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Meeting the Nutrition and Water Targets of the Sustainable Development Goals: Achieving Progress through Linked Interventions

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE IFPRI

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R4D Learning Series

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Cover image: Women carry harvested rice in baskets atop their heads in rural Benin. Source: Jawoo Koo/IFPRI.

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CONTENTS

ACRONYMS

EGM	Expert group meeting
HLPF	High-level Political Forum
IWRM	Integrated Water Resources Management
SDG	Sustainable Development Goal
WASH	Water supply, sanitation and hygiene
WLE	CGIAR Research Program on Water, Land and Ecosystems
UNSCN	United Nations System Standing Committee on Nutrition

SUMMARY

The United Nations Sustainable Development Goals (SDGs) emphasize the need to address the most pressing issues of today: the conservation of a healthy environment that supports the health, wellbeing, economic development and growth of humankind, contributing to peace and security for all. The SDGs are highly interlinked through complex systems with multiple entry points as possible solutions, but also potentially multiple adverse outcomes from negative feedback effects from some of these solutions.

This paper describes the key water-nutrition linkages reflected in SDG 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) and SDG 6 (ensure availability and sustainable management of water and sanitation for all) as well as the opportunities and challenges to meet both these goals.

Ending hunger and malnutrition requires access to safe drinking water (SDG 6.1) as well as equitable sanitation and hygiene (SDG 6.2). The underlying productivity (SDG 2.3) and sustainability (SDG 2.4) of agricultural systems is dependent on adequate availability (SDG 6.4 and 6.6) of good quality (SDG 6.3) water. Moreover, water and related agro-ecosystems (e.g., wetlands in SDG 6.6), which are embedded in sustainable landscapes, are important contributors to sustainable agriculture (SDG 2.4).

Key gaps in our knowledge of SDG 2-SDG 6 linkages include 1) lack of understanding of and action on linkages between agricultural water use and nutrition, 2) lack of understanding of and investments in measures that ensure nutrition with more variable water supplies under climate change, 3) insufficient accounting for the nutritional impact of increased competition for water resources, 4) limited understanding of the nutritional impacts of water resource management, and 5) inadequate understanding of intersectionalities in water and food security.

Key policy recommendations to address these gaps include capacity building on the linkages between water and nutrition, changes in investments toward nutrition-sensitive water infrastructure and management and water-sensitive nutrition interventions. Moreover, support for additional research is needed to increase our understanding and develop synergistic solutions in the five areas identified as key knowledge gaps on water-nutrition interactions. More research is also needed on emerging research findings, such as 1) water supply, sanitation and hygiene (WASH)–nutrition linkages, 2) irrigation–nutrition linkages, and 3) the current status of water quality and the spatial and temporal distribution patterns of pollutants in water environments. As both water resource and nutrition realities can vary dramatically across communities, solutions need to be targeted and should be co-developed by local communities to ensure resilience, inclusion and sustainability. Finally, solutions should be based on existing evidence, should include monitoring of both water and nutrition indicators, and should be adjusted to the fluid conditions of water and dietary transitions.

1. INTRODUCTION

Water and nutrition are linked in multiple ways, but few of these interlinkages are well understood. While the evidence base on several key water–nutrition linkages, such as those between water, sanitation, hygiene and nutrition is developing and between irrigation and nutrition is beginning to emerge, little is known about several other potentially important linkages. These include the associations between water pollution and health or between water resource management and nutrition; and even less is known about the interactions across these various linkages. The importance of understanding these connections has been highlighted as we pursue the United Nations Sustainable Development Goals (SDGs), which challenge mankind to meet both water security and food and nutrition security goals, while also improving water-based ecosystems. It has become increasingly clear that progress toward these goals can only be achieved if measures in the food and nutrition space do not constrain progress on SDG 6 on water and if measures undertaken to support targets under SDG 6 also support nutrition outcomes.

To support these objectives, this paper provides an overview of water–nutrition linkages as reflected in the SDGs, even though the evidence base on some of these linkages is still growing. It also identifies key gaps in these linkages and suggests a way forward to support the achievement of both water and nutrition goals and targets.

This paper was developed to consolidate key ideas and knowledge gaps around nutrition and SDG 6 on water for the United Nations System Standing Committee on Nutrition (UNSCN), a committee that aims to maximize UN policy coherence on nutrition and supports consistent delivery by the UN system for nutrition. In June 2018, The UNSCN convened an Expert Group Meeting (EGM) on *Nutrition and the Sustainable Development Goals (SDGs) under Review* as a preparatory meeting in advance of the High-level Political Forum (HLPF; ministerial meetings) in July 2018. The purpose of the EGM was to deepen the understanding of the impact of nutrition on the achievement of the SDGs and the corresponding impact of the SDGs on nutrition. The outcomes were intended to provide substantive inputs into the thematic reviews through strengthening synergistic policy efforts and reducing or eliminating policies and investments that might constrain outcomes for the SDGs, with the goal to attain the overarching objectives of resilience, inclusion and sustainability.

