SDG 2 END HUNGER, ACHIEVE FOOD SECURITY AND IMPROVED NUTRITION AND PROMOTE SUSTAINABLE AGRICULTURE

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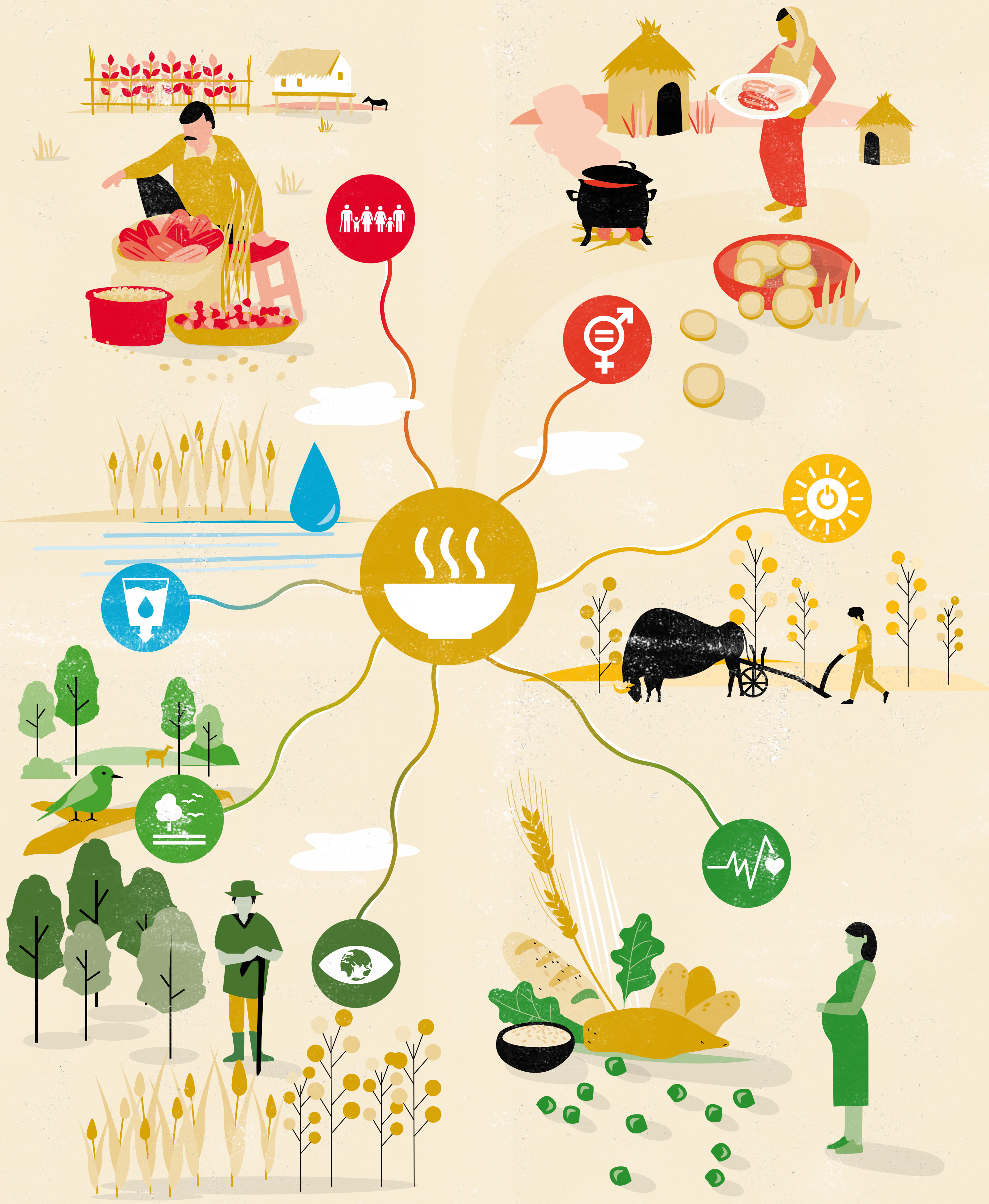

INTRODUCTION

SDG2 integrates and links food security, nutrition and a sustainable and climate-resilient agriculture. A focus on the role of small producers in the agriculture sectors is an important element. This multi-dimensional goal encompasses several specific targets, and these can be subdivided into three interrelated components: ending hunger and improving nutrition (social dimension: 2.1, 2.2), achieving food security through productivity improvement and income increase (economic dimension: 2.3, 2.a, and to a certain extent 2.b and 2.c), and promoting sustainable agriculture (environment dimension: 2.4, 2.5).

This brief description of SDG2 – the 'entry level goal' for this assessment – is followed by an overview of interactions at goal level between SDG2 and the other 16 SDGS. Taking into account all the underlying targets of this entry goal, a set of key interactions is then identified between the SDG2 targets and those of other SDGS, focusing on interactions with high magnitude or strong impacts based on available scientific literature and expert knowledge. The typology and seven-point scale for characterising the range of positive and negative interactions described in the opening chapter to this report is used to assess the selected target-level interactions and the context in which they *typically* occur. Illustrative examples from different world regions show how these linkages manifest in practice. Policy options that can enhance positive and reduce negative interactions between now and 2030, and beyond are also described. The chapter concludes with a list of key knowledge gaps related to the interactions studied.

KEY INTERACTIONS AT GOAL LEVEL

2 + 1

Ensuring that all people have access to safe, nutritious and sufficient food all year round is inextricably linked to poverty eradication and, as such, addressing undernutrition is indivisible from addressing poverty. According to the World Bank (2007), growth in agriculture is at least twice as effective in reducing poverty as growth in any other sector. There are multiple pathways through which increases in agricultural productivity can reduce poverty; key among these are increased incomes and associated multiplier effects stimulating employment in the rural and urban non-farm sectors through forward and backward linkages. However, success in agriculture does not always reduce poverty and not for everyone. This is the case in Brazil where agricultural growth in some regions has been concentrated in a dynamic export-oriented sector of large capital-intensive farms. As a result, agricultural employment declined with few poverty reduction effects. Moreover, in pursuing some of the SDG2 means of implementation, such as trade liberalisation, poverty levels might increase for some strata of society, at least in the short term and if no safety nets are established (Winters et al., 2004). Furthermore, some policies developed to improve food security for the poor, such as price controls, may have perverse impacts, such as depressing farm income. Although some evidence indicates a shift in the concentration of poverty levels from rural to urban areas, rural people continue to represent the largest segment of the world's extreme poor. However, while a large proportion of the world's extreme poor are concentrated in sub-Saharan Africa (World Bank, 2016), South Asia remains home to the largest concentration of undernourished people.

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Synergies and trade-offs can also occur between the five targets and three implementation mechanisms of SDG2. Generally the targets of ending hunger and achieving food security benefit from achievements on the economic (productivity improvement) and environmental front (sustainable agriculture) and are supported by investments in agricultural research, trade and market development. However, trade-offs can occur between the agricultural economy versus sustainability focused targets. For example, yield gaps are particularly high in sub-Saharan Africa for some of the region's major staple crops (World Bank, 2007). Closing these gaps through agricultural productivity improvement can, however, constrain the sustainability of agriculture. As an example, Duflo et al. (2008) found that in the short term, productivity increases in Kenya may be achieved most cost-effectively through the use of inorganic fertilisers, but this can adversely affect ecosystems and, in the long-term, the sustainability of the agricultural sector and its productive capacity. Based on a comprehensive meta-analysis, Ponisio et al. (2015) found a large heterogeneity in the performance of all types of production system and that diversification practices appear to be key in enhancing yields and profit. In this sense, solutions that support both productivity enhancements and sustainable agro-ecosystems do exist. Examples are context-specific and can include crop rotation to enhance soil health, permanent soil protection by cover crops or residues, no-till agriculture, increased nutrient use efficiency, low- or high-tech precision agri cultural methods, integrated soil fertility and integrated land and water management approaches (Rosegrant et al., 2014). Trade-offs can also occur between targets for agricultural production and nutrition, because increase in the agricultural production and affordability of low-nutrient and energy-rich foods can contribute to macro and micronutrient deficiencies (Johnston et al., 2014). In addition, trade-offs may arise if rural infrastructure development does not pay attention to the needs of smallholder food producers as well as biodiversity protection. Lastly, international trade patterns may enhance or constrain the economic situation of small-scale food producers.

2 + 3

Malnutrition remains one of the main contributors to the global burden of disease. Globally, 45% of child deaths under the age of five are linked to malnutrition – prominently in sub-Saharan Africa (WHO, 2016). In other words, being malnourished in any form carries significant risks to health and well-being. Agriculture influences mental, emotional and physical health directly through its ability to provide a sufficient quantity of nutritious foods for direct household consumption or in the marketplace. Quality food and nutrition status is a fundamental and crucial driver for health and well-being. However, unsustainable agricultural practices can constrain or even counteract healthy lives as a result of soil degradation and water pollution due to excessive use of chemicals (fertilisers, pesticides) and poor crop and livestock management practices; health risks associated with air pollution (e.g. sugar cane burning, or swamp drainage and clearing for agriculture), zoonotic diseases and poor food safety practices. Adequate consumption of a range of micronutrients over the course of a lifetime is also key to ensure a healthy and balanced diet and can be influenced by the diversity of foods grown. However, while improving agricultural production is essential for nutrition outcome, there are many complementary pathways including nutrition education, enhanced childcare practices, and empowerment of women in the household that are important to achieve nutritional outcomes (Ruel et al., 2013).

2 + 4

Chronic undernutrition, such as stunting, reduces intellectual capacity with possibly lifelong, irreversible consequences and might also affect subsequent generations (Victora et al., 2008). Undernutrition thus acts as a drag on education: compounding the negative effects of many other characteristics of poverty, it is associated with delayed school enrolment, impaired concentration, more schooling lost to illness, and drop-out before completion. Just as health outcomes and nutritional status are inextricably linked, the ability to learn and the nutrition of a child are mutually supportive. Moreover, a mother's educational level is an important determinant of the nutritional status of her children. Micronutrient deficiencies also affect learning ability. Almost 2 billion people worldwide are believed to be lacking in dietary iodine, including around 240 million children, and this is correlated with up to a 15-point reduction in IQ levels (WHO, 2013; Webb, 2014). Tackling undernutrition can reinforce educational efforts because children can concentrate and perform better in school with potentially lifelong positive impacts on earning capacity and well-being. Equal access to education for sustainable development and sustainable lifestyles interacts positively with food and nutrition security and also more sustainable agriculture. Such education can play a key role in helping people move towards more sustainable farming methods, and for under standing nutrition information. Similarly, in countries with high obesity rates, nutrition education can reduce the risk of non-communicable diseases such as heart disease, stroke, diabetes and cancer. Not addressing food security and nutrition and associated agricultural production practices also affects education outcomes negatively when children are kept out of school because they need to work on farms for subsistence production or elsewhere to help generate income to purchase food. Worldwide, 60% of all child labourers in the 5–17 year age group are engaged in agriculture (including farming, fishing, aquaculture, forestry, and livestock), amounting to over 98 million girls and boys (ILO, 2016).

2 + 5

Gender inequalities are the most pervasive of all inequalities, and interactions between this goal and the other SDGs are strong. Ending hunger and improving nutrition is crucial for women due to their key roles in food production, food preparation, and child care, but also because of their special vulnerabilities related to reproductive health. Furthermore, undernourished girls and women are often least able to take advantage of development resources (be it microcredit, schooling or paid jobs) because of lower work capacity due to undernutrition, sickness and inability to travel or join meetings that could be to their benefit. They are therefore less able to contribute to the goals of equality and empowerment. Empowering women in agriculture through increasing their decision-making over agricultural production and incomes has been shown to improve both family health and nutrition outcomes. According to the FAO, if women farmers had the same access to agricultural inputs, education and markets as men the number of hungry people could be reduced by 100–150 million in the 34 countries studied (FAO, 2011). Thus, through providing greater access to resources and productive assets for sustainable agriculture to women, SDG2 is also enabling gender equality and women's empowerment.

