Department of Animal Science

WATER SCARCITY IS GREATEST THREAT TO GLOBAL FOOD SECURITY

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Without water there is no food. It cannot be stated more plainly than that. Fresh water supplies are facing increasing pressure globally from climate change and growing populations (Immerseel et al., 2020; Milly and Dunne, 2020). Water is a neglected, and often ignored, dependency that threatens our ability to feed an ever-increasing global population. Many areas of the world currently face water scarcity (Alcamo et al., 1997; Liu et al., 2017), and the projected increase in global population suggests that increased food demand is expected in the future, with a direct effect on agricultural water usage (Mancosu et al., 2015). Furthermore, because of increased water insecurity and drought due to climate change, water use for irrigation is expected to increase, leading to potential conflicts and competition between agriculture and other sectors of the economy. Global **food security depends on a resilient agricultural system**, which, in turn, depends on a consistent freshwater supply, whether from rainfall or irrigation. Globally, agriculture is the largest consumer of water, accounting for approximately 70 percent of total water withdrawals (Johnson et al., 2001; FAO, 2011). The poultry industry, like others, must act to use water more wisely and as efficiently as possible. Live production of poultry on a global scale requires huge amounts of water, particularly in relation to production of corn and soybeans which make up most commercial poultry feeds. In addition, an average-size poultry processing plant may use **3.8 to 7.6 million liters of water daily**. Ensuring that sufficient water is available in the future will become increasingly challenging as various sectors of the economy compete for what freshwater is available.

Water scarcity

Water scarcity has been a concern in developing countries for decades. However, water scarcity is rapidly becoming a major global issue (Beekman, 1998; Casani et al., 2005; Hoekstra, 2014; Liu et al., 2017). Shiklomanov (1998) estimated that the agricultural sector accounted for two thirds of the total global water withdrawals and almost 90 percent of total global water consumption. Numerous factors, including climate change, population growth, increasing dietary shifts toward animal protein as developing nations become more affluent, irrigated agriculture, seawater intrusion and greater competition and demands for domestic and industrial water, all contribute to this developing issue (Meneses et al., 2017). Poultry's universal acceptability, high nutritional value and recognized health benefits have **propelled it to the top position of animal protein** in the world, accounting for 35 percent of global animal protein production according to FAO (2022). The continuing growth in global population and the recent African swine fever outbreak across various Asian countries have put additional pressure on the poultry industry to increase its capacity and output.

Water scarcity resulting from physical, economic or institutional constraints is currently a problem for one third of the world's population (Molden et al., 2007). About 1.2 billion people suffer physical water scarcity, meaning they lack enough water to satisfy demand. Symptoms of physical water scarcity include severe environmental degradation, pollution, declining groundwater supplies and water allocations, in which some groups win at the expense of others (International Water Management Institute (IMWI), 2007). Another 1.5 billion people are affected by economic water scarcity, where human and/or financial resources are likely insufficient to develop local water systems, even though the supply might be adequate if it could be exploited (Molden et al., 2007). Symptoms of economic water scarcity include scant infrastructure development, meaning there is little to no distribution system (supply lines, piping or canals) to get water to the people, and, where infrastructure exists, the distribution of water may be inequitable.

Sub-Saharan Africa is one of many regions around the world facing water scarcity issues where the problem is particularly severe. Sub-Saharan Africa is characterized by economic water scarcity and water development in the region could greatly assist in poverty reduction (IMWI, 2007). However, most governments fail to invest adequately in the maintenance of irrigation and drainage systems. Inadequate management and operation, along with failure to sufficiently maintain systems, results in the systems' declining performance and subsequent need for rehabilitation (World Bank, 2022). Institutional water scarcity can often be traced back to ill-adapted or poorly functioning institutions, even in the presence of adequate water supplies. In this case, laws, rules and a more supportive organizational framework are key to mitigating water problems (Molden et al., 2007).

The rapid **rise in global meat production is putting increased pressure on water resources**. Livestock production is a very water-intensive agricultural operation, with about one third of the total water that is utilized in global agricultural production assigned to animal production (El Sabry, 2023). In addition, from 1998 to 2008, water use in the food industry increased by approximately 40 percent and has continued to grow (Klemes et al., 2008; Meneses et al., 2017). For example, in conventional poultry processing systems, access to water is particularly critical for the maintenance and disinfection of the processing areas, as well as in processing operations

such as scalding, chilling and carcass washing (Micciche et al., 2018). Water requirements have become limiting factors for economic growth in China and India (Klemes et al., 2008).