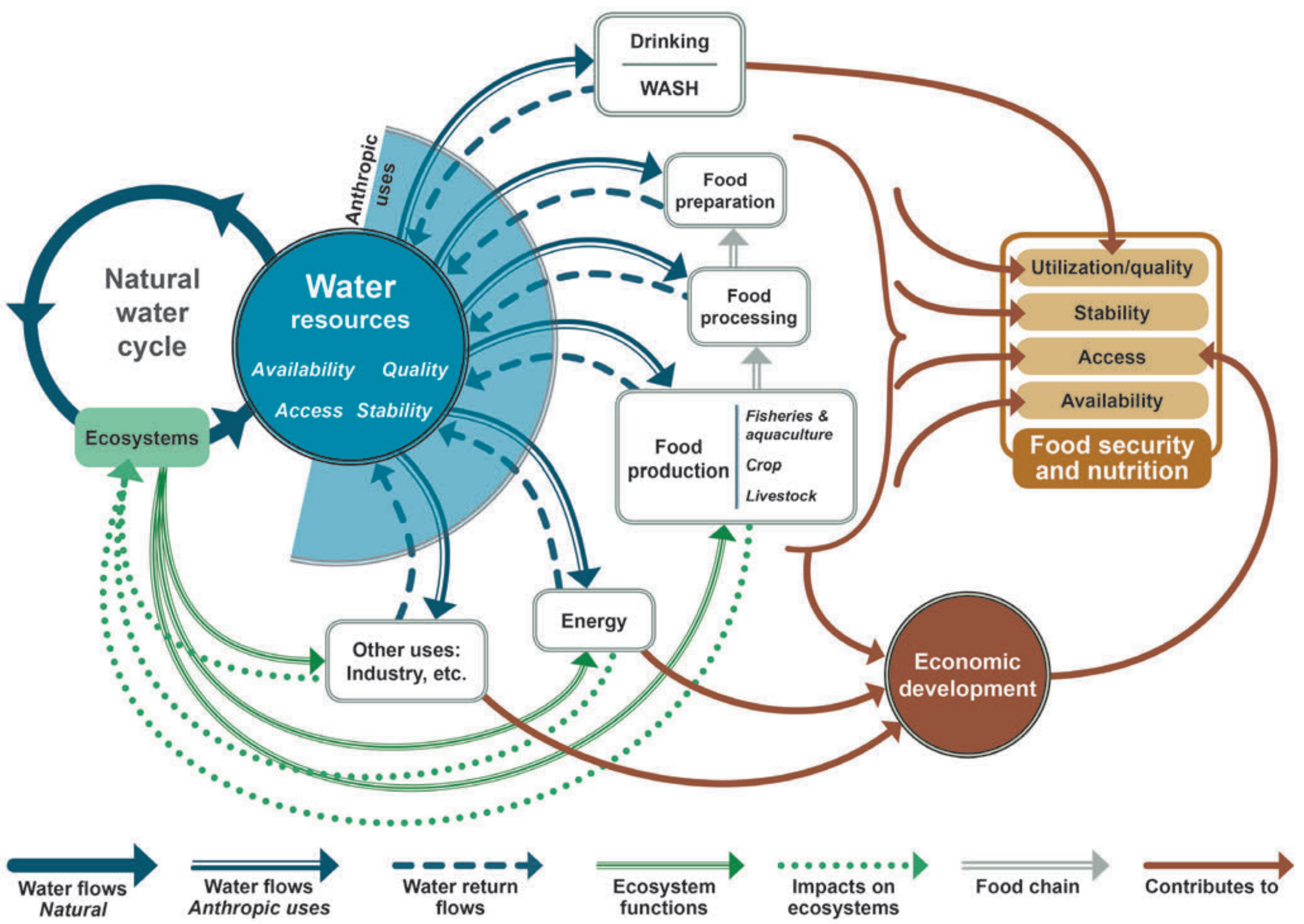
2. WHAT DOES WATER HAVE TO DO WITH NUTRITION?

Water is an irreplaceable resource for food security, nutrition, and health. Pathways from water to nutrition include the provision of safe water for drinking and other domestic uses, water for industrial processes, and water of acceptable quality for irrigation, fisheries and crop production as well as for agricultural processing and for many food-related industrial processes. Water is also essential for energy production, including hydro-electricity, biofuel production, and cooling of most other forms of energy production. Access to clean energy, in turn, is positively associated with human health, food security and nutrition (see Figure 1 for an illustration of water–nutrition linkages). Overall, economic development fueled by safe and sufficient water is a strong contributor to food security and nutrition. Pollution of water resources from agro-processing, other industries, agriculture and domestic sewage, in turn, adversely affects water-based ecosystems and the potential of water resources to support food and nutrition security.

In terms of the relative strength of the linkages, more than 70% of all freshwater withdrawals are currently used for agriculture, and about 85% of withdrawn resources are consumed in irrigated agricultural production. With these resources, irrigated crop areas generate 40% of global food production on less than a third of global harvested area (Ringler 2017). At the same time, most crops continue to depend only on rainwater, and most irrigated crops also benefit from precipitation.

Total consumptive water use is expected to increase by around 50% globally between 2000 and 2050 (Rosegrant et al. 2013). Among these, domestic and industrial demands for water, while accounting for smaller shares of total demand, are growing much faster and are putting increasing pressures on water use in agriculture. In addition, while industrial and energy-generating processes, food processing and domestic purposes account for relatively smaller water uses, they do tend to pollute water bodies more, in terms of pollutants per unit of water used.

FIGURE 1. LINKAGE FROM WATER TO FOOD SECURITY AND NUTRITION.



Source: HLPE 2015.

3. HOW TO IMPROVE LINKAGES BETWEEN SDG 6 ON WATER AND SDG 2 ON NUTRITION

Included in the Agenda 2030 for Sustainable Development (the SDGs) are two goals that are most relevant here. Goal 2 is "End hunger, achieve food security and improved nutrition and promote sustainable agriculture", while Goal 6 is "Ensure availability and sustainable management of water and sanitation for all". Management of water, food security and nutrition are clearly interlinked, given that the production of food is largely based on water.

A quick glance at Tables 1 and 2 suggests a variety of interdependencies between SDG 6, on water, and SDG 2, on food security and nutrition. Ending hunger and malnutrition requires access to safe drinking water (SDG 6.1) as well as equitable sanitation and hygiene (SDG 6.2). The underlying productivity (SDG 2.3) and sustainability (SDG 2.4) of agricultural systems is dependent on adequate availability (SDG 6.4 and 6.6) of good quality (SDG 6.3) water and thus of many of the targets encapsulated in SDG 6. More specifically, in much of the world, irrigation is a key contributor to greater agricultural productivity, and lack of access to water is a key determinant of low-yield growth in regions such as sub-Saharan Africa. Moreover, water and related agro-ecosystems (e.g., wetlands in SDG 6.6), which are embedded in sustainable landscapes, are important contributors to sustainable agriculture (SDG 2.4).