2 + 6

Progress in working towards 'zero hunger' is highly dependent on progress in ensuring availability and sustainable management of water and sanitation. Agriculture is by far the main water user. Irrigated agriculture accounts for 70% of water withdrawals and a higher share of water consumption. The interactions between SDG2 and SDG6 are undisputable with some targets enabling the achievement of others, while others are constraining and yet others are in conflict. Two of the most obvious ways to lift agricultural productivity are to expand access to irrigation and to increase the use of synthetic fertilisers and pesticides. But unless carefully planned and managed, both activities have the potential to undermine the availability, sustainability and quality of water for agriculture and for other water users. Similarly, livestock waste can constrain the protection of water-based ecosystems. Ensuring sustainability of agricultural production systems can help address this constraint. Currently about 663 million people still lack access to safe water and 2.4 billion do not have access to adequate sanitation (UNICEF/WHO, 2015). Evidence suggests a direct link between unsafe drinking water and adverse nutrition outcomes through various infectious water-borne and water-related diseases, such as malaria, diarrheal disease, and nematode infections as well as a more recently studied phenomenon called environmental enteric dysfunction, an acquired disorder of the small intestine (Dangour et al., 2013). Finally, demand for biofuels is projected to increase dramatically in the medium-term under different climate mitigation strategies; competition for water (and land) with SDG2 targets and SDG6 targets is likely to increase as a result.

2 + 7

Sustainable agriculture as well as food security and nutrition are highly dependent on energy security (affordable, easily accessible, and reliable energy supplies), because energy is often used to increase food production (agricultural chemicals, machinery, irrigation, post-harvest processing, storage and transportation, etc.). Remote agricultural areas without access to fertilisers and pesticides or electricity connections (or solar pumps) face greater challenges in increasing agricultural productivity. Conversely, agricultural production can play an important role in achieving affordable, reliable, sustainable and modern energy for all through the production of biofuels and biogas. Global energy demand is expected to increase by 48% between 2012 and 2040 – with most of the increase among the developing non-OECD nations (EIA, 2016). The interactions between these trends and SDG2 depend on (climate) policy and fossil energy prices, but could mean that more crops are diverted for use as biofuels. Furthermore, methane production from agricultural wastes (animal or plant-based) can contribute to meeting the renewable energy targets set for 2030, as can dedicated bioenergy resources (agroforestry or biofuels crops).

2 + 8

Agriculture provides a livelihood for many of the most poor and vulnerable people and supports pro-poor economic development. By increasing sustainable agricultural productivity and incomes of smallholder women and men, SDG2 can participate in sustainable economic growth. Key areas for women's participation in economic growth through agriculture include ensuring their access to financial services knowledge and markets, strengthening agriculture capacity to climate adaption, and increasing investment in rural infrastructure. Especially in remote rural areas that are cut off from most alternative employment opportunities, agriculture is often the only viable source of both employment and food and nutrition security. When rural economies develop, productivity growth in agriculture has shown to be a key aid to overall economic growth through releasing surplus labour to non-agricultural sectors, thereby spurring growth in these sectors and in the overall economy. Advances in decoupling economic growth from environmental degradation may be constrained by a focus limited to doubling agricultural productivity. Moreover, the agriculture sector is known to have an important buffer function during economic crises, with people losing their jobs in cities during financial turmoil switching to temporary employment in the agriculture sector. This was well documented during the Asian financial and economic crisis of 1989/1990 (e.g. Rosegrant and Hazell, 2000). Another important linkage relates to employment. Agricultural production strategies and systems can constrain the achievement of decent employment as 60% of all child labourers in the 5–17 year age group are engaged in agriculture (ILO, 2010). Moreover, the agriculture sector in some countries thrives on temporary migrant workers, often with limited legal and other protection. Finally, some economic growth strategies can constrain advancement of the agriculture sector, for example, if countries choose import-substitution industrialisation policies to move agrarian into industrialised economies, by taxing the agricultural surplus and moving the resources to the industrial sector (Rosegrant and Hazell, 2000).

2 + 9

With changing demographic conditions and changing patterns of food demand, there is a growing need for the design and development of more efficient integrated systems of food production, processing, preservation and distribution as well as reliable transportation and logistics infrastructure with roads facilitating access to markets (Knox et al., 2013). Infras tructure including affordable and water-use efficient irrigation, transportation, communication (e.g. internet access) and market (e.g. cold chain) facilities, could make a major contribution to achieving SDG2. Moreover, with growing climate variability and extremes, resilient transportation infrastructure, allowing food transport from surplus to climate stressed areas, will become increasingly important. Access to physical infrastructure is in this sense an important factor for the interaction between productivity and income. From an SDG2 perspective, developing and upgrading rural infrastructure, integrating small-scale enterprises into value chains, and enhancing investment in agricultural research are aligned with SDG9; however, if such infrastructure, research and financial services favours some producers over others, then achieving targets under SDG9 might constrain achievement of some SDG2 targets and/or reduce equity in access to such infrastructure (UN, 2016). For instance, more resilient infrastructure, such as larger dams supporting irrigation infrastructure, or wider, asphalted roads may address the needs of agri-exporters while ignoring those of smallholders and the food insecure. Such infrastructure may also accelerate biodiversity loss, over-extract of water resources, and ignite other unsustainable practices.

2 + 10

Hunger and food security are closely related to poverty, and thus to inequality. Reduction or elimination of inequality in the policy and legal arenas should enhance food and nutrition security as well as sustainable agricultural production. Empowering small-scale food producers, both women and men (who represent an important segment of the world's extremely poor) and ensuring their equal access to resources such as land, facilitates the reduction of inequality. Of note, trade liberalisation, an implementation mechanism suggested under SDG2, can adversely affect achieving the equality targets under SDG10, if small-scale farmers are not linked to value chains and markets and other non-competitive farming enterprises face import prices below local and national production costs. Trade liberalisation can also constrain a country's capacity to provide some forms of subsidies to domestic farmers or consumers to address internal inequalities. However, trade liberalisation can also support achieving SDG2 through making food more affordable to poor farmers, most of whom are net buyers of food, and to consumers.

2 + 11

Progress in food security and nutrition, increased agricultural productivity and more sustainable food production systems will reinforce the inclusiveness and sustainability of cities. Specifically, increased agricultural productivity – freeing up agricultural land for urban growth – can support progress on expanding green spaces and other city expansion needs. However, cities are generally built on prime agricultural land with stable water resources and uncontrolled expansion on these areas might constrain achieving SDG2, by removing further land resources and by consuming and polluting water resources. Urban agriculture can address this potential trade-off to some extent, through growing food on soil-less agriculture or hydroponics, vertical farming, aeroponics, nutrient-film-techniques, aquaponics, and through recycling of nutrients in wastewater. Urban agriculture thus can contribute to social welfare and sustainable development of cities and can support development of green spaces. It can also contribute to waste avoidance and recycling of organic waste in cities (Goldstein et al., 2016). Advancing rural-urban linkages will support sustainable agricultural productivity and income generation – peri-urban environments often house high-value vegetable and livestock production systems whose sustainable management is key to urban food and nutrition security. Of note, urban dwellers tend to consume more processed foods and, at least in low-income developing countries, tend to house more obese people and in some places (e.g. cities in Latin America and elsewhere) also more undernourished people than rural areas. Addressing the triple burden of malnutrition (obesity, undernutrition and micronutrient deficiencies) is therefore an important linkage between SDG2 and SDG11 that deserves further attention.

2 + 12

Most aspects of SDG12 support progress in SDG2 and vice versa. For example, the 10-year Framework of Programmes on Sustainable Consumption and Production Patterns is housed at UNEP (and not at UN FAO) and aims at raising awareness, building capacity, developing information as well as synergies and cooperation toward more sustainable food systems, which directly strengthen all areas of SDG2. Similarly, the subsequent efficiency, waste and loss reduction targets and the aim to manage chemicals more judiciously directly support SDG2 in terms of increased productivity and more sustainable natural resource use. While SDG2 focuses more on the production end and nutritional outcomes, SDG12 focuses on the processing, distribution and procurement side of the food system, which complements and completes the food system perspective. However, if developing countries, where most food is produced, distributed and consumed, would use the SDG12 focus on industrialised countries as a reason to not make progress on SDG12 themselves or would await funding and support from industrialised countries before embarking on progress, then some aspects of SDG2 (and SDG12) might not be achieved. An additional constraint could develop if the implementation mode proposed for rationalising inefficient fossil-fuel subsidies is implemented in agriculture and the food value chain without putting alternatives in place. The direct elimination of such subsidies could lead to increased food prices which, in turn, could constrain achieving 'zero hunger' by making food less affordable to the poor.

2 + 13

Rising temperatures, changing precipitation patterns, and the intensity and frequency of extreme weather events adversely affect agricultural production systems, particularly those in developing countries, which in turn constrains the achievement of 'zero hunger' and nutritional objectives under SDG2.
It is important that investments in agriculture increase the sector's resilience and adaptive capacity to climate change; for example, by mobilising large funds for climate mitigation and adaptation. How climate adaptation and mitigation options are implemented in the agriculture sector under the climate change frameworks (e.g. through biofuel development, short-term coping mechanisms or long-term adaptation/mitigation strategies) will be decisive for achieving SDG2. At the same time, unsustainable agriculture, deforestation and other types of land use account for about 24% of total anthropogenic greenhouse gas (GHG) emissions (IPCC, 2014). Achieving SDG13 will thus require the reduction of GHG emissions in agriculture and related activities and depending on which actions are taken, ending hunger, doubling agricultural productivity and ensuring more sustainable food production systems may be achieved faster or slower, or not at all. A range of actions could be impactful in this area, such as a moratorium on further expansion of agricultural areas into tropical forests or peatlands, a tax on highly emitting livestock production systems, increased

R&D toward new technologies that increase fertiliser nutrient use efficiency levels of plants, the accelerated adoption of no-till agriculture, and additional support to agroforestry systems. By integrating action on sustainability with action on productivity improvement (smart agriculture) and soil organic matter sequestration, agriculture could be seen as part of the solution not only to mitigate agricultural GHG emissions but also to strengthen adaptation strategies.

2 + 14

More than 3 billion people depend on marine and coastal resources for their livelihoods (United Nations, 2015b). More sustainable ocean fisheries and better access for small-scale fishers and residents of small-island states to these resources will support food security and nutrition in the long term. More research and solutions for ocean acidification would also support food security and nutrition. However, strong marine protection limiting fisheries development in the short term, can adversely affect the hunger and nutrition targets of SDG2 and can constrain livelihoods and food security of poor populations in coastal areas. Sustainable agricultural practices can support the prevention of marine pollution from land-based activities, including nutrient pollution, and can facilitate the conservation and sustainable development of the oceans. However, poorly managed agricultural processes and activities (such as nutrient runoff and diffuse pollution) may have adverse impacts on water supply and the oceans. A well-known example of largely agricultural-driven pollution is the hypoxia in the Gulf of Mexico (Hufnagl-Eichiner et al., 2011). Similarly, clearing coastal habitats such as mangrove forests that protect coastlines and sustain coastal habitat for intensive aquaculture production, could help end hunger and improve nutrition over the short term, but could also exacerbate food security concerns over the long term.

2 + 15

The Millennium Ecosystem Assessment identified agriculture as the major cause of land use change, land degradation and desertification (MEA, 2005). As such, SDG15 could constrain the aim of zero hunger, improved nutrition and increased agricultural productivity, at least in the short term. A key trade-off is *extensification*, namely a focus on low-input agriculture (e.g. some organic agricultural systems), to preserve existing agro-ecosystems versus *intensification* where inputs per unit of land are substantially increased with better seed and other technologies and management practices. While intensification reduces the need to expand agricultural areas, in many cases water consumption and pollutant runoff are increased. In some cases, increased income from intensified agriculture might accelerate deforestation, but globally, the long-term focus on intensification in much of the world has reduced deforestation rates dramatically. On the other hand, SDG15 largely supports sustainable agricultural production and genetic diversity. For SDG2 and SDG15 to become mutually reinforcing, sustainable ecological processes need to be supported, without adverse impacts on land, water and biodiversity (e.g. pollinators) and without further deforestation and associated biodiversity losses and climate change impacts. The conservation of forests, wetlands, mountains and drylands can constrain increases in both agricultural production area and crop yield as well as livestock number and yield, unless this increased production is achieved using more sustainable management practices. Other linkages between SDG2 and SDG15 concern the conservation of genetic diversity of seeds, plants and animals; an area with shared targets.