Furthermore, in 2010, the **United States alone used 1.1 trillion liters of potable fresh water each day**, or 3,000 liters per capita each day (Maupin et al., 2014). While the water used for producing poultry is decreasing, the industry consumes approximately 113 liters (L) of water for every kilogram (kg) of poultry (live weight) produced (Putman et al., 2017). The water footprint (WF) is a water metric measurement that has been used to accurately calculate water use in relation to final product output. According to Mekonnen and Hoekstra (2010; 2012), the WF per kg of meat for beef cattle, sheep, pig, goat and chicken is 15,400, 10,400, 6,000, 5,500 and 4,300 liters of water, respectively. Much of this water footprint is related to growing rainfed and irrigated crops to produce food for the livestock. More than **80 percent of global agricultural land is rainfed**, thus only green water (rainfall) is consumed (IMWI, 2007). In addition, approximately 20 percent of the total cultivated land is irrigated with blue water (surface and groundwater) and contributes 40 percent of the total food produced worldwide (World Bank, 2022). Irrigated agriculture is, on average, at least **twice as productive per unit of land as rainfed agriculture**, thereby allowing for more production intensification and crop diversification (World Bank, 2022). However, future demand on water by all sectors will require as much as **25 to 40 percent of water be reallocated** from lower to higher productivity activities, particularly in water stressed regions. In most cases, this **reallocation is expected to come from agriculture** due to its high share of water use (World Bank, 2022).

Climate change and water management

Climate change is projected to **reduce average yields** over the next century for major US field crops — corn, soybeans, rice, sorghum, cotton, oats and silage — under both irrigated and dryland production systems (Marshall et al., 2015). While irrigation is widely viewed as an important adaptation to climate change, USDA Economic Research Service (ERS) simulation analysis projects that field crop acreage will decline because of climate change (rising temperatures, shifting rainfall patterns, etc.) throughout the current century (Table 1).

Table 1. Percent changes in total US production (average percent change)

	2040	**2060**	**2080**
Barley (bushels)	-.06	-3.5	**1.0**
Corn (bushels)	-8.7	-13.8	-16.2
Cotton (bales)	-6.1	-5.6	-5.9
Hay (dry tons)	-0.6	**2.7**	**4.2**
Oats (bushels)	-10.7	-16.1	-20.8
Rice (cwt)	-2.5	-4.2	-6.8
Silage (dry ton)	-9.5	-13.1	-14.4
Sorghum (bushels)	-5.4	-14.0	-17.0
Soybeans (bushels)	-8.8	-11.9	-14.3
Wheat (bushels)	**1.3**	**5.6**	**11.6**
Note: Percent changes in total US production include irrigated and dryland production when averaged over future climate change scenarios and compared to reference production levels that assume no climate change.			

Source: Adapted from USDA Economic Research Service.

The increasing global temperatures and more variable rainfall associated with climate change would also impact production as well as flock health and animal welfare (El Sabry et al., 2021; Abbas et al., 2022; Morgado et al., 2022). Heat alters birds' behavioral and physiological responses, leading to decreases in production (Lara and Rostango, 2013), with implications for bird health and welfare both during growth and transport. Numerous factors affect the daily water requirement for poultry including age (Xin et al., 1994), housing conditions (temperature, lighting program, etc.), performance level and feed related factors (El Sabry et al., 2023). Water can also be used to provide evaporative cooling thus decreasing temperature within housing and increasing production (Tao and Xin, 2003).

Although several factors contribute to water scarcity, including global population growth, urbanization, water pollution and/or poor management of water resources, **climate change is the main threat to the sustainability of freshwater resources** (Arnell et al., 2011; UNICEF, 2021; Leal Filho et al., 2022). Water scarcity occurs when freshwater demand exceeds the available supply (Kummu et al., 2016). A small **3 percent of the world's water is freshwater**, but only 0.5 percent is useable. The remaining 2.5 percent is unavailable because it is locked up in the atmosphere and soil, polar ice caps and glaciers, or is highly polluted or lies too far beneath the earth's surface to be extracted at a reasonable cost. According to the FAO (2020), water scarcity primarily affects people in rural areas, with around 3.2 billion people currently living in water-stressed agricultural areas.