The three implementing mechanisms of SDG 2 (2.A-2.C) can all be strengthened through a focus on water (see Table 1). Implementing mechanism SDG 2.A on investment and technology development for increased agricultural productivity could be supported through irrigation and complementary infrastructure as well as by precision tools, such as moisture sensors or advanced irrigation scheduling tools. Mechanism SDG 2.B calls for open trading systems. Such systems can, through the import of water embedded in traded food, improve both water and food security as well as nutrition in water-scarce countries. This is of particular importance in countries located in the Middle East and North Africa that are otherwise more likely to overexploit often non-renewable, groundwater resources.

Implementation mechanism SDG 2.C relates to ways to limit extreme food price volatility. Much of this volatility is triggered by extreme climate events and water variability,

TABLE 1. SDG 2 TARGETS AND IMPLEMENTING MECHANISMS.

TARGETS	
2.1	By 2030 end hunger and ensure access by all people, the poor and people in vulnerable situations including infants, to safe, nutritious and sufficient food all year round
2.2	By 2030 end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons
2.3	By 2030 double the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
2.4	By 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality
2.5	By 2020 maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional and international levels, and ensure access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge as internationally agreed
IMPLEMENTING MECHANISMS	
2.A	Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks to enhance agricultural productive capacity in developing countries, least developed countries
2.B	Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round
2.C	Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, to help limit extreme food price volatility

Source: UN 2017a.

which can reduce food production in parts of the globe, resulting in real or perceived shortages in global food markets which can, in turn, trigger panic on food markets and spiraling food prices, with adverse impacts on nutrition. The 2007/08 food price crisis is an example of this linkage. Interventions in the water sector that reduce climate variability and change can thus support to reduce price volatility. A recent IMPACT model study supports the importance of addressing water variability to reduce price volatility. It compares today's agricultural production with a counterfactual in which water storage, allocation and delivery capacity was able to maximize the use of all available water in existing irrigation systems. Among staple crops, the effect on prices was greatest for rice, not only reducing its mean global price, but also affecting the variance in price. The probability that the price of rice could exceed USD 400 per ton was reduced from 21% to 0.7% through investment in water security for irrigation (Sadoff et al. 2015).

The following sections describe in greater detail the various contributions of SDG 6 to nutrition, target by target.

TABLE 2. SDG 6 TARGETS AND IMPLEMENTING MECHANISMS.

TARGETS
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
IMPLEMENTING MECHANISMS
6.A By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.B Support and strengthen the participation of local communities in improving water and sanitation management

Source: UN 2017b.

Target 6.1: "By 2030, achieve universal and equitable access to safe and affordable drinking water for all"

Universal and equitable access to safe and affordable drinking water is essential for nutrition and health, and some evidence exists on the linkage between water supply and nutrition. While in the SDG 6 targets, water supply and sanitation are separated, when it comes to improving nutrition and health outcomes, these water interventions are in reality typically combined with hygiene under a water supply, sanitation and hygiene (WASH) package. Ensuring all WASH projects incorporate nutrition objectives can enhance impact and help to achieve SDG 2 targets.

Access to safe water is associated with reduced incidence of enteric infection and reduced incidence of disease in pregnant women. Access is also important for reducing maternal and neonatal mortality rates. This in turn can reduce stunting and improve nutrition outcomes during the first 1,000 days (Cumming and Carincross 2016). However, recent published and unpublished studies of combined water supply (and sanitation and hygiene, as relating to Target 6.2) interventions find mixed evidence for nutrition benefits (Null et al. 2018; Luby et al. 2018). Thus, while such investments are important inputs to achieving nutrition objectives, they are not necessarily sufficient and might be overshadowed by other factors adversely affecting nutrition outcomes (see also Box 1).

WASH is also critical for survival in the first phase of many emergencies and for resilience in succeeding phases. People affected by humanitarian crises, such as natural disasters, or who are displaced by conflict, are generally at a much higher risk of illness and death from disease. Inadequate access to WASH infrastructure as well as poor and crowded living conditions exacerbate this risk, increasing susceptibility to diarrheal and infectious diseases transmitted by the fecal–oral route as well as by vectors associated with poor sanitation, waste management and drainage (EHG 2018). However, providing sufficient water and sanitation facilities alone will not guarantee proper use, nor positive impact on public health. It is critical that communities have the necessary knowledge and understanding to prevent WASH-related diseases and that they are included in the process of designing and maintaining those facilities. Moreover, improved understanding of previous humanitarian and development projects and social influences could also improve WASH interventions during emergencies (Yates et al. 2017).

Target 6.2: "By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations"

Similar to access to safe water, evidence exists on linkages between access to adequate sanitation, hygiene practices and nutrition. But the body of evidence needs expansion. Including nutrition-focused guidelines in WASH interventions could help to ensure a greater impact on nutrition.

Access to improved sanitation is associated with better health and nutrition outcomes (Freeman et al. 2017). Smith and Haddad (2015) calculated that roughly 14% of the total decline in stunting between 1970 and 2010 resulted from improved sanitation. Reducing the practice of open defecation in particular may have the greatest impact on child health (Wolf et al. 2018). In 2015, 892 million people worldwide still practiced open defecation, and 2.3 billion people lacked adequate sanitation facilities, with the highest rates observed in Central and South Asia (30%) and sub-Saharan Africa (23%) (WHO and UNICEF 2017).

Delivering equitable access to sanitation services and making progress on Target 6.2 requires a better understanding of access and usage barriers. Disparities in access to sanitation and hygiene are driven by a range of interrelated and complex factors, such as socioeconomic status, gender, age and location. Children who lack access to sanitation are more likely to be malnourished, and these deprivations interact to magnify the effects of undernutrition (WBG 2017). Moreover, it is crucial to understand and consider the vulnerabilities of different groups. This includes the associated health consequences of low-quality services or lack of services overall, including for women and young girls with regards to menstrual hygiene (House et al. 2012) and for those with disabilities (White et al. 2016). These considerations should inform the design of WASH infrastructure, policies and programs.

BOX 1. WASH AND NUTRITION LINKAGES—WHAT DO WE KNOW?