2 + 16

Achieving SDG2 is highly dependent on political stability, peace, just and inclusive societies, and effective accountable and inclusive institutions. Hunger and food insecurity are sources of political instability, conflict and war – to the point that hunger is, at times, deliberately used in conflicts as a weapon to starve opponents into submission (seizing or destroying food stocks, livestock, cutting off marketed supplies of food, targeting farmers, land-mining, etc.). And, if food insecurity is not already a factor contributing to war and civil strife, then hunger and undernutrition are often the result of such activities, as farmers need to leave their land to flee insecurity, abuse and destruction and/or agricultural inputs or outputs cannot be moved to where they are needed, and support through food aid is often restricted or not available. On the other hand, effective, transparent and accountable institutions are needed at all levels of government to support sustainable agriculture, food and nutrition security and the empowerment of certain marginal groups such as women, indigenous peoples, family farmers, pastoralists and fishers. Justice for all and non-discriminatory laws lead directly or indirectly to securing fair access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities. Armed conflict and broader forms of violence undoubtedly undermine the achievement of food security, improved nutrition and sustainable agricultural systems. Civil war and conflict are also detrimental to the preservation of seed and plant banks, as the impacts on ICARDA's (International Center for Agricultural Research in the Dry Areas) gene bank in Syria has shown (Bhattacharya, 2016). Conversely, food insecurity has the potential to become the leading cause of conflict in the 21st century in the absence of national, regional and global political measures to enhance food solidarity, particularly in crisis situations.

2 + 17

SDG17 lists the main enablers for implementing the entire SDG framework, with structures around five sub-categories: finance, technology, capacity-building, trade, and systemic issues (including policy and institutional coherence, multi-stakeholder partnerships, data, monitoring and accountability). These are all linked with SDG2. For instance, finance enhancement can reinforce investment in rural infrastructure for agriculture. Enhancing technology and capacity building can also lead to the strengthening of agriculture's capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters. Enhancing multi-stakeholder partnerships, data, monitoring and accountability, and especially policy and institutional coherence, should also positively impact SDG2. Some trade-offs can emerge insofar as trade liberalisation may not fit with some countries' policy spaces, if they seek to establish and implement policies for poverty eradication and sustainable development. Furthermore, non-discriminatory international trade regulation may limit the capacity for some countries, mostly those in development, to protect their national agriculture production and small-scale food producers.

KEY INTERACTIONS AT **TARGET-LEVEL**

SDG2 is an integral part of the 2030 Agenda, linking to all 16 other SDGS. This section analyses some of these interactions, from the perspective of SDG2, with a selected set of SDGS in detail at the target-level. SDGS were selected based on the strength of the interactions with SDG2 and the magnitude and scale of impact in relation to the overall objective of the 2030 Agenda, while ensuring a balanced consideration of the economic, social and environmental dimensions. Target-level interactions are judged to fall within one of seven categories and are scored accordingly: indivisible (+3), reinforcing (+2), enabling (+1), consistent (0), constraining (-1), counteracting (-2), and cancelling (-3). Following a generic analysis of the selected interactions, specific examples are provided to illustrate how interactions unfold in different geographical and policy contexts.

Seven goals were selected for detailed analysis:

SDG1
SDG3
SDG5
SDG6
SDG7
SDG13
SDG15

SDGS were selected based on the strength of the interactions with SDG2, while ensuring a balanced consideration of the economic, social and environmental dimensions. While there are also obvious linkages between SDG12 and SDG2, it was considered that these are less insightful than those between SDG2 and the other SDGS selected for detailed analysis.

Illustrative examples are used to show the context-dependency of the interactions and provide a more practical entry point to characterising SDG2 interactions among the ‘integrated and indivisible’ SDGS. These concern three geographic regions:

West Africa (Senegal)
Amazonia
California (USA)

SDG 2 + SDG 1

TARGETS	KEY INTERACTIONS	SCORE	POLICY OPTIONS
2.1, 2.2 ⟶ 1.1, 1.2	Food and nutrition security are indivisible from the eradication and reduction of poverty	+3	Strengthen interaction issues via national, regional and international governance. Co-design and co-develop mechanisms to mitigate the negative interactions and target particular resiliency needs by ensuring that the poor and small-scale food producers' interests are fully addressed
2.3 ⟶ overall SDG1	Increasing small-scale food producer productivity and income reinforce the fight against poverty	+2	
2.3 ⟶ 1.4	Equal access to land and other productive resources is directly aligned with securing equal rights to economic resources	+2	Advance agricultural research and development with a focus on pro-poor technology development; with complementary investments in safe drinking water, social protection systems, and rural roads
2.3 ⟶ 1.5	Increasing agricultural productivity without sustainability (2.4) will increase vulnerability to climate-related extreme events and other shocks – primarily in developing countries and for poor segments of societies. Thus, 2.3 and 2.4 need to be achieved in tandem	-1/ -2	Increase small-scale food producer capacities and empowerment (knowledge, economic resources, basic services, rights); in particular put in place the economic mechanisms that increase the wealth of small farmers and reduce their vulnerability to uncertainties: access to land, access to productive and non-productive assets Enhance diets and improve nutritional outcomes of a population to break the intergenerational cycle of poverty and at the same time generate accelerated shared economic growth. Such interactions could be reinforced via social programmes in nutrition education
2.4 ⟶ 1.5	Enhancing adaptive capacity in agriculture may enhance the resilience of the poor as long as they are fully included in adaptation strategies	0/ +1	Build resilience by setting up pro-poor policy frameworks and safeguards for poor and vulnerable small-scale food producers within a competitive market environment
2.b ⟶ 1.b	Removal of trade restrictions could constrain the creation of pro-poor policy frameworks by limiting the range of policy actions, at least in the short term	-1	Ensure inclusive participation in trade negotiations and in addressing trade related issues. Consider the situation of the poorest countries in the agriculture sector and design trade policy accordingly. Address factors leading to market failure such as limited market access. Set up complementary policies to trade reform – such as strengthening social protection systems for those losing out from trade and develop capacities to explore beneficial changes Consider the role of diversification in strategies to improve production, productivity, employment, income nutrition and sustainability, as well as to reduce risks associated with market volatility, climate change and natural disasters

KEY POINTS

SDG2 enables and can reinforce SDG1 through enhanced food and nutrition security – which are essential to reduce poverty and eradicate extreme poverty

Supporting small-scale food producers can lead to substantial poverty reduction as rural people constitute the largest segment of the world's ultra-poor

A possible constraint is the potential impact of trade liberalisation, because small-scale farmers, at least in the short term, might be adversely affected by import surges and highly competitive foreign products or food dumping practices

If targets on agricultural productivity and on ensuring sustainable food production are not implemented in tandem, the poor and those in vulnerable situations are likely to be most affected

KEY INTERACTIONS

There are many pathways through which increases in agricultural productivity can reduce poverty. Food and nutrition security **(2.1, 2.2)** are inextricably linked to reducing and eradicating poverty **(1.1, 1.2)**. Without proper nutrition, humans cannot reach their full potential. Enhancing diets and improving nutritional outcomes of a population is important to break the intergenerational cycle of poverty and at the same time generate accelerated shared economic growth. Effects will have many beneficial impacts on individuals, families, communities and countries (IFPRI, 2015).

Although recent data show the rural/urban gap in poverty to be declining, with the poor urbanising faster than the population as a whole (Chen and Ravallion, 2007), rural people still represent a large proportion of the world's extreme poor (i.e. those living on less than US$ 1.90 per day). With wide regional variation, 80% of the world's poor live in rural areas, 64% work in agriculture, 44% are 14 years old or younger, and 39% have no formal education (World Bank, 2016).

It is usually assumed that growth in agriculture is at least twice more effective in reducing poverty than change in any other sector (World Bank, 2007). In this sense, a focus on small-scale food producers and aiming at doubling their agricultural productivity and incomes (through equal access to land and other productive resources and inputs) **(2.3)**, and on resilient agriculture and adaptation practices **(2.4)** should provide significant means to achieve SDG1. Such a focus can even reinforce targets on access to equal rights to economic resources and basic services (including control over land) **(1.4)** and on building resilience of the poor and those in vulnerable situations **(1.5)**. Women are identified in both SDG1 and SDG2 as a target group to support and empower.

However, interactions between the means of implementing SDG2 and SDG1, such as removal of trade restrictions in world agricultural markets **(2.b)** versus the creation of pro-poor policy frameworks **(1.b)** can be constraining. There is a surprising number of knowledge gaps about trade liberalisation and poverty, with disputed evidence on 'automatic' long-term gains, which remain elusive even though often asserted (Chabe-Ferret et al., 2007). In terms of developing countries, some research suggests that the consequences of agricultural trade liberalisation are very uneven. In middle-income developing countries, liberalisation can be a source of substantial growth, particularly in a high-performing export sector. However, in poorer countries such as Least Developing Countries (LDCs), liberalisation can have overall negative consequences, owing to terms-of-trade effects and supply-side constraints (Bureau et al., 2006). Negative consequences will necessitate further special and differential measures by countries in trade regulations. Without these, **target 2.b** can constrain the achievement of doubling incomes of small-scale food producers **(2.3)** by setting-up a competitive market environment, which might not be pro-poor unless safeguards, for example in the form of social safety nets, are implemented for poor and vulnerable farmers.

Furthermore, **targets 2.3** and **2.4** need to be achieved in tandem as one can counteract the other, and negatively affect the poor and those in vulnerable situations. Unsustainable agriculture, deforestation and other land use changes, currently responsible for 24% of global GHG emissions (IPCC, 2014), can counteract **target 1.5** by increasing the exposure of vulnerable populations to climate-related extreme events and other economic, social and environmental shocks and disasters – primarily in developing countries and poor segments of societies. In addition, land-use change, conventional agricultural practices and pesticide use can impact negatively on the health and diversity of pollinators and the provision of pollination. Many of the world's most important cash crops are pollinator-dependent – crops such as coffee and cocoa in developing countries, or almonds in developed countries, represent an important source of income. Pollinator loss will constrain economic development, employment and income for millions of people and limit capacity to reach SDG1 (IPBES, 2016). Finally, the objective of doubled agricultural productivity **(2.3)** could, if successfully achieved, lead to substantial declines in producer prices, rendering farming non-profitable, and leave many farmers worse off unless safety nets are put in place and non-competitive farmers are successfully integrated into other employment opportunities.

KEY UNCERTAINTIES

The main uncertainty is that pursuing SDG1 and SDG2 targets does not always reduce poverty and improve food and nutrition security everywhere and for everyone. As such, there is no guarantee that pro-poor agricultural development policies reduce poverty everywhere or that poverty-focused policies improve food security everywhere. To ensure that pro-poor policies are always conducive to enhanced food and nutrition security and sustainable agriculture requires a complex policy framework that differs by geography and status of development. There is no one-size fits all, which is why poverty reduction policies do not necessarily make everyone food secure.

KEY DIMENSIONS

Time: The contribution of SDG2 to SDG1 has different time dimensions depending on the policy instrument or investment made. For instance, conventional agriculture based on synthetic chemical inputs could help alleviate hunger and thus help achieve SDG1 in a shorter time than a focus on more sustainable agriculture might; however, intense agriculture without taking sustainability into account can reduce the long-term ability to produce food for future generations.