Water scarcity eventually leads to food insecurity because crops and livestock require water to survive and grow. The USDA ERS indicates that the number of food insecure people in 2022 was estimated at 1.3 billion, an increase of 118.7 million people from the ERS 2021 estimate (Zereyesus and Cardell, 2022). Sub-Saharan Africa had the highest share of people who are food insecure at 51 percent, reflecting the effects of food price inflation for low-income populations across the region (Zereyesus and Cardell, 2022). Some countries have advanced faster than others in the progress made in the management of water in agriculture. Other countries facing water scarcity challenges may not have an incentive to act in a timely manner or lack the expertise and infrastructure to do so. However, failure to act in response to climate change will prove problematic in the future. Flexibility is going to be increasingly important for the future of agriculture. In addition, the ability of food systems to address food insecurity in the face of water scarcity presents a triple challenge of 1) ensuring food security and nutrition for a growing global population, 2) supporting the livelihoods of millions of people working in the food supply chain around the world and 3) doing so in an environmentally sustainable manner that limits habitat loss and reduces anthropogenic greenhouse gas emissions (OECD, 2021). This challenge is made more daunting because, unfortunately, **water is rarely on the agenda** when food insecurity is discussed, despite its importance to food systems and its susceptibility to climate change.

Food waste and water management

We cannot expect to achieve sustainable food production if water resources are not properly managed. As increasing numbers of nations become more affluent and shift towards more nutritious and healthier diets, the effects on water usage will increase. Food items like meat, fruits and vegetables, either directly or indirectly, come with a large water footprint that must be considered. In addition, something rarely discussed in the same context with water scarcity and

climate change is food waste, but this issue must receive additional attention in the future. Globally, **30 to 50 percent of food is lost to waste** (Gustavsson et al., 2011; Godfray et al., 2010). Food waste is also the waste of resources, including the water that it took to produce that food. The causes of waste differ between high- and low-income countries. Most food waste in low-income countries occurs on farm and in transporting and processing food. In high-income countries, most of the food waste occurs at the consumer level, such as retail stores, food services and at home (Rethinking Food Waste through Economics and Data, 2021), and very little is lost on farm or in transportation or processing. Unfortunately, food waste at the consumer level in high-income countries is primarily associated with discarding usable food and the failure to consume food within the "best if used by" date, then disposing of the item regardless of the food's continued quality and edibility past that date.

In addition, Parfitt et al. (2010) indicated three global trends positioned to influence the rates of food waste. Urbanization and the contraction of the agricultural sector is the first trend. Approximately 55 percent of the world's population now lives in urban areas, and that number is expected to grow to 68 percent by 2050 (United Nations, 2018). This will lengthen food supply chains and place food at an increased risk of waste due to added exposure during transportation, processing and at-home consumption. The second trend is the diet transition mentioned earlier. As incomes rise in many low-income countries, these higher incomes are often accompanied by increased consumption of meat, dairy, fish and fresh fruits and vegetables. These foods tend to have shorter shelf lives than grains and starchy alternatives and are more prone to increased waste. The final trend is an increase in international trade. Global trade results in increased imports that can undercut domestic equivalents in many low-income countries (Brown et al., 2015). Imports are then marketed in supermarkets that dispose of large quantities of edible food simply for reasons of appearance, despite its continued quality and edibility. Increasing food production must be a high priority going forward to feed an increasing global population. However, efforts to save the 30 to 50 percent of food that is currently wasted must also be a high priority. Decreasing food waste is critical to maintaining an affordable and sustainable food supply, not to mention improving water management programs and addressing global water scarcity issues.

Summary

Water scarcity has a major impact on food security. The water issue is made even more complex than it may appear on the surface because many procedures and policies that appear to have nothing to do with water management make a bigger difference on water resources and food production than even agricultural and water management practices. However, **individuals making the decisions often do not consider water into the equation**. Therefore, water managers should better communicate these concerns, and policymakers should be more aware of how their decisions may affect the water scarcity issue. Achieving universal **global food security is perhaps the greatest challenge facing the world today**. Food waste must be reduced, and water scarcity must be addressed if we hope to achieve global food security. Climate change will make addressing food security more challenging because the risks extend beyond water scarcity and agricultural production to other elements of global food systems that are critical for food security, including the processing, storage, transportation and consumption of food. Adaptation strategies can assist in reducing food-system vulnerability to climate change and reduce detrimental effects on food security, but political and socioeconomic conditions can impede the adoption of technically feasible adaptation options. Yet, as the world's leading source

of animal protein, the **poultry industry has a responsibility** in addressing water scarcity and improving global food security.

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