Community-based childcare center volunteers filling cistern for hand washing, Malawi. *SOURCE:* Melissa Cooperman/IFPRI

Access to safe water supply as well as to improved sanitation and hygiene practices can decrease the incidence of diarrhea in young children. A systematic review and meta-analysis of health impacts of water and sanitation interventions show reductions in diarrhea morbidity, with evidence supporting greater reductions in diarrhea for households that have piped water connections and that are situated in communities with higher coverage of improved sanitation (Wolf et al. 2014). Some evidence suggests that reductions in the number of episodes of diarrhea in children under two years of age can reduce the probability of stunting, and thus reductions in the exposure to contaminants could bring benefits for child health and nutrition (Checkley et al. 2008).

While poor sanitation is implicated as the second leading risk factor for child stunting worldwide (Danaei et al. 2016), the causal links between improvements in WASH environments and nutrition are still under investigation. Reviews have reported modest effects of water quality, sanitation and handwashing interventions on height-for-age of children under five years of age, independent of the effects on diarrhea (Dangour et al. 2013; Freeman et al. 2017). Moreover, environmental enteric dysfunction may be a major causal pathway between poor WASH environments and child stunting (Humphrey 2009). Although recent studies have found that combined WASH and nutrition interventions are not consistently more effective in the prevention of diarrhea and improving child growth than are single interventions (including nutrition-specific interventions) (Luby et al. 2018; Null et al. 2018), the importance of WASH for these outcomes should not be dismissed (Arnold et al. 2018; Coffey and Spears 2018; Cumming and Curtis 2018; Menon and Frongillo 2018). Access to adequate quantities of safe water enables hygiene behaviors that beneficially influence child health and nutrition, such as handwashing, washing utensils and containers, and cleaning objects and surfaces used by children (Howard and Bartram 2003). Lack of access to a continuous source of safe water can have negative health consequences if households revert to using unimproved sources of water for even short periods of time (Hunter et al. 2009). Finally, reductions in exposure to harmful pathogens have the potential to improve morbidity rates not just for one household, but also for the surrounding community through the positive externality of a reduced contaminant load (Eisenberg and Fuller 2016; Harris et al. 2017; Miguel and Kremer 2004).

Target 6.3: “By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse”

Addressing water pollution and treating wastewater is essential to maintaining water quality appropriate for food production, and thus in improving nutrition outcomes. Nutrition and health should be recognized as benefitting from improved implementation of Target 6.3, and adverse impacts from pollution need to be better monitored and documented.

More than 330 km^3 of pathogen-laden municipal wastewater (equivalent to four times the Nile River) are being discharged globally to our rivers, lakes and seas every year, most of it untreated (Mateo-Sagasta et al. 2015). Microbiological pollution is aggravated by the booming livestock and aquaculture sectors and their associated wastes (Mateo-Sagasta et al. 2018). Currently, severe pathogen pollution affects around one-third of all river stretches in Latin America, Africa and Asia, putting the health of millions of people at risk (UNEP 2016).

Water pollution adversely affects human health and nutrition. Water pollution in the form of biological, chemical and industrial pollutants can contribute to diarrhea in addition to other diseases, including cancer. While microbiological water pollution is the biggest health concern, water bodies receive increasing amounts of chemical contaminants from cities, industries and agriculture, aggravating impacts on public health through different pathways.

Pollution of irrigation and drinking waters with naturally occurring chemical contaminants, such as arsenic, or with industrial toxic agents, agrochemicals or emerging pollutants (such as endocrine disruptors or antibiotics) are just examples of increasingly significant health problems. As a result of widespread water pollution, the global area of cropland irrigated with polluted water is growing. For example, the irrigated cropland influenced by untreated urban wastewater has reached about 36 million hectares in peri-urban areas, equivalent to the size of Germany (Thebo et al. 2017). This does not include areas irrigated with arsenic-contaminated waters or waters polluted by industrial waste or other agro-pollutants.

Agriculture is considered a diffuse source of water pollution. The pollutants tend to be dispersed across the landscape, entering water bodies through multiple pathways. Fertilizer use on crop land and livestock animal excreta are key sources of agricultural water pollution. Excessive Nitrogen (N) and Phosphorous (P) in water bodies results in eutrophication, that is when algae grow faster than normal, killing other aquatic life by depleting oxygen. The presence of nitrogen-based compounds in drinking water can also be directly harmful to human health. Domestic and agricultural pollution of water sources can contribute to blue baby syndrome (in which high levels of nitrates in water can cause methemoglobinemia–a potentially fatal illness–in infants) and many other maladies determined by the nature of the pollutant. Polluted water is commonly used for food processing and preparation in low-income countries and informal markets, where affordable drinking water is not available (Drechsel and Evans 2010). Many food-borne illnesses can be traced back to low-quality water used in food production, post-harvest processing and/or food preparation (HLPE 2015). In 2010, the global burden of food-borne disease was estimated at 33 million years lost due to ill-health, disability or early death, and 40% of the food-borne disease burden is among children under five years of age. Food-borne diarrheal disease agents caused 230,000 deaths in 2010, particularly non-typhoidal salmonella enterica, which causes diarrheal and invasive disease (WHO 2015).

Use of wastewater or polluted water for the irrigation of crops, and particularly nutrient-dense vegetables, is likely to result in millions of disease incidences ever year, largely unreported, as well as in thousands of deaths (Thebo et al. 2017). Similarly, the use of polluted water and lack of proper hygiene in local markets, in food preparation at home and in agro-food processing can harm nutrition and health outcomes. Some of this pollution is directly caused by agricultural management practices, while other pollution derives from lack of treating industrial and municipal wastewater and some originates from the mining industry.

Water pollution caused by agriculture is rapidly increasing, particularly in developing countries (Mateo-Sagasta et al. 2018; Xie and Ringler 2017), threatening progress on nutrition and health.

Target 6.4: "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity"

Reducing water scarcity and ensuring more sustainable water withdrawals can support nutrition and health outcomes. But, a focus on increasing water-use efficiency in irrigated agriculture might have the opposite effect. Agriculture is the largest water user, yet sustainable agricultural water use is not explicitly called for in the SDG 6 targets, and linkages between agricultural water use and nutrition and health are not addressed. This puts in peril progress on nutrition and health.