Geography: There is a gradual shift from rural to urban for the majority of the poor and food insecure populations, a transition that has already happened in Latin America and that will soon be complete in parts of Asia and especially in Africa. Nevertheless, remote rural areas are still likely to contain some of the poorest and most food insecure people for decades to come.

Governance: Trade-offs between SDG2 and SDG1 can be mitigated by national, regional and international governance. Compensation mechanisms can be designed, if needed, to ensure that the poor and small-scale food producers' interests are taken into account in the design of pro-poor policy frameworks. Furthermore, mechanisms such as targeted cash and food transfer systems for the rural and urban poor, market-based mechanisms to increase demand for smallholder production through public procurement (e.g. the National School Feeding Programme, and Food Purchase Programme in Brazil) or water and land rights for rural dwellers, can play important roles in ensuring convergence and synergies between the two goals.

Technology: Advances in agricultural research and development (with a focus on gender-responsive, pro-poor technology development), with complementary investments in safe drinking water, social protection systems, and rural roads, would all support poverty alleviation while also enhancing food and nutrition security. Supporting institutions, such as secure land and water rights, and sound governance mechanisms that ensure access by the poor to natural resources to grow and access food, are also crucial. Technology development, innovative agricultural practices, and the application of traditional practices and ancestral knowledge in agriculture can mitigate potential constraints between **targets 2.3** and **2.4** and thus help reach targets under SDG1. For instance, Climate Smart Agriculture could support sustainable increases in agricultural productivity, farmers' incomes, and can help build resilience to climate change which would benefit the poorest and most vulnerable.

Directionality: The interactions are close to being unidirectional, as long as poverty reduction does not reduce access to food and nutrition and does not adversely affect sustainable agricultural production systems.

SDG 2 + SDG 3

TARGETS	KEY INTERACTIONS	SCORE	POLICY OPTIONS
2.1, 2.2 ⟶ 3.1, 3.2	Ensuring food and nutrition security directly creates conditions that lead to the reduction of maternal mortality and preventable deaths of newborns	+1/+2	Develop strong, open and independent institutions that promote nutritive and healthy food to reinforce the synergies between the two goals; implement nutrition-focused policies; support nutrition security through complementary pathways such as social and human capital programme devel opment, including on nutrition education, enhanced childcare practices, and empowerment of women in the household
2.1, 2.2, 2.3, 2.4 ⟶ 3.3	Food and nutrition security and stable agricultural employment help reduce communicable diseases owing to better nutrition and health status and because better rural incomes help prevent the pursuit of unsafe practices leading to communicable diseases	+1/+2	Promote sustainable agriculture including farming diversification techniques that reduce use of hazardous chemical inputs
2.3 ⟶ 3.9, 3.1, 3.2, 3.4	Increasing agricultural productivity via conventional agriculture can increase soil and water pollution constraining the reduction of deaths and illness caused by hazardous chemicals. Such chemicals can adversely affect human health, particularly of newborns, but can also affect perinatal death and cancer outcomes in the overall population	-1/-2	Support better rural incomes, stable agricultural employment, nutrition and health status, and help prevent the pursuit of unsafe practices leading to communicable diseases Further support understanding and raise awareness among governments, industry, and consumers, that agriculture, food, nutrition, health, culture, the environment, and the achievement of SDGs are strongly interdependent
2.3 ⟶ 3.4	Doubling agriculture productivity by mainly focusing on low-nutrient and energy-rich foods (calories) will constrain the fight against non-communicable diseases. This interaction is also counterbalanced by targets on nutrition	-1	Set up appropriate measures to counteract the increased health risks from irrigation services (e.g. malaria); or other agriculture-related health risks, such as those associated with pesticides and fertilisers
2.3 ⟶ 3.3	Extensification of agriculture may increase deforestation. Often accompanied by irrigation, intensification can, in some regions, increase the incidence of waterborne diseases if no hazard mitigation measures are taken, leading to an increase in communicable diseases such as malaria, counteracting its prevention	-2	Set up incentives and regulations in favour of sustainable agriculture and against uncontrolled deforestation to limit malaria increase and other diseases

KEY POINTS

Providing those in vulnerable situations with sufficient, safe and nutritious food contributes to reduced maternal mortality and preventable deaths of newborns and children under 5 years of age. Food and nutrition security and stable agricultural employment can also help reduce epidemics of communicable diseases such as AIDS, malaria, and tuberculosis, among others

Depending on the agricultural practices used, doubling agricultural productivity may constrain the elimination of death and illness from water and soil pollution and the ending epidemics of communicable diseases such as malaria

If nutrition security is not fully embraced, a focus on low-nutrient and energy-rich foods may counteract the reduction of premature mortality from non-communicable diseases

KEY INTERACTIONS

Good health is not possible without good nutrition – the two are indivisible. Ending hunger, improving nutrition and achieving food security through sustainable agriculture reinforces the reduction of maternal mortality (**3.1**) and creates positive conditions for ending the preventable deaths of newborns and children under 5 years of age (**3.2**). In this sense, a major item of **target 2.2** is to address the fundamental problem of malnutrition, both undernutrition and obesity. Although agricultural productivity improves food availability, better nutrition for children does not follow automatically (Masset et al., 2011). Creating an enabling environment for nutrition improvements requires more holistic approaches, including investment in social and human capital programme development, nutrition education, enhanced childcare practices, and empowerment of women in the household (Ruel et al., 2013).

Food and nutrition security and stable agricultural employment strongly enable the reduction of epidemics such as HIV (**3.3**) due to better nutrition and health status and better rural incomes helping prevent the pursuit of unsafe practices leading to communicable diseases. For instance, a recent study in Africa showed how local rainfall shocks can be a large source of income variation for rural households and can increase infection rates in HIV-endemic rural areas (Burke et al., 2015). According to this study, income shocks explain up to 20% of variation in HIV prevalence across African countries, suggesting existing approaches to HIV prevention could be bolstered by helping households manage income risk better.

There are negative interactions between reducing premature mortality from non-communicable diseases (**3.4**) and diets dominated by low-cost, highly processed food, which continue to increase worldwide. Over the past 50 years, consumption of sugar has tripled worldwide. Like tobacco and alcohol, 'added sugar' has been identified in many studies as a driver for abuse that could lead to diseases such as liver toxicity and other chronic diseases (Lustig et al., 2012). Negative interactions are mitigated by targets aimed at fighting malnutrition (**2.1, 2.2**).

Depending on the agriculture practices used to double productivity, potential constraints can occur for reducing the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution (**3.9**). For example, forest fires and soil cultivation in Amazonia are responsible for a significant erosion of land surfaces. Erosion of oxisols was identified as one of the main mercury enrichment processes in floodplains. Deforestation thus increases soil mercury mobilisation by runoff, which may explain the increase in mercury burden in Amazonian aquatic ecosystems in newly colonised watersheds (Roulet and Maury-Brachet, 2001).

Chemicals used in pesticides and fertilisers can adversely affect human health, particularly for newborns, but can also affect perinatal death and cancer outcomes in the overall population – thus constraining the achievement of targets concerning maternal mortality **(3.1)**, mortality of newborns and children under the age of five years **(3.2)** and mortality from non-communicable diseases **(3.4)** (Daniels et al., 1997; Vinson et al., 2011; Brainerd et al., 2014). In addition, conventional agricultural practices leading to pollinator loss may constrain production of pollinated crops such as vegetables, fruits, nuts, seeds, and oils. Many of these pollinator-dependent food products are important dietary sources of vitamins, micronutrients and minerals, without which the risks of malnutrition could increase (IPBES, 2016).

Doubling agricultural productivity **(2.3)** could constrain the reduction of premature mortality from non-communicable diseases **(3.4)** if this increase focuses on low-nutrient and energy-rich foods, such as cereals, tubers, and fats. These agricultural products are contributing to the triple burden of undernutrition, micronutrient deficiency, and obesity with its associated health issues, such as stunting, anaemia, and diabetes (Tappy et al., 2010). The poor are adversely affected in this respect because energy-rich, low-nutrient foods are becoming more affordable to them worldwide (Bernard, 2015). **Target 2.1** aims to limit this negative interaction by pointing to the need for safe and nutritious food and **target 2.2** focuses on eliminating both under-nutrition and obesity. Prevention, including a healthy and well-balanced diet, is pivotal to avoiding disease, a worsening of health-related conditions and hospitalisation. While emphasising productivity, the need for diversification of food production (not mentioned in **target 2.3**) may provide broader options for healthy diets.

Potential trade-offs could arise between the target to double agricultural productivity **(2.3)**, which may lead to practices and outcomes such as deforestation or irrigation that, in turn, lead to an increase in communicable diseases such as malaria **(3.3)**. Changes in biodiversity due to deforestation have been reported to have adverse effects on the risk of malaria in the Brazilian and Peruvian regions (Whitmee et al., 2015; Li et al., 2016). Mosquitoes that transmit malaria can benefit from deforestation due to the creation of new breeding sites, a reduction in biodiversity (including impacts on predators/prey relations), and the creation of favourable microclimates for mosquitoes to survive and reproduce (e.g. by increasing humidity). Past studies have shown that increased numbers of vectors following irrigation can lead to increased malaria in areas of unstable transmission, where people have little or no immunity to malaria parasites, such as in the African highlands and desert fringes (Ijumba and Lindsay, 2001). For instance, in northern Ethiopia, the construction of micro-dams and irrigation systems to minimise dependence on rainfed agriculture and improve food production systems led to an increase in the incidence of malaria among children under 10 years of age living near dams (Ghebreyesus et al., 1999). Similarly, failures in agriculture and vulnerability of the poorest to agricultural shocks can increase HIV AIDS infection rates, with further increases driven by poor nutritional status.

KEY UNCERTAINTIES

How consumer behaviour and preferences might change over time is unclear, especially regarding the adoption of healthier consumption patterns, and might affect or be affected by trends and methods for agricultural intensification and land use.

KEY DIMENSIONS

Time: Changes toward more sustainable and nutrition-sensitive agriculture to support healthy lives can be implemented in a relatively short period – focusing on agricultural products that enhance nutrition, without adversely affecting overall food availability. However, changing dietary patterns to address obesity can take much longer to achieve; similarly adverse impacts from poor agricultural practices can be quickly visible but might be difficult to address.

Geography: Remote rural areas contain some of the poorest and most food and health insecure people (75%). Although all regions are affected by non-communicable diseases, chronic disease disproportionately affects low- and middle-income countries where nearly three quarters of deaths occur (28 million) (WHO, 2014). Once considered a high-income country problem, overweight and obesity are now an increasing issue in low- and middle-income countries, especially in urban settings.

Governance: Strong and open institutions in favour of promoting nutritious and healthy food can play a significant role in reinforcing the synergies between SDG2 and SDG3. Incentives and regulations in favour of sustainable agriculture and against uncontrolled deforestation would mitigate some of the trade-offs.

Technology: Innovation in agricultural practices, or in highly nutritive (new) food products (insects, etc.) can also address some of the trade-offs between SDG2 and SDG5.

Directionality: Mostly unidirectional – SDG2 affects SDG3, but poor health status can also reduce the absorption of food; here health-based solutions can help improving SDG2 outcomes.

