seen a rush for farmland and large-scale land acquisitions, mainly by private but also by public investors and agribusiness. Many of those large-scale agricultural investments were done by foreign investors in the Global South for the purpose of industrial food and biofuels production.

With land acquisition often comes the right to withdraw the water linked to it.

Therefore 'land grabbing' is usually associated with 'water grabbing', be it in the form of precipitation falling on that land and used by crops (green water) or blue water for irrigation. Moreover, emerging evidence suggests that large-scale land transactions contributed to deforestation and soil degradation, and compromised smallholder well-being - raising concerns about their effects on land and food systems' sustainability (Liao et al. 2021). Land grabbing has therefore been largely criticised for sustainability concerns and especially for their impact on land and water rights of smallholder farmers. International guidelines have been developed to promote responsible international agricultural investments, but their implementation has remained weak. While the global land rush observed in 2007-2011 has slowed down, land acquisitions continue to be an important trend which reached a staggering total targeted size of 33 million hectares for agricultural and transnational deals (Land Matrix Initiative 2021). Moreover, a large fraction of acquired land has yet to be put into agricultural production, so the full extent of their impact on water resources remains yet to be seen. (For data and analyses on large-scale land acquisitions see Land Matrix).



Higher consumption of meat

Income growth in low- and middle-income countries has driven a change in preferred diets from a largely cereal based diets towards higher consumption of meat and dairy products, fruits and vegetables. Consumption of beef, lamb and goat, for example is projected to rise by 88% between 2010 and 2050 (WRI 2018). This has implications for the water demand for food production, in particular, and the sustainable use of natural resources, in general. The water footprint of animal food products, especially meat, on average is larger than the water footprint of crop food products with equivalent nutritional energy value.

Estimates are that the average water footprint per calorie for beef is 20 times larger than for cereals and starchy roots. If measured per unit of protein, the water footprint of beef is 6 times larger than the one of pulses. (Mekonnen and Gerbens-Leenes 2020) Detailed footprint assessments, however, need to take into account local contexts and aspects such as animal feed. For example, while beef in general has a larger water footprint than pork or chicken meat, the feed of cows mainly consists of roughages from pasture land that is less suitable for human food production, whereas chickens feed on crops produced on agricultural land that could otherwise be used for food production for human consumption (**Gerbens-Leenes et al. 2013**). Diets rich in meat, particularly that of ruminants such as cattle, also cause higher emissions of greenhouse gases, especially methane, resulting from enteric fermentation; Moreover, they contribute to land-use change and deforestation for pastures and fodder production, causing carbon dioxide emission. A continuing trend in increased meat consumption will therefore have direct and indirect impacts on water systems.

Soil-less indoor cultivation

In soil-less, or hydroponic, farming, plants are grown in nutrient infused water instead of soil. More recently this technology is also applied in vertical systems, further reducing the space required and thus making it appropriate also for urban applications (as e.g. in a super market in New York).

Soil-less farming techniques can present significant advantages over traditional soil-based systems, as it allows for easier recirculation of water and efficient use of nutrients.

Commonly cited estimates are that closed hydroponic systems recirculating water supplies can save 60 - 90% of water use and 20 – 30% of fertilizer use over outdoor, soil-based cultivation (The Global Food System: An Analysis). Moreover, the yields of soil-less cultivation systems are generally much higher than those of soil-based systems due to more precise control of nutrient delivery, oxygenation, pH, and temperature. In the controlled environment of indoor hydroponic systems, certain varieties of plants, such as leafy greens, can produce up to 12 harvests per year as opposed to one or two annual yields in outdoor fields.

Hydroponic systems have long been considered too high-tech and costly for smallholders in developing countries. Larger scale hydroponic systems require substantial starting capital and a variety of high-tech inputs (precision management tools and software). They have therefore been considered to be commercially viable only for producing high-value vegetable crops in the developed world (The Global Food System: An Analysis). For example, hydroponic techniques are already used for the majority of tomato and bell pepper cultivation in the Netherlands. But over the past decades several pilot projects have developed successful small-scale approaches in developing countries. Dairy farmers in the Indian state of Maharashtra, for example, in recent years have successfully produced quality green fodder using a simple low-cost hydroponic system. And the FAO has supported pioneering projects in Gaza and Jordan as well as Namibia.

Agroecology

Recent years have seen a growing trend towards low-impact or resource-conserving agricultural practices, as an alternative to the resource-intensive agricultural systems. While the percentage of agricultural land under alternative low-impact practices is still rather small and under-researched, they provide a promising frontier for food system innovation, including towards more sustainable use of water resources. Approaches include agroecology, conservation agriculture, agro-forestry, permaculture, etc.

Agroecology is a holistic approach that aims at creating and maintaining productive agro-ecosystems with little-to-no external chemical inputs, by increasing biological diversity and sustainably managing local land and water resources via a wide range of farming practices. It puts strong emphasis also on the social dimension and builds on local knowledge and the active engagement and participation of farmers. There is increasing evidence showing the positive impacts of agroecology on the environment, on biodiversity, on farmers' incomes, on resilience, and on adaptation and mitigation to climate change (FAO 2019). Agroecology is integral to FAO's Common Vision for Sustainable Food and Agriculture and FAO has formulated 10 Elements of Agroecology in 2018 Agroecological practices include promoting precipitation infiltration in the soil, mulching to limit evaporation, and other sustainable land and water management practices. The World Overview of Conservation Approaches and Technologies WOCAT provides a catalogue of good practice examples. Agroecology is especially promising for rural smallholders who are most vulnerable to both water and food insecurity. SDC's Global Programme Food Security promotes agroecology through a number of projects.