Water scarcity compounds the risks that the poor face in accessing water resources for household and agricultural use. For example, water scarcity increases the time spent collecting water, the burden of which falls mainly on women and young girls, reducing their time available for caregiving or schooling (Sorenson et al. 2011). Seasonal water shortages may also result in households using unsafe water sources, contributing to higher incidence of water-related disease. Conflict-induced water insecurity can place populations at severe risk of disease and malnutrition.

Water scarcity also reduces the capacity of water bodies to dilute pollution and can put food production at risk both in the lean season and, in cases of severe and long-term drought, throughout the year. As such, improving water productivity, i.e., using less water per unit or value of nutritious food produced and directing water to more nutritious crops, is beneficial for food security and nutrition.

However, the measurements and drivers used for water-use efficiency must be carefully considered. High-tech irrigation interventions yield several benefits for farmers - including higher incomes and lower labor, energy and fertilizer costs (IFC n.d.). However, these interventions often lead to an increase in water consumption (in part because farmers tend to extend the area under irrigation) and subsequent reduction in downstream water availability. Thus, increasing water-use efficiency without reducing overall water allocation to irrigation schemes or farmers will generally not result in overall water savings that can be used by downstream users or ecosystems (Grafton et al. 2018). As such, misguided interpretation of Target (and Indicator) 6.4. could put at risk the achievement of nutrition and food security targets.

While some forms of irrigation can increase water shortages for domestic uses and thus nutrition and health, others can provide water for multiple uses and improved nutrition. Currently ongoing research under the USAID-supported Feed the Future Innovation Lab on Small Scale Irrigation suggests that small-scale irrigation can positively affect households' economic access to food and nutritional outcomes of women and children, particularly when irrigation is defined beyond the use of buckets and watering cans in agriculture (Passarelli et al. 2018).

Target 6.5: "By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate"

Integrated water resources management (IWRM) that considers the nutritional impacts of decisions on affected populations can help to safeguard the quality and quantity of water resources for household and productive uses, contributing to nutrition outcomes. To obtain positive outcomes in this area, nutrition would need to be explicitly added to water resource management programs.

IWRM has been defined by the Global Water Partnership (GWP 2000) as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."

Transboundary cooperation helps reduce tension and conflicts in transboundary basins, and as such contributes to water, food and nutrition security. For instance, farming operations within transboundary waters may overuse or pollute the waters of a neighboring country downstream, thus hindering food security and sustainable agriculture or posing challenges to the ecosystem of the downstream neighbor. One of the indicators for the achievement of Target 6.5 deals with the proportion of transboundary basin area with an operational arrangement for water cooperation. By providing scrutiny of policy and its implementation across boundaries, this indicator facilitates the proper implementation of policy around water, including its use for irrigation and food production. However, without special attention to nutrition, pursuit of IWRM is unlikely to achieve strong benefits for improved nutrition and health.

The concept of IWRM has received some criticism in terms of workability—as various water users compete with each other and relatively few inducements and regulations for IWRM implementation exist (see for example Biswas 2008). A newer concept, the water–energy–food nexus concept, considers entry points from three different sectors, i.e., water, energy and food, and hence gives the nexus approach the latitude to more easily incorporate nutrition into water discourses. However, there is no evidence to date, that nexus analyses and implementation have strengthened nutrition outcomes.

Target 6.6: "By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes"

While the protection of water-related ecosystems intuitively contributes to nutrition and health outcomes, it can be challenging to generate evidence on these linkages; this area of study is neglected and needs to be developed. Studies are needed to develop guidelines that help ensure that interventions for Target 6.6 are credited with supporting nutrition and health outcomes. This would require explicity co-monitoring and evaluating changes in the target indicator (i.e., the change in the extent of water-related ecosystems over time) together with key nutrition indicators.

Water and related ecosystems underlie all agricultural production, and healthy ecosystems are essential for healthy people (WLE 2014). Healthy water-related ecosystems provide a series of provisioning, regulating, supporting and cultural ecosystem services, many of which, in turn, support nutrition and health outcomes. It is estimated that freshwater ecosystems globally contribute at least 59.5 million tons of fish annually (inland fisheries 11.5 million tons; freshwater aquaculture 48.0 million tons). Due to difficulties in monitoring, this is most likely an underestimate, but equates to 50% of all food fish. Moreover, these systems also provide other important aquatic species of high nutritional value. As noted by Contini and Cannicci (2008) the productivity levels of freshwater–wetland ecosystems are among the highest in the world, also producing grazing and thus food that supports small scale farmers.

Protection and conservation of watersheds can have protective effects on child health and nutrition, by reducing seasonal water shortages, sediment loads and the incidence of waterborne and insect vector–transmitted diseases (Herrera et al. 2017). Environmental degradation has been associated with food insecurity, and malnutrition and certain ecosystem types are associated with greater infant mortality (Fanzo et al. 2017), but little evidence has been generated on these linkages.

Infrastructure development, such as dam construction, can have both positive and negative impacts on water-related ecosystems and nutrition. Dams can either be a support to irrigation, if the stored water is used for that purpose, or they can adversely affect irrigation development (Zeng et al. 2017). Reduced flows below dams can have substantial negative impacts on ecosystem services, including availability of water for riparian irrigation and (by blocking fish migration routes and altering flow regimes) yields of fisheries and other aquatic species, which are often essential sources of protein and micro-nutrients for the poorest and most marginal groups of society. The controversies surrounding dam development and downstream fisheries in the Mekong region highlight a major point of contention in one of the largest freshwater fisheries in the world (Geheb and Pukinskis 2012) where the fisheries and associated livelihoods are at risk due to substantial upstream hydropower dam development.