SDG 2 + SDG 5

TARGETS	KEY INTERACTIONS	SCORE	POLICY OPTIONS
2.1, 2.2 ⟷ overall SDG5	Ensuring food and nutrition security reinforces women's empowerment. In turn, women's empowerment is enabling nutrition security due partly to their role in food production and preparation and their greater inclination to spend resources they control on family nutrition and health	+2	Support policies that ensure adequate and sufficient diets for everyone; as well as policies that strengthen women's empowerment in agriculture. Promote equal access to productive resources, rights and services in agriculture can reinforces the synergetic interactions between women's empowerment and food and nutrition security Further explore and invest in in gender-equitable agricultural innovations. Technologies that improve access to assets and resources and save women's time are particularly important for women's empowerment
2.3 ⟶ 5.5, 5.a	Promoting investment in rural infrastructure, securing equal access to productive resources (including land), and increasing income strengthens women's empowerment and gender equality	+2	
2.a ⟷ 5.b	Access to technology is an important lever to enable women's empowerment in agriculture and overall – the two means of implementation mutually reinforce each other	+1	

KEY POINTS

SDG2 interacts with and reinforces the achievement of SDG5 in many ways, ranging from food and nutrition security for all, and especially for women and girls, to gender equality in access to productive resources, and to promoting gender-equitable investment in rural infrastructure

SDG2 facilitates the use of technologies to promote women's empowerment along agricultural value chains, for enhanced nutrition outcomes, and in the maintenance of genetic resources

KEY INTERACTIONS

Targets 2.2 and **2.3** include a specific reference to the need for gender equality for achieving the full agricultural and nutrition potential envisioned. Ensuring food security with a special focus on reducing undernutrition in adolescent girls and women of childbearing age will support them to take full advantage of development resources. Empowering women is crucial for achieving SDG2 due to the important role many women have in food production, food preparation, child care and for overall nutritional outcome in families, as well as their specific vulnerabilities related to reproductive health (Pinstrup-Andersen, 2011; Duflo, 2012). Recognising that women are often over-represented among the rural poor, **target 2.3** calls for a doubling of the agricultural productivity and incomes of small-scale food producers, particularly women. **Target 2.3** links investment in sustainable agriculture with the establishment of pro-poor and gender sensitive development strategies. Smallholder female farmers face specific barriers to increasing agricultural productivity, such as restricted access to information, technologies, finance, and voice in farmer-related associations, compounding restrictions imposed by unequal access to education in many countries and regions. Since women's lack of, or limited access to, productive resources is among the main reasons why they are poorer and often less efficient than men as economic agents (Asian Development Bank, 2013), by promoting investment in rural infrastructure with equal access to productive resources (including equal access to land, technologies and financial services), **target 2.3** can help increase women's full and effective participation at all levels of decision-making **(5.5)**, and can reinforce women's equal right to economic resources as well as access to financial services and ownership over their land and other forms of property **(5.a)**. Unequal access to land is a major factor limiting empowerment of women farmers because land is a pivotal resource for meeting subsistence needs, and for accessing other goods and services, such as credit. If women farmers had the same access to agricultural inputs, education and markets as men the number of hungry people could be reduced by 100–150 million in the 34 countries studied (FAO, 2011).

By promoting investment in agricultural research and extension services, as well as technology development, **target 2.a** enhances the use of enabling technologies to promote women's empowerment **(5.b)**.

KEY UNCERTAINTIES

There is insufficient knowledge about links between gender equality and several aspects of SDG2. Food systems and gender equality are highly location-specific and therefore require contextualised and integrated research, policies and investments.

KEY DIMENSIONS

Time: For improvements in SDG5 to *translate* into improvements of SDG2 may take generations because social norms related to gender inequality change slowly.

Geography: Linkages between SDG5 and SDG2 are highly location-specific.

Governance: Strong institutions establishing gender responsive development strategies are key to capitalising on synergies between SDG2 and SDG5.

Technology: Gender-responsive agricultural technologies and innovations have a large potential to bridge the gender gap in agricultural productivity, food security and nutrition, and can reinforce positive synergies between SDG2 and SDG5. Technologies that improve access to assets and resources and save women's time are particularly important for women's empowerment in agriculture.

Directionality: The tendency is a bidirectional positive interaction between SDG2 and SDG5.

SDG 2 + SDG 6

TARGETS	KEY INTERACTIONS	SCORE	POLICY OPTIONS
2.4 ⟶ 6.3	Sustainable agriculture enables the improvement of water quality by reducing pollution	+1	Promote sustainable agricultural technologies that support land and soil quality improvement and the protection/restoration of water related ecosystems. For instance: more diverse rotations and associations in agriculture (including industrial agriculture) are often less energy-consuming and use fewer pesticides and fertilisers, lowering freshwater toxicity
2.4 ⟶ 6.6	Sustainable agriculture, improving land and soil quality reinforces the protection/restoration of water-related ecosystems	+2	
2.2, 2.1 ⟵ 6.1, 6.2	Safe and affordable drinking water and adequate and equitable sanitation are essential to address undernutrition	+2	
2.3 ⟶ 6.1, 6.2, 6.4	Competition over water can result in trade-offs. Intensive conventional agriculture can constrain and in some cases counteract access to safe drinking water, proper sanitation, and the fight against water scarcity	-1/ -2	Promote sustainable agricultural technologies and research/ technology activities, such as breeding of drought tolerant crops, or use of advanced irrigation technologies to reduce water use in agriculture; develop guidelines for sustainable agricultural water use to engage all sectors on the important topic of water savings
2.3 ⟶ 6.3, 6.6	Pollution due to unsustainable agriculture can constrain or even counteract the reduction of water pollution and the protection / restoration of water and related ecosystems	-1/ -2	Enhance institutional capacity, and improve communication and coordination between public departments to design coherent water resource policies and regulatory practices to address water scarcity and pollution

KEY POINTS

Sustainable agriculture that helps maintain ecosystems and progressively improves soil and land quality should lead to the improvement of water quality and quantity through reduced pollution and should reinforce the protection and restoration of water-related ecosystems

Some targets are reinforcing, with SDG6 enhancing access to safe and affordable drinking water for all, and adequate and equitable sanitation for all being essential for ending all forms of malnutrition

Increasing agricultural productivity can limit access to safe drinking water and adequate and equitable sanitation, which, in turn, can increase the number of people affected by water scarcity and pollution

Conventional food production and processing systems can constrain the reduction of water pollution and can counteract the protection and restoration of water-related ecosystems, including aquifers

KEY INTERACTIONS

Pressure on freshwater resources is increasing throughout the world. With food production responsible for the largest share of freshwater withdrawals, SDG2 is highly dependent on the achievement of several SDG6 targets.

Irrigated agriculture accounts for 70% of water withdrawals globally, and this can rise to more than 80% in some regions (FAO-AQUASTAT, 2016). Global demand for water is expected to grow significantly for all major water use sectors, with total demand expected to increase by about 20% by 2050 (Connor and Webber, 2014). In this context, ensuring sustainable agricultural practices that help maintain ecosystems and progressively improve soil and land quality **(2.4)** should lead to improvement of water quality **(6.3)** and protection and restoration of water-related ecosystems **(6.6)**. These positive synergies are often bidirectional. For example, ending all forms of malnutrition **(2.2)** has strong and direct links with enhancing access to safe and affordable drinking water for all **(6.1)**, and adequate and equitable sanitation for all **(6.2)**.

Expansion of agricultural land to avoid overuse of chemicals, can lead to deforestation and adverse impacts on water-based ecosystems. Similarly, unsustainable intensification of agriculture **(2.3)** to help end hunger can lead to overuse, and pollution of water resources, which in turn could exacerbate food security concerns. Demand for various types of biomass is projected to increase dramatically in the medium-term, due to population growth, growing wealth, urbanisation, and changing d ietary patterns (OECD/FAO, 2014). In this context, competition over water can result in trade-off between SDG2 (mainly **2.1, 2.2, 2.3, 2.a**) and SDG6.

Conventional food production can deplete groundwater resources, pollute water bodies (e.g. eutrophication), and can reduce non-agricultural water availability and use, such as for drinking water (e.g. through soil degradation and resulting siltation of downstream reservoirs). Reversal of land and water degradation, and pumping of groundwater from greater depth are generally very costly, energy-intensive, and adversely affected by climate change. Intensification of land use might also reduce water quality and availability where rates of water extraction for irrigation exceed rates of replenishment. In this context, doubling agriculture productivity **(2.3)** could have negative impacts on universal access to safe drinking water **(6.1)**, and adequate and equitable sanitation **(6.2)** and counteract the reduction of people suffering from water scarcity **(6.4)**.

Conventional food production and processing systems release pollutants that build up in the environment, including waste and pollution of water supplies. They also have negative impacts on overall efficiency of water and land use for other ecosystem services – which constrain the reduction of water pollution **(6.3)** and the protection and restoration of water related ecosystems, including aquifers **(6.6)**.

Non-achievement of SDG6, can adversely affect food prices and increase food price volatility **(2.c)**, in addition to constraining all other targets under SDG2. Nevertheless, while food price volatility is higher with insufficient water availability in agriculture, functioning food markets can help move food from water abundant to more water constrained regions **(2.b)**.

KEY UNCERTAINTIES

Water availability for food systems is under growing threat from increasing non-agricultural demands, agricultural uses, and climate change. How these various factors will play out and what level and type of investments will be undertaken to reduce these risks and uncertainties is a further uncertainty.

KEY DIMENSIONS

Time: Some elements of the interactions are short-term (i.e. no water, no food, no safe drinking water, and no proper nutrition), while others are longer-term (e.g. water pollution and longer-term degradation).

Geography: (1) Linkages are geography- and climate-specific, but some general 'rules' hold (i.e. no water, no food unless trade in food is well established). Water productivity in kcal per m³ varies widely among crops, cropping systems, and water and agricultural management practices, which are subject to cultural preferences and traditions. (2) Global trade in goods and water-intensive products (virtual water flows) can offset high national water consumption levels, allowing countries with limited water resources to rely on water resources in other countries. Approximately 40% of the world's population lives in transboundary river or lake basins with hydrological and associated social and economic interdependencies. In countries where competition over and pollution of transboundary water resources increases, tensions and conflicts between countries can arise.

Governance: Governance over water resources remains relatively weak, particularly in terms of water quality, which affects food and nutrition security in many ways. Strong institutions and policies as well as regulations on water resources are essential for addressing some of the competition over water use between SDG2 and SDG6 targets. Good governance and strong institutions could also help ensure that agricultural productivity is increased through sustainable agricultural practices, which in turn enable the achievement of some SDG6 targets.

Technology: A wide range of technologies that affect water use in agriculture are in use and more are under development. They range from low-cost technologies, such as rainwater harvesting to the breeding of drought, heat and submergence tolerant crops, to advanced irrigation technologies that support irrigation scheduling and accurately and on time meet crop water demands and the use of precision agriculture techniques, including the use of soil, plant and weather sensors. Further observations, technologies, modelling and decision-support systems based on soil moisture to improve targeted irrigation can play an important role in enhancing the sustainable use of fresh water.

Directionality: Interactions are bi-directional. For example, maintaining water quality might constrain the doubling of agricultural productivity but would support nutrition security.

SDG 2 + SDG 7

TARGETS	KEY INTERACTIONS	SCORE	POLICY OPTIONS
2.3, 2.4 ⟶ 7.1, 7.2	Increasing food productivity and farmers' revenues may enable the increase of renewable energy in the global energy mix via biofuel production. This may also increase access to affordable, reliable and modern energy services	+1	Design policies geared toward avoiding competition for land between energy and food purposes and 'land grabbing' Promote the creation of sustainable bioenergy-related jobs and diversified income for small food producers Maximise energy production from agricultural wastes Promote local production of renewable energy and ensure careful planning and multi-stakeholder participation in large infrastructure development projects that may impact freshwater ecosystems, agricultural lands and local communities' livelihoods. Further explore technology for higher crop yields, and target bioenergy production on degraded land if competition with land and water for food can be avoided
2.3, 2.1 ⟵ 7.3, 7.1	Affordable energy and improving energy efficiency for agriculture may facilitate increases in food production, farmer revenues, and indirectly food and nutrition security	+2	
2.3 ⟶ 7.1, 7.2	Competition over land and water can results in trade-offs. Doubling agricultural production may constrain the use of water at the expense of increasing renewable energy sources (e.g. hydropower) or the use of other water-related energy sources	-1/ -2	
2.1, 2.2 ⟶ 7.1, 7.2	Food and nutrition security may constrain the use of water and land, at the expense of energy production such as bioenergy	-1	

KEY POINTS

Agroforestry, biofuel crops, and the use of agricultural waste can enable an increase in renewable energy in the global energy mix

Agriculture aiming at energy production can enable the increase of small farmers' revenues through more diversified production, and support universal access to affordable, reliable and modern energy services

Affordable energy and better energy efficiency can enable increased agricultural productivity and revenues and by doing so, provide broader support for ending hunger and malnutrition

Competition over the same resources (land and water) may result in negative interactions between SDG2 and SDG7. Increased agricultural production and food and nutrition security may constrain the use of land and water for bioenergy, thus limiting the increase of renewable energy and constraining universal access to energy. Similarly, bioenergy development can constrain use of agricultural by-products for soil fertility enhancement and can adversely affect food and nutrition security targets through competition for land, water and biomass

KEY INTERACTIONS

Ending hunger, undernutrition and food insecurity through sustainable agriculture interacts at several levels with ensuring access to affordable, reliable, sustainable and modern energy for all. With worldwide energy demand expected to increase by 48% between 2012 and 2040 (EIA, 2016), agroforestry, biofuel crops, and the use of agricultural wastes (animal or plant), can support progress on SDG7. In this sense, sustainable agriculture, mainly through doubling agricultural productivity (2.3) and ensuring sustainable food production systems (2.4) can help increase the share of renewable energy in the global mix (7.2). In addition, biofuels as part of the production mix can lead to the diversification of agriculture from which farmers can benefit and thus lead to positive synergies with **target 2.3** focusing, among other things, on doubling revenues of small-scale food producers. This can facilitate and enable universal access to affordable, reliable and modern energy services (7.1).