From water use efficiency to effective use of water

With increasing demand for food and limited water and other natural resources, the key question will not only be how to produce more food with less water – but also how limited water resources can be used most effectively to achieve food and nutrition security, while preserving livelihoods and ecosystems at the same time.

Efforts to increase water use efficiency alone, have delivered mixed results over the past decades, and sometimes even caused negative side-effects. More recently, the research paradigm therefore shifted away from a focus on irrigation efficiency and the performance of irrigation systems. Instead, experts from research and development practice call for a more holistic view, a systems perspective, to answer questions of how water can be used more effectively towards achieving broader development goals such as food security or economic development. As water resources move through the natural and anthropogenic water cycle, this also requires analysing water and food systems at different scales, from field level to global scales. (See e.g. Zhu et al. 2019, Giordano et al. 2017)

At field level

As water flows through the natural water cycle, increasing irrigation efficiency at field level, e.g. though drip-irrigation or reuse of effluents, may result in less water discharging into ground and surface water, and therefore less water being available for ecosystems and other users downstream. Latest research on increasing water productivity for agricultural food production at field level, therefore, looks at so called "real water savings", where water saved, becomes actually available for other uses. A recent study commissioned by FAO concludes that water productivity gains can not only be achieved by applying irrigation water more efficiently to save water.

Water productivity can be increased even more effectively through improved agronomic practices that support crops in more effectively using water to develop biomass, and thus increase yield per unit of water consumed (Van Opstal et al. 2021). Effective interventions to increase water productivity include, for example, better timing of water supplies and improving non-water inputs, such as fertilisers. Agroecological approaches and conservation agriculture, such as permaculture, mulching, land levelling or zero tillage that avoid evaporation from soils have also shown to be effective. Efforts to increase water productivity, however, often come along with costs for farmers that need to be considered in assessing their benefits.

Moreover, when striving towards food and nutrition security water may be used more effectively, when used for more nutritious crops instead of staple crops – or for cash crops that allow buying nutritious food (thus when water is re-allocated from lower to higher-value use in irrigation). The concept **"nutritional water productivity"** has been used to reflect how effective water use is in ensuring nutrition, see for example a recent study analysing opportunities in Ethiopia (Lundquist et al. 2021). Increasing water productivity towards nutrition security may also mean combining agricultural projects with interventions to increase access to water for hygiene. The guidance note on Nutrition-sensitive Water and Irrigation Management published by the World Bank gives further insights.

At basin level

Assessing water productivity can help to allocate water towards more effective use of water for set basin-wide goals. Remote sensing information, such as those provided through FAO WaPOR, can help assess water productivity for agricultural production across basins - and thus provide relevant information on, for example, where in the basin water can be used most effectively to support basin wide food security. However, if considerations of water productivity indicate that water could be allocated more effectively, the social and political implications of reallocating water from one part or riparian state of a basin to another, need to be kept in mind.

In transboundary basins, finding win-win solutions or ways to share benefits from water allocation can be challenging - but it can also provide an opportunity to foster transboundary cooperation. SDC's Blue Peace Central Asia initiative has recently conducted a Water Footprint Analysis (upcoming) to assess the interconnectivity of the region with regard to water and food security. It shows that upstream countries in the basin import food and use water for hydropower production, whereas downstream countries export food largely produced in rainfed agriculture, including to their upstream countries.

At global level

In water scarce regions where options to meet food demand from local produce are insufficient, food security objectives may be met more effectively by importing food (and thus the virtual water contained therein) than by using the limited water resources more efficiently for domestic agricultural production. However, the potential impact of increased agricultural production in exporting areas needs to be considered, as well as the environmental impacts relating to transportation of the produce, including preservation, packaging, and potential loss along the way.

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Recent scientific advances in modelling, use of remote sensing and other Environmental Big Data can support decision making in this regard. The research project ViWA for example, developed models and tools that could support identification of water-use efficient region as potential exporters while assessing the impact on ecosystems of increased water use in these areas.

Trends in food systems show that supply chains of food products are becoming longer and more international. This may also come along with more diverse water-related and other risks to supply chains. New water footprinting methodologies allow assessing water risk hotspots along global supply chains (see e.g. the WELLE Tool). Besides assessing risks, they can also inform decision making about where along the global supply chain, efforts in water saving can be most effective in reducing negative environmental impacts.

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The "**Trend Observatory on Water**" of the Swiss Agency for Development and Cooperation (SDC) aims at informing the RésEAU, SDC's Water Network, and interested parties about relevant emerging trends and innovative approaches for development cooperation in the water sector. Initiated by SDC's Global Programme Water and run by adelphi, it analyses how major global trends can affect water resources and management practices in the future. Through various communication formats and its website https://hazu.swiss/deza/trend-observatory-on-water it aims to raise awareness of opportunities that arise for more sustainable solutions, but also of the risks and challenges that might come along with them.

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