In terms of nutrition, the data produced by Indicator 6.6.1 provide insights on the extent of changes in water-related ecosystems, thus indicating any change in extent that may mean a loss of food production potential. This includes aquatic food resources as well as crops grown in aquatic environments, such as floating rice, many vegetables, edible algae, etc. The indicator also reveals the quantity of water in rivers and in groundwater aquifers, a change of which could adversely affect irrigated food production, fisheries and livestock production. However, the indicator has not been credited with supporting food production and nutrition, which is often at the root of contestations between water for food and protection of ecosystems.

4. THE IMPACT OF DIETS ON WATER RESOURCES

Agricultural systems have expanded and intensified in response to the growing demand for food and as a consequence of changing diets (Mateo-Sagasta et al. 2018). Because agriculture is the major anthropogenic use of water, changing consumption trends, including transitions to more dairy, red meat as well as energy-dense and processed foods—in addition to their impacts on health and nutrition—are increasingly degrading water quality and reducing water availability for people and the planet. This puts in jeopardy the achievement of all SDGs.

Worldwide, about 1.9 billion people are overweight, and of these, more than 600 million are obese, with 62% living in low- and middle-income countries. Dietary preferences are changing, and unhealthy diets, with excess fats and meat, tend to have higher water footprints (Mateo-Sagasta et al. 2018). A recent study suggests that, in India, even modest changes in diets could help address projected reductions in the availability of freshwater and improve diet-related health outcomes (Milner et al. 2017). These issues have been described by the Water Footprint Network (http://waterfootprint.org/en/), which visualizes the quantities of water used in daily activities, including food production and domestic water use, and indicates the pressures these uses exert on freshwater resources.

Thus, it is not only important that improvements in SDG 6 targets strengthen nutrition outcomes; it is also important that advances in SDG 2, and particularly dietary guidelines and nutrition-specific and nutrition-sensitive approaches, support SDG 6 targets, in particular improvements in water quality, reduction in anthropic uses of water, and restoration and improvements of water-related ecosystems. In 2015, the United States Department of Agriculture's advisory panel on dietary guidelines for the first time recommended to include environmental sustainability as part of the guidelines. However, in the end, the department considered environmental sustainability to be outside the scope of its mandate on nutritional and dietary information (Fischer and Garnett 2016). Other countries have moved ahead considering environmental sustainability, in addition to health and nutrition considerations in their guidelines, including Brazil and Sweden.

Cooling processed tomato sauce cans at Pratibha Foods Processing Unit in Sonipat District, Haryana, India. *SOURCE:* Katrin Park/IFPRI

5. KEY GAPS IN SDG 6–NUTRITION LINKAGES

In addition to the key messages listed in Section 3, as part of the description of linkages between SDG 6 and nutrition, the following are key areas that require further analyses to ensure that progress toward SDG 6 supports nutrition outcomes and that a nutrition focus does not adversely affect important SDG 6 targets. Key gaps are as follows:

Key gap 1: Lack of understanding of and action on linkages between agricultural water use—the key human water use—and nutrition

As already mentioned, SDG 6 does not explicitly mention the role of water in providing for nutrition, even though many of its targets provide key aspects that would support both sustainable agriculture and nutrition. Without a focus on sustainable agricultural water management, neither SDG 6 targets, nor SDG 2 goals and targets can be achieved.

Water for agriculture has the potential to improve nutrition and health through several pathways. The four key pathways from agricultural water use to nutrition include the income pathway; the agricultural diversification and production pathway; the women's empowerment pathway; and the WASH pathway (Domènech 2015; Ringler and Domènech 2013). These pathways are summarized below:

- **The income pathway:** Irrigation-induced increases in agricultural production and commercialization of production, as well as in water for local aquaculture, can lead to increased incomes, lower food prices for consumers and thus increased food access and increased diversity of foods available in markets.
- **The agricultural diversification pathway:** Increases in agricultural diversification on subsistence farmers' own plots can increase their dietary diversity and enhance direct consumption of micronutrient-rich foods such as fruits, vegetables, and animal-sourced foods and also support their cultivation in the dry season.
- **The women's empowerment pathway:** Irrigation, as a productive asset, can improve women's empowerment through increased asset ownership, control over resources and reduced time spent on water collection. If the source of irrigation water is also used for domestic water uses, improvements in the proximity and cleanliness of water sources and technologies for water extraction could support women's empowerment through time savings, allowing more time for self-care and infant and young child feeding. Whether and how irrigation influences women's empowerment depends on many factors, including women's control over decisions regarding which technologies are adopted and how they are used, who contributes the labor for irrigation, and who controls the output and income from irrigated crops (Theis et al. 2017; Passarelli et al. 2018).
- **The WASH pathway:** In many countries, water provided for irrigation is also used for water supply and sanitation purposes, which can improve the overall WASH environment in and around the household, reducing exposure to fecal contamination and the risk of infectious diseases.

On the other hand, if irrigation or any form of water management in agriculture, is not properly conducted, agricultural productivity might decline, negatively impacting nutrition, health and women's empowerment. Increasing the availability of water around the household or farm can introduce vectors for malaria, dengue and schistosomiasis as well as bacteria responsible for cholera, dysentery and other diseases if preventive measures are not taken. For example, excess standing water may provide habitat for vectors, and wastes may become recycled back into the drinking water. Research on the question of whether irrigation increases malaria prevalence has proven the issue complex. Irrigation schemes and dams are built to contribute to economic development and poverty alleviation, which tends to improve peoples' health and nutritional status. However, some studies indicate that under certain circumstances higher rates of malaria transmission are found in communities living in the vicinity of dams and irrigation schemes (Kibret et al. 2016). This is especially the case in areas of unstable transmission, where people have little or no immunity to malaria parasites, such as in the African highlands and desert fringes. Similarly, poor irrigation practices with runoff of Nitrogen and Phosphorous or soil salinization and water logging can adversely affect health and nutrition of both soils and humans.

Irrigation water quality may influence the nutritional quality of irrigated crops. Nevertheless, the potential positive or negative effects of using waters of different qualities on the nutritional value of crops remains poorly researched and deserves further attention.