Reciprocally, improving energy efficiency (7.3) and better access to affordable, reliable and modern energy services (7.1) can provide crucial leverage such as better access to water-pumping and irrigation systems, or other energy-intensive agriculture technologies, such as processing, storage and transportation systems for agricultural commodities. Such positive interactions should enable the targets on productivity and enhanced incomes (2.3) and on ending hunger and malnutrition (2.1, 2.2). Competition over the same resources may result in negative interactions. Food and nutrition security (2.1, 2.2) as well as the increase in agricultural productivity and income (2.3) may constrain the use of land and water at the expense of bioenergy production and overall renewable energy deployment – that is, water is needed for all types of energy production, but particularly for bioenergy, hydropower, thermal power production, coal, solar systems (7.1, 7.2).

In the case of hydropower production, large dam infrastructure can constrain food systems, both for fisheries and for food supply due to changes in the timing, quantity and quality of the water released for irrigation. Moreover, similar to other large-scale energy-dense agricultural commodities, large-scale biofuel production systems can adversely impact water, soil and land quality and would need to be implemented using sustainable management practices. Furthermore, raising levels of irrigation to increase agricultural productivity, but also the higher energy requirements for pumping water over long distances could exacerbate this competition and further deepen negative interactions between SDG2 and SDG7.

Those interactions are highly context dependent, and synergies or trade-offs can emerge depending on the type of the biomass, the relative shares of food and biofuel production (and subsidies), and the potential indirect spillover effects due to international trade structures and patterns. Good governance and coherence are key to mitigate negative interactions and explore the synergies between SDG2 and SDG7. In this sense, farm activities could be promoted toward maximising energy production from agricultural wastes, and reinforced synergies between **targets 2.3** and **2.4** and **targets 7.1** and **7.2**.

KEY UNCERTAINTIES

Key uncertainties remain regarding future bioenergy production levels, which are currently largely driven by subsidies and climate policies. The role of bioenergy production can both support and constrain the achievement of SDG2, and can constrain SDG2 more so than other renewable energy sources. Other critical uncertainties concern competition over natural resources between SDG2 and SDG7, many of which are driven by rapid changes in innovation, and changes in cost structures and subsidies for alternative technologies.

KEY DIMENSIONS

Time: Interactions between SDG2 and SDG7 (synergies and trade-offs), can have both immediate and longer-term impacts. For example, lack of energy availability in rural areas prevents the extraction of deep groundwater resources for irrigation until the area is electrified or diesel or solar pumps are accessible, a process that can take time. Application of energy in the form of fertilisers can quickly boost food production with results visible at the end of the growing season. Bioenergy-SDG2 linkages have both shorter-term and longer-term elements: production of energy sources can be achieved in a season (or a few years depending on the plant) while longer-term soil, land and water quality and sustainability implications might take years to materialize.

Geography: Linkages are highly location-specific, but changes in one country can also have spill-over impacts on other parts of the world given the nature of international trade structures and patterns.

Governance: Good governance, careful planning designed via inclusive and open policymaking are important. Such governance mechanisms need to study potential positive and negative linkages between SDG2 and SDG7 investments. For instance, integrative participation of local small food producers in renewable infrastructure construction (e.g. hydropower) or large-scale biofuel production is key to ensure coherence among the goals and identify a wider range of impacts.

Technology: Technological change has a significant impact on the interactions between SDG7 and SDG2. For example, continued energy-based innovation is helping to increase water, land and energy efficiency in agriculture. Climate smart agricultural practices can enhance the use of agricultural wastes (animal or plant) in support of local and sustainable energy production.

Directionality: The linkage can be bi-directional. For example, solar-powered pumps can deplete groundwater resources that are fundamental to food security; thus making energy accessible to all might compete with the sustainability of food production. But making energy accessible to all should also put more energy in the hands of the rural poor for agricultural use (such as fertilisers). Regarding biofuel, relations might be asymmetric. For example, growing bioenergy crops may undermine the eradication of hunger more than implementation of SDG2 would affect and limit the generation of renewable energy sources.

SDG 2 + SDG 13

TARGETS	KEY INTERACTIONS	SCORE	POLICY OPTIONS – IN ADDITION TO THE COMPLEMENTARY ONES HIGHLIGHTED FOR SDG 2/SDG 7 AND SDG 6
2.4, 2.5 ⟶ 13.1	Resilient agricultural practices and maintaining and giving access to seeds/plant/animal genetic diversity should reinforce adaptation to climate change	+2	Design policies and mechanisms to foster and support agricultural action plans with triple wins for food security, adaptation and mitigation. Promote resilient strategies and practices, including market- and regulatory-based measures
2.a ⟶ 13.2, 13.3, 13.b	Enhancing international cooperation in agriculture research, science, and services should enable climate change measurements and raise awareness on climate challenges, and promote mechanisms to address them	+2	Support science and research in agricultural adaptation and mitigation. Enhance international cooperation and build scientific capacity (especially in developing countries) in agriculture research, science, and climate science and services
2.3, 2.4, 2.5 ⟵ 13.b	Positive feedback from raising awareness and capacity on climate change impacts (mitigation and adaptation) to setting up sustainable and productive agriculture practices, and maintaining biodiversity	+2	Support multi-stakeholders platform and science / society / policy interfaces: including scientists, civil society organisations, farmers, policy decision-makers
2.3 ⟶ 13.1	Unsustainable agriculture focusing solely on productivity may counteract climate adaption by increasing climate instability and extreme events	-2	

KEY POINTS

SDG2 directly affects SDG13, since today's agriculture directly accounts for about 14% of greenhouse gas emissions. Similarly, SDG13 directly affects SDG2

SDG2 targets on resilient, sustainable food production and genetic diversity reinforce resilience and adaptive capacity to climate change and risks. Under some conditions, they can also support climate mitigation

By enhancing international cooperation and building joint initiatives, SDG2 enables the integration of climate change measures into national policies, strategies and planning and awareness raising on climate mitigation and adaptation

Boosting agriculture productivity relying solely on 'business-as-usual' agricultural practices may counteract resilience and adaptive capacity to climate change. Instead, sustainability and productivity improvement within SDG2 need to be realised in tandem to ensure synergies with SDG13 targets

KEY INTERACTIONS

Agriculture accounts for about 14% of GHG emissions and 24% when forestry and other land uses are included (IPCC, 2014), a close second in global GHG emissions after electricity and heat production. Deforestation, livestock emissions, and soil and nutrient management, are some of the key drivers. At the same time, the challenge is to meet the needs of a growing world population and rising average incomes per person which implies an increase in demand for all agricultural commodities especially livestock products. SDG13 focuses mainly on climate adaptation issues, but in acknowledging the role of the United Nations Framework Convention on Climate Change, the goal also indirectly addresses climate mitigation and the main aim of the Paris Agreement signed in December 2015 to keep global temperature rise this century well below 2°C above pre-industrial levels (UN, 2015a). The Paris Agreement does not set specific parameters on climate mitigation targets for the agriculture sector which is very briefly mentioned within the Agreement preamble, but many of the country-level strategies (94%) presented through Nationally Determined Contributions (NDCs) do include mitigation action in the agricultural sector; albeit without clear benchmarks. Through the NDCs, the integration of climate change measures into national planning (**13.2**) is already underway but close follow-up work on the integration of strategies to mitigate climate change in agriculture are still needed. Overall, SDG2 targets converge with the Paris Agreement.

Beyond climate mitigation, sustainable food productions systems (**2.4**) that strengthen capacity for adaptation, and that progressively improve soil and land quality will reinforce the pursuit of resilience and adaptive capacity to climate change and risks (**13.1**). Improving soil properties such as Carbon Stock will contribute to adaption to climate variability, that is, higher Soil Carbon stock will improve water availability for crops, and crops will adapt to adverse and erratic weather. In addition, by maintaining the genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their wild species (**2.5**), and ensuring their access to farmers will offer efficient options for adaptation and resilience to climate change. Furthermore, **target 2.a** on enhancing international cooperation might facilitate the integration of climate change measures into national policies, strategies and planning (**13.2**) by providing, for example, science-based evidence. International support can also help raise awareness on climate mitigation and adaptation (**13.3**). Feedbacks from SDG13 to SDG2 are also synergetic as land food production is generally reinforced by a stable climate – in contrast to extreme weather events (droughts, floods). Food from fisheries for instance is also reinforced by protecting the climate, because that limits ocean warming and ocean acidification and, indirectly, the loss of marine biodiversity and fish resources. In this sense, the positive feedback from **target 13.3** on raising awareness and capacity on climate change mitigation is very relevant. However, going beyond awareness raising is essential to give practical effect to this synergy because agricultural productivity could fall dramatically, especially in developing countries (Cline, 2007) as well as global food production from marine ecosystems. Potential interactions from SDG2 achievement may counteract SDG13. Should **target 2.3** rely solely on 'business-as-usual' practices with conventional and unsustainable agriculture production driven by short term productivity improvements and leading to negative impacts such as soil quality decrease and/or deforestation; resilience and adaptive capacity to climate change (**13.1**) and climate mitigation efforts will be offset.

Sustainability and productivity improvement within SDG2 needs to be fully realised in tandem to ensure synergies with SDG13 targets. Solutions do exist to enable a shift from a negative to more positive interactions. For instance, 'smart and climate-sensitive agriculture approaches, such as the '4 per 1000 Initiative' launched by France on the side of COP21, or the initiative for the Adaptation of African Agriculture (AAA) launched upstream of COP22, aim at reconciling food security with climate mitigation by engaging in resilient and sustainable agriculture practices. Building capacity and awareness raising are also key to design converging actions in doubling agricultural production in a sustainable way, combat climate change, and ensure the use of well adapted natural resources for better climate resilience, such as traditional crop varieties as well as new biotechnologies.

KEY UNCERTAINTIES

The time required to bridge the gap between sustainable agriculture practices and food security worldwide is highly uncertain and cannot yet be predicted. There are also uncertainties on climate variability and its impact on current agro-ecology and adaptive agricultural practices.

KEY DIMENSIONS

Time: Conventional agriculture will impact negatively on climate mitigation and adaptation over the short, medium and long term. Bridging the gap between sustainable agriculture practices and food security worldwide will take time but can be achieved progressively.

Geography: There is strong variation in country-level approaches to climate and agriculture. China, the largest agricultural GHG emitter, is followed by India, and Brazil. Advanced economy agricultural producers such as the USA or Australia, also have large agricultural GHG emissions. Indonesia, a large emerging economy, is an important agricultural GHG emitter and the top emitter in land-use change and forestry. Other agricultural GHG emitters are much smaller, such as those in sub-Saharan Africa.