Key gap 2: Lack of understanding of and investments in measures that ensure nutrition under more variable water supplies, i.e., droughts and floods, under climate change

Changes in runoff patterns and evaporation, increased salinity, unreliable rainfall patterns, and increased incidence and intensity of drought are some of the ways in which climate change is already affecting and will continue to affect the availability of freshwater. Changes in rainfall, temperature and sea levels are expected to increase the frequency and intensity of disasters such as droughts, hurricanes, cyclones and severe floods. Some of the expected increase will be in regions that historically have not been impacted by natural disaster, but much of the increased incidence will be in regions that are traditionally vulnerable, in other words, drier regions will get drier and wetter regions will get wetter (IPCC 2014).

The occurrence and manifestation of climate change may intensify water–nutrition linkages both positively and negatively. Malnutrition is perceived as one of the five most substantial health impacts of climate change (IPCC 2007, 2012). Decreased water quality and availability in some areas could result in increased sanitation problems and waterborne diseases such as diarrheal disease (Krishnamurthy et al. 2012), while, *ceteris paribus*, the transmission of vector-borne diseases is projected to increase with climate change (Akresh et al. 2011). Changes in rainfall (level, pattern or variability) can result in increased aridity of agricultural land, leading to reduced food production, but potentially also to increased flooding, both of which can affect nutritional status, particularly stunting outcomes (Akresh et al. 2011; Phalkey et al. 2015), potentially due to a loss in livelihood and decreased access to food.

Droughts have also been linked to an increase in mosquito-borne illnesses, such as West Nile virus, malaria and dengue, which are known risk factors for anemia and undernutrition. On the other end of the weather spectrum is increased incidence of severe flooding, which can damage agricultural land and increase the incidence of waterborne diseases that lead to poor nutrition outcomes. Drought has the potential to lead to food shortages as well as loss of income, resulting in slowed growth in children younger than two (Hoddinott and Kinsey 2001). Flooding has short- and long-term effects on child height, through changes in food consumption and infectious disease burden (Danysh et al. 2014; del Ninno and Lundberg 2005; Rodriguez-Llanes et al. 2011).

Additionally, changes in climate may result in a lack of water for hygiene, flood damage to water and sanitation infrastructure as well as contamination of water sources through overflow, the latter especially concerning human and animal waste entering waterways (McMichael et al. 2006). Resulting health impacts include increased risks of food- and waterborne diseases (Fanzo et al. 2017).

Watering seedlings at Tithokoze Farm, Mpingu, Malawi. *SOURCE:* Melissa Cooperman/IFPRI

Key gap 3: Accounting for the nutritional impact of increased competition for water resources

Increasing urbanization, industrialization and population growth, and the consequent increase in water demand, necessarily competes with agricultural water demand. Thus, water policy that is harmonized across different water users can help to mitigate the potential adverse impacts on nutrition.

Lack of cooperation on the use of transboundary water resources can potentially impact food security and nutrition, when the quality and quantity of water resources available in one location are inadequate as a result of poor distribution and inequitable use. However, it is currently not common practice to consider the nutritional consequences of transboundary water decisions and agreements. More experience and policy guidance is needed in this area.

Key gap 4: Understanding women's and men's roles in achieving water and food security

Needs and agency of women around water is not addressed in SDG 6, beyond the sanitation target. However, it is clear that women have more varied roles and needs around water for both productive and reproductive uses and that, similarly, women have special roles and needs around nutrition. A joint assessment of water–nutrition–gender linkages is lacking in SDG targets and indicators, and, while linkages are intuitive, there is currently limited evidence on this topic.

In addition to these four key gaps, other areas in the water–nutrition field that require further research include, but are not limited to

- The linkages between WASH and obesity: Limited understanding exists of the relationship between contaminated water and unsafe sanitary environments and consumption of fried foods and sugary drinks as alternatives to fresh foods and water (Onufrak et al. 2014);
- Better understanding of the sources and pathways of fecal contamination that most strongly affect child nutrition in different contexts, across rural, urban and high-density areas, and the interventions that are most effective to interrupt these pathways;
- Impacts of the use of marginal quality water on the nutritional value of food and nutrition outcomes;
- Impacts of dietary change on all aspects of SDG 6; and
- Health and nutrition benefits related to the protection and conservation of water-related ecosystems, including through reduced pathogen transmission, increased livelihood opportunities as well as food and nutrition security.

6. KEY MESSAGES AND POLICY ACTIONS

As this document has shown, the linkages between water and nutrition are broad and persuasive. The nutrition target in SDG 2 cannot be achieved unless progress is made in achieving key targets under SDG 6. At the same time, achieving all SDG 2 targets and adequate nutrition for all could well impose substantial pressure on achieving many of the SDG 6 targets; they may thus be seen to be competing goals. To strengthen positive linkages between the water and nutrition goals and to avoid that advances in nutrition constrain advances in water targets, and vice versa, better linkages between these two SDGs and their targets are urgently needed. The following lays out a few entry points where more progress is needed.

a. Billions of people still do not have access to safe drinking water and lack adequate hygiene and sanitation services, putting them at risk of avoidable infections and disease that negatively impact nutritional status and health.

   Proposed policy actions: Improve current financing and planning mechanisms to allow for installation of new and updating of existing infrastructure, to deliver both quality and sufficient quantity of water, and to address barriers in accessing water. These developments in financial and grey infrastructure should be accompanied by context-specific and culturally sensitive behavior change communication campaigns that improve knowledge and understanding of the importance of proper WASH practices for nutrition and health. Additional research is needed to better understand WASH–nutrition linkages, which would then inform these policies.

b. Irrigation, being the single most important recipient of freshwater withdrawals with potential to influence nutritional outcomes in several direct and indirect pathways, has not been given enough attention for its role in improving nutritional outcomes. Almost no data collection, analysis and monitoring processes exist that support the understanding of how irrigation can strengthen nutrition.

   Proposed policy actions: Support research on rigorous analysis of irrigation–nutrition linkages that provides the evidence base on whether irrigation can be promoted on its merit to improve nutrition, in addition to its potential for higher yield. This includes the identification of irrigation typologies that are particularly adept for improving nutritional outcomes, that allow the irrigation of a diverse set of crops and that sustainably increase the amount of land under irrigation. The impact of combined irrigation–WASH–nutrition interventions as opposed to standalone interventions in improving nutritional outcomes also needs to be explored.

c. Reducing water pollution (biological and chemical) and treating wastewater is essential for decreasing preventable diarrhea, food-borne illness and, in turn, undernutrition.

   Proposed policy actions: Support research on the current status of water quality and the spatial and temporal distribution patterns of pollutants in water environments to better understand levels and risks for both aquatic ecosystems, but also nutrition and health. Develop a combination of approaches to address water pollution, including regulations, economic incentives and information dissemination. Enforce feasible regulations to protect water quality, giving priority to addressing major polluters as well as water bodies with highest pollution and largest potential adverse impact on nutrition and health. Widespread uptake of solutions in the pollution space requires accessible advisory services and training for farmers to adopt good practices.

d. Water scarcity is on the rise and compounds the risks the poor face in accessing water resources for household and agricultural use. Water scarcity also reduces the capacity of water bodies to dilute pollution and can put food production at risk. Therefore, addressing water variability, scarcity and competing uses is beneficial for food security and nutrition.

   Proposed policy actions: A large body of measures in the policy, institutions and technology space exist to address water scarcity, variability and competing uses. However, these need to be tailored to local conditions, ensuring that the poorest women and men receive special consideration and that linkages to nutrition are understood, highlighted and addressed.

e. As discussed, healthy water-related ecosystems provide a series of provisioning, regulating, supporting and cultural ecosystem services, many of which in turn support nutrition and health outcomes. However, these linkages are poorly understood. Many research initiatives, such as the CGIAR Research Program on Water, Land and Ecosystems (WLE), have developed basic understandings on these linkages, but further linkages with the nutrition community are needed to enhance the positive linkages from ecosystems to nutrition outcomes.

   Proposed policy actions: More evidence needs to be generated on linkages between water-related ecosystems and health and nutrition. This will be challenging, but places to start include assessing the effects of protection and conservation of watersheds on child health and nutrition, and further exploring how environmental degradation affects food insecurity and malnutrition.

f. Including target communities in decision making is crucial to creating appropriate policies that are successful in the water–nutrition space. Using smart technologies, that are culturally sensitive (including to gender and social norms), could improve all aspects of water resources and water, sanitation and hygiene management.

   Proposed policy actions: Both water resource and nutrition realities can vary dramatically from place to place, and so do water interventions to support nutrition and nutrition interventions that affect water outcomes. As a result, solutions need to be targeted to be relevant, and, whenever possible, should be co-developed or solely developed by local communities themselves following the development of awareness on the linkages.

g. Different diets have different water footprints. An increase in the demand for food with large environmental footprints is contributing to unsustainable agricultural intensification and water quality degradation.

   Proposed policy actions: The right policies and incentives can encourage people to adopt diets that are more sustainable and healthy and therefore moderate the increase in the demand for food with large water footprints. Dietary guidelines that account for environmental impacts, taxes, subsidies and environmental food labelling may all play a role in changing food choices, combined with broader environmental awareness campaigns.

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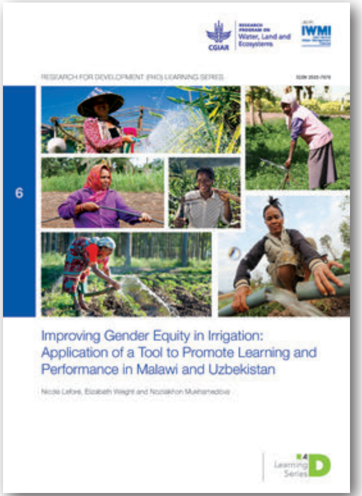

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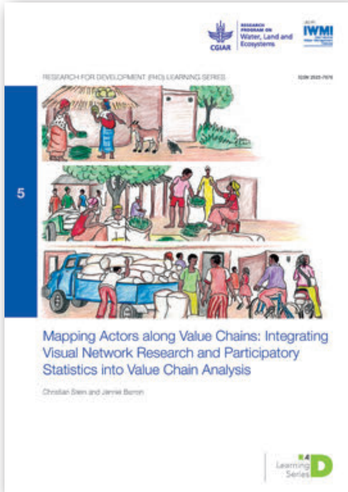

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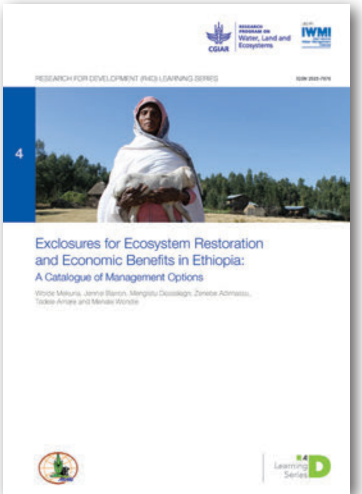

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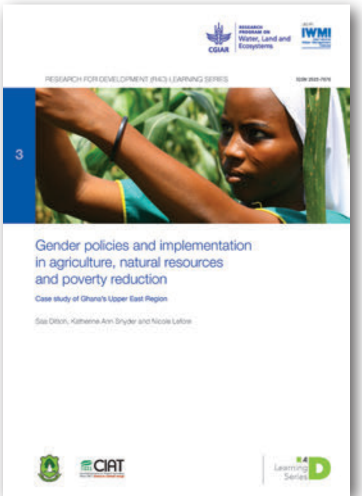

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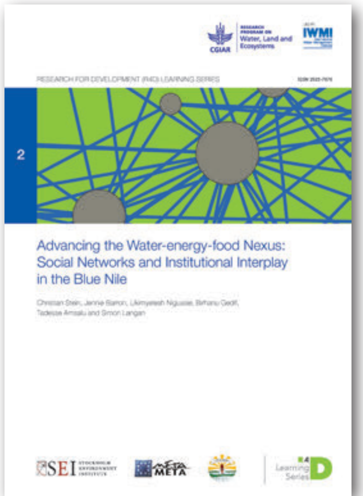

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