Governance: Climate Smart Agriculture and resilient strategies and practices can be promoted by a range of policy approaches, including market- and regulatory-based measures. Sustainable practices, resilient technologies and consumer preferences can be guided and supported by policymaking. Furthermore, setting a carbon price for agriculture could push forward the adoption of agricultural productivity measures.

Technology: Science and research play a major role in agriculture adaptation and mitigation. Biotechnology, and location-appropriate crop varieties that are resistant to fluctuations in temperature and precipitation are key to provide climate adaptation solutions to farmers. Land management to maintain and increase soil organic carbon stock should be promoted to reinforce synergies between adaptation and mitigation. Climate Smart Agriculture can help provide practical solutions to climate change challenges, as well as food security through the use of farming methods that match local conditions (e.g. agroecology, agroforestry, conservation agriculture, landscape management).

Directionality: Bidirectional. A change in agriculture practices is necessary to limit global climate change over the long term, and food production is reinforced by a stable climate.

SDG 2 + SDG 15

TARGETS	KEY INTERACTIONS	SCORE	POLICY OPTIONS – IN ADDITION TO THE COMPLEMENTARY ONES HIGHLIGHTED FOR SDG 2 / SDG 13
2.4 ⟶ 15.1, 15.2, 15.3, 15.4	Agriculture impacts on the well-being of terrestrial ecosystems (sustainable food production system and agriculture practices) should reinforce the maintenance of terrestrial ecosystems and the prevention of land as well as biodiversity erosion	+2	Maintain and provide access to seeds/plant/animal genetic diversity Set up appropriate monitoring systems at the correct scales to understand how agriculture impacts on land degradation and biodiversity loss. Developed landscape-scale management approaches to address some of the trade-offs between biodiversity conservation and agriculture development Support multi-stakeholder platforms and science / society / policy interfaces: including scientists, civil society organizations, farmers, policy decision-makers. Giving space to traditional knowledge is key in this regard
2.3, 2.4 ⟵ 15.3, 15.5, 15.8	Combatting desertification, restoring degraded land, and reducing the impact of invasive species as well as fair and better access to genetic resource enable sustainable agriculture	+1	
2.a ⟶ 15.a, 15.b	Enhancing investment in international agriculture cooperation can participate in resource mobilisation for sustainable management of ecosystems	+1	
2.3 ⟶ 15.1, 15.2, 15.3, 15.5	Intense agriculture and revenue increase based solely on agricultural productivity without sustainability may counteract ecosystem protection/restoration, and increase deforestation and land degradation	-2	

KEY POINTS

Sustainable and resilient agriculture practices aligned to ecosystems protection can reinforce conservation, restoration and sustainable use of terrestrial ecosystems, sustainable forestry and arresting deforestation, and contribute to the restoration of degraded land and soils, as well as combatting desertification

Maintaining genetic diversity and its access is aligned with promoting the fair sharing of genetic resources, and slowing or preventing the extinction of endangered species

Enhancing investment in international cooperation, technology, and gene banks could facilitate the mobilisation of financial resources to conserve and sustainably use biodiversity

Extension of agricultural areas can lead to an increase in agricultural income but can also increase deforestation

If increasing agricultural productivity relies on practices and technologies that contribute to land and soil degradation and high GHG emissions, targets focused on the conservation, restoration and sustainable use of terrestrial ecosystems, forests, soils and biodiversity might not be achieved

KEY INTERACTIONS

Agriculture is one of the key drivers of change in biodiversity, ecosystems, forests, desertification, and land and soil quality. Those interactions are usually closely related to the relationship between productivity and income, with a growing need for sustainable agriculture practices. SDG2 has many direct interactions with SDG15. Any actions aiming at achieving **target** 2.4 on sustainable and resilient agriculture practices aligned to ecosystems protection, and the progressive improvement of land and soil quality would reinforce the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services (**15.1** and **15.4** on mountain ecosystems); sustainable forestry and the halt to deforestation (**15.2**); and combatting desertification and promoting restoration of degraded land and soil (**15.3**). In addition, maintaining the genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their wild species and ensuring their fair access to farmers (**2.5**), is aligned with **target 15.6** on the utilisation of genetic resources, and the extinction prevention of threatened species (**15.5**). Investment in international cooperation, research and technology (**2.a**) can also provide important resources to conserve and sustainably use biodiversity and ecosystems (**15.a**, **15.b**) and restore degraded lands and soils, thus contributing to a reduction in desertification.

Similar to several SDG2 interactions with other goals, sustainability targets need to be fully integrated with food productivity and small-scale farmers' income improvement targets (i.e. **2.3**, and indirectly **2.1** and **2.2**). Access to markets (mainly via roads) can promote the extension of agricultural areas, particularly for cash crop cultivation, and might lead to an increase in agricultural productivity and income (Khandker et al., 2009). However, this could lead to deforestation – counteracting **target 15.2** on halting deforestation and increasing afforestation and reforestation globally; and other negative externalities for the environment. Furthermore, should the need for food productivity rely on practices and techniques responsible for land degradation, high GHG emission (i.e. the 'business-as-usual' scenario), and land pollution, this will counteract **targets 15.1, 15.2, 15.3** and **15.5**.

Intensive agricultural management with high use of agrochemicals and intense tillage, grazing or mowing, can counteract SDG15 (especially **15.5**). Animal pollination is a key regulating ecosystem service in nature – almost 90% of wild flowering plants depend on animal pollination. Intensive agricultural management, pesticide use and land-use change are key drivers of pollinator loss. Insecticides (especially neonicotinoids) have been demonstrated to have lethal and sublethal effects on pollinators. It has been estimated that 16.5% of global vertebrate pollinators and more than 40% of invertebrate pollinator species such as bees and butterflies are facing extinction (IPBES, 2016). Alternative forms of agriculture and sustainable pest control methods need to be promoted to address pollinator decline and their multiple implications on terrestrial ecosystems.

KEY UNCERTAINTIES

The appropriate scale at which to take stock and analyse interactions between SDG2 and SDG15 is a key uncertainty. Such interactions are highly context dependent and require different analytical frames and landscape-scale approaches.

KEY DIMENSIONS

Time: Restoration of degraded land might take several years to achieve lasting positive impacts.

Geography: Linkages are context dependent since the level of land degradation and biodiversity status differ from one region to another. Local and indigenous peoples' rights and livelihoods and valuable local knowledge should be considered in conservation efforts aimed at preserving and restoring biodiversity.

Governance: Governance can play a significant role in developing better interactions between SDG2 and SDG15 through programme and planning settings such as the plan for Actions launched by the UN Convention to Combat Desertification, including targets to achieve land degradation neutrality (LDN; Orr et al., 2017), and Biodiversity (IPBES) aimed at achieving food security.

Technology: Sustainable land management (i.e. the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions; Dumanski and Smyth, 1993) should be promoted. Sustainable land management is a way to harmonize the complementary goals of providing environmental, economic, and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the land (soil, water and air) resource.

Innovative agroecology techniques such as ecological pest management can play an important role in reinforcing positive interaction between SDG2 and SDG15. For instance, the push-pull system – using repellent plants (push) and trap plants (pull) to control agricultural pests, or the use of key beneficial insects such as arthropod predators and parasitoids for biological control of key pest species.

Directionality: Mostly bidirectional. Unsustainable agriculture practices impact local and global ecosystems via GHG emissions. Biodiversity protection should constrain such agricultural practices and could foster new practices aligned with the sustainable use of terrestrial ecosystems.

ILLUSTRATIVE EXAMPLES OF INTERACTIONS BETWEEN SDG2 AND THE OTHER SDGS

This box presents a summary of the more detailed country analyses of critical interactions between SDG2 and the other goals presented in Annex 1.

THE COMPOUND CHALLENGES OF DEFORESTATION, FOOD AND ENERGY PRODUCTION FOR CLIMATE MITIGATION, ECOSYSTEM PROTECTION AND HEALTH IN THE AMAZON REGION

The Amazon, the world's largest tropical rainforest, is subject to intense economic development to support agriculture, cattle ranching, large-scale hydropower generation and biofuel production, leading to deforestation and land degradation, with cascading effects and feedbacks on water availability and quality, climate change mitigation, biodiversity and human health. Thus, a large set of targets and SDGS are mutually constraining and reinforcing in this fragile ecosystem. Developing a framework and action plan to meet key SDG targets without irreversible losses to other targets will be essential for areas such as the Amazon.

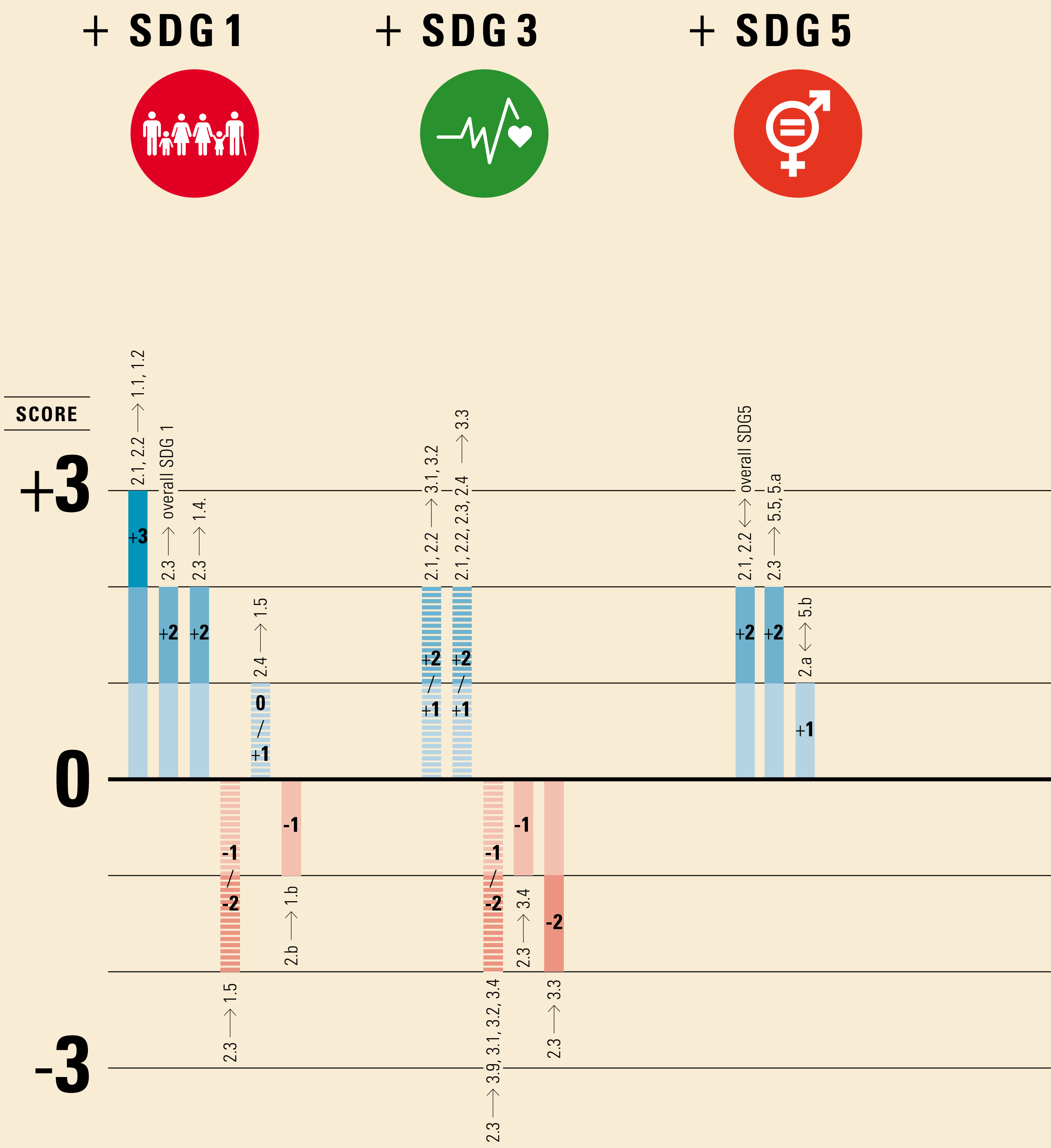
PUTTING SUSTAINABLE LAND MANAGEMENT AT THE HEART OF SENEGAL'S NATIONAL DEVELOPMENT STRATEGY

Senegal in West Africa is highly dependent on agriculture, with about 60% of the population employed in this sector. The country is also highly vulnerable to drought, and increasingly so with the onset of climate change. With growing demographic pressures and a fast-developing economy, these challenges are exacerbating. Sustainable land and water management are key areas identified by the government to ensure food production and optimal carbon sequestration.

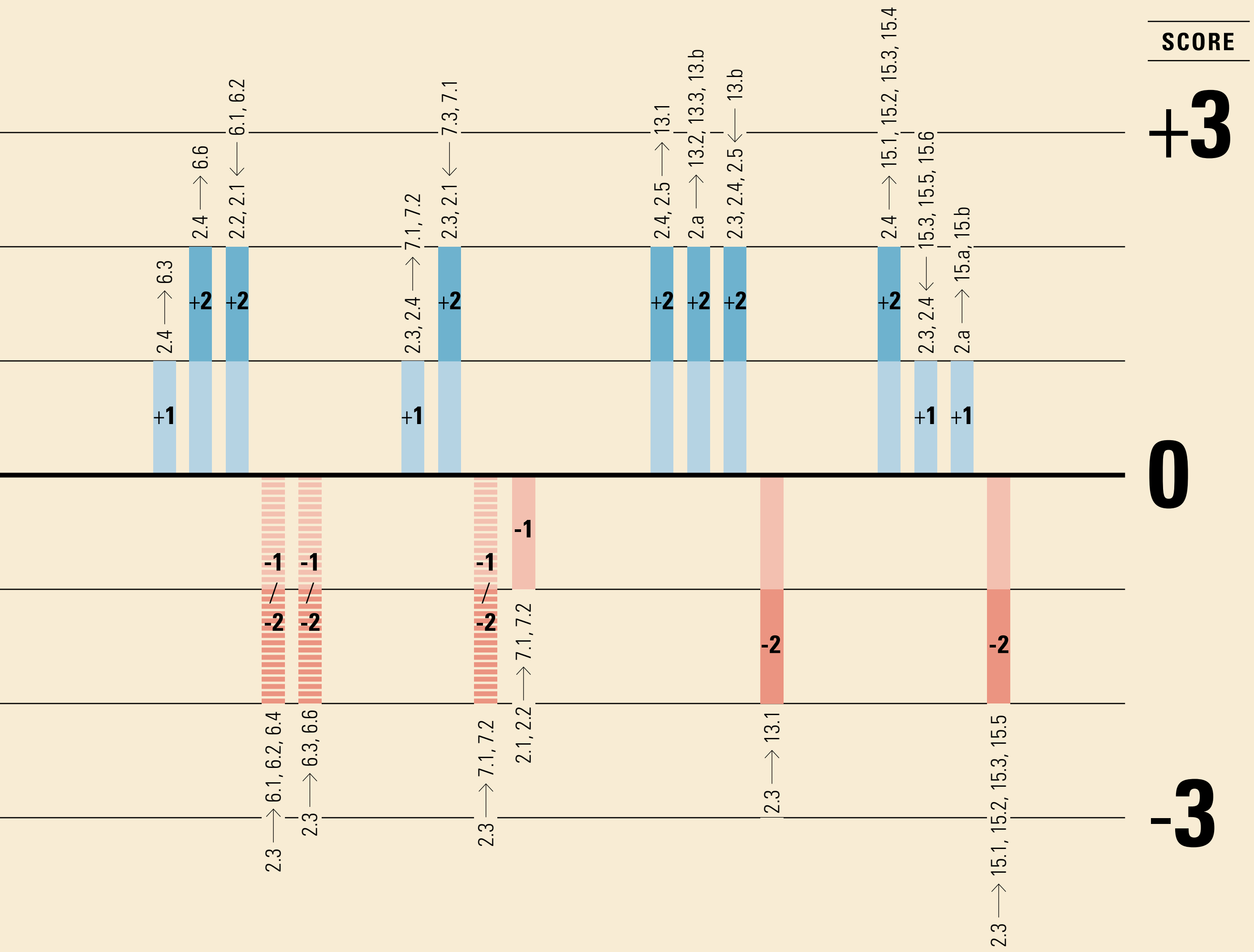
IMPLEMENTING CLIMATE SMART AGRICULTURE TO ADDRESS CALIFORNIA'S WATER CHALLENGES

While California is best known for Silicon Valley, a dynamic, high-value agriculture sector contributes substantial nutritional diversity to the country and to national exports. However, environmental impacts, such as associated with particulates from fertilisers and dust, nitrate leaching and substantial water consumption constrain the achievement of health, water quality and availability targets. In a region prone to periodic drought, achieving Climate Smart Agriculture will be key to the achievement of SDG2 and other interlinked goals and targets.

KEY INTERACTIONS
SDG 2 WITH OTHER GOALS



+ SDG 6 + SDG 7 + SDG 13 + SDG 15



KNOWLEDGE GAPS

Knowledge gaps and their order of magnitude differ for various reasons, and can vary from one geographical area to another. In this context, science empowerment and capacity building on research, data collection, analysis and assessments on SDG2 and its linkages are essential to identify pathways toward meeting multiple SDGs. Investments and advances in agricultural research and development will be important for reducing negative linkages among SDG2 targets and between SDG2 targets and other SDG goals and targets. For example, global scientific cooperation (south-north, south-south, triangular) is necessary for universal science to make progress on issues such as the impact of climate change on agricultural production and nutritious quality of food produced, or the spread of pathogens and invasive species.

Building and strengthening long-term observation and information systems for sustainable development is key. To date, SDG2-related observation systems and systems that might help identify risks for related SDG goals and targets receive insufficient financial support, and are therefore subject to uneven quality and poor coverage. For example, adequate data systems are not yet in place to predict food crises with sufficient accuracy, because data are not collected at a high enough frequency or to a sufficient level of detail. Lack of standardisation of data is a further challenge. Similarly, data are not yet available to identify when and where uses of agricultural land for biofuels (to support energy and climate goals) may harm the environment or reduce food security and increase stunting. Information is insufficient concerning which agricultural lands in a watershed, as well as which agricultural technologies and practices, are most detrimental to water availability and water quality for downstream urban and industrial developments and coastal ecosystems. Access to existing data may also be an issue. Some government agencies are reluctant to share data with other agencies; this could be due to poor data quality, because the data show poor performance by the agency concerned, or because sharing the data might be perceived as losing power. These challenges are heightened in interdisciplinary and multi-agency settings.

The broad scope of the SDGs challenges research, policymakers and the development community to work across disciplines and silos – something that is easily proclaimed but remains difficult to achieve. The section provides a non-exclusive list of knowledge gaps that have been identified in relation to the goal and target interaction analysis in the previous sections.

2 + 1

The extent to which progress in SDG2 supports achievements in SDG1 is not a priority knowledge gap because achievements are largely synergetic. However, a better understanding is needed of how trade openness may impact smallholder farmers and how adverse impacts can be prevented.

2 + 2

There is a need to develop new science, technology and innovation and associated institutions to reconcile **targets 2.3** and **2.4**; these will be location-specific and will change dynamically over time. There is also a need for better understanding of which interventions work best to achieve zero malnutrition, particularly in the short SDG timeframe.

2 + 3

Insights are needed on incentives that would allow agricultural producers and processors to use their potential to contribute to more sustainable food-production practices that benefit nutritional and health outcomes.

Linkages between agro-ecological practices and food quality, as well as understanding of the impact of climate change (e.g. CO_2 concentration) on food quality are major research gaps.

There are also important knowledge gaps regarding the impact of agricultural water pollution on human health.

2 + 5

There is insufficient knowledge concerning gender equality and several SDG2 targets in many regions, given that food systems and gender equality are highly location-specific.

Agricultural research and development are generally gender-blind; that is, women's needs for innovation – such as new varieties of plant, livestock, and fish, and for new technologies are usually not addressed. Women's participation and perspectives in agricultural research and development can support social transformation. Adopting gender responsive methodologies can help in the development and introduction of new technologies.

2 + 6

Large uncertainties remain between SDG6 and SDG2 as a result of synergistic and counteracting targets, depending on geography, agricultural practice and target. Growing water variability is adding uncertainty to agricultural production systems with potentially adverse impacts for most SDG2 targets. More research is needed on how SDG2 and SDG6 targets can be achieved in tandem. In particular, more research is needed to understand how key water targets (i.e. safe drinking water) can be met through more sustainable agricultural practices.

Irrigation is essential for increasing crop productivity and even more so under climate change. Irrigation increasingly depends on groundwater sources. Groundwater depletion and the growing competition for water must be better understood and managed. Observational and spatial planning tools are needed, as are institutional innovations for more sustainable water stewardship in agriculture.

2 + 7

More analyses are needed on energy-agricultural linkages and impacts on food (and energy) systems, to help ensure that both SDGs achieve progress in tandem. This is particularly challenging because the energy sector is highly dynamic and agricultural and food systems are rapidly becoming increasingly energy dependent.

2 + 13

Rainfed agriculture continues to predominate globally and some regions, such as sub-Saharan Africa depend almost entirely on the regularity of seasonal cycles for food production. As precipitation patterns become less certain, new tools are needed for accurate, highly granular seasonal drought predictions, as well as on changes in onset of precipitation.

The effect of land use change on local and regional precipitation patterns and insights on measures to mitigate land use change in areas that affect precipitation patterns need further study.

Feedbacks between land use change and global climate must also be clarified, especially in the tropics. Additional scientific knowledge needs to be generated on agricultural science, technologies and innovations and associated institutions that meet both mitigation and adaptation targets.

Finally, the impact of climate change (CO_2) on the nutrient content of crops needs to be further studied and assessed.

2 + 15

Research, combining local knowledge with technological advances, is needed to identify technologies, practices and institutions that optimally reduce adverse impacts on terrestrial habitats and freshwater resources and avoid further deforestation and land degradation. Such research needs to be tailored to different ecologies, geographies and farm sizes, with particular support needed for smallholder farmers. Data and information at the landscape scale on the relationships between ecosystems management and provision of ecosystems services are lacking – data on long-term ecological impacts from various agricultural practices are, however, key to define the optimal allocation of management options at the landscape scale and achieve SDG2 and SDG15 concurrently.

There is a lack of wild pollinator data (species identity, distribution, abundance) in several regions. Long-term monitoring of pollinators (status and trends for most species) and pollination around the world is urgently required.

CONCLUDING COMMENTS

The SDG2 targets have multiple reinforcing and constraining linkages with the other 16 SDGs. These multiple linkages provide both challenges and substantial scope for solutions to reinforce positive and mitigate counteracting interactions. Agriculture is at the center of the food-energy-water-climate nexus and also has strong linkages to human health. Agriculture and associated changes in land-use are also key to national adaptation and climate mitigation strategies, adaptation being particularly crucial for less industrialized countries.

Policy and governance play a fundamental role: coherent and coordinated policies together with appropriate institutions can enable net environmental and development gains in complex situations and in so doing, can help ensure that adverse impacts can be reduced or avoided. However, in many geographical, political, social, economic and environmental contexts, food security targets dominate policy agendas with potentially longer-term adverse impacts on several other goals and targets such as those related to climate, health, biodiversity, water and energy security as well as to food and nutrition security itself. In such contexts, in-depth understanding of local situations will be critical to better understand interactions between SDG2 and the others goals, and provide specific management options with minimum trade-offs.

Overall, there is a need for inclusive multi-sector approaches across government departments/ministries and other stakeholders (research institutions, NGO, private sector, etc.) that fully consider environmental boundaries. Building on these general considerations, the seven summary tables in the target-level interactions section provide options for how policy could address the interactions in practice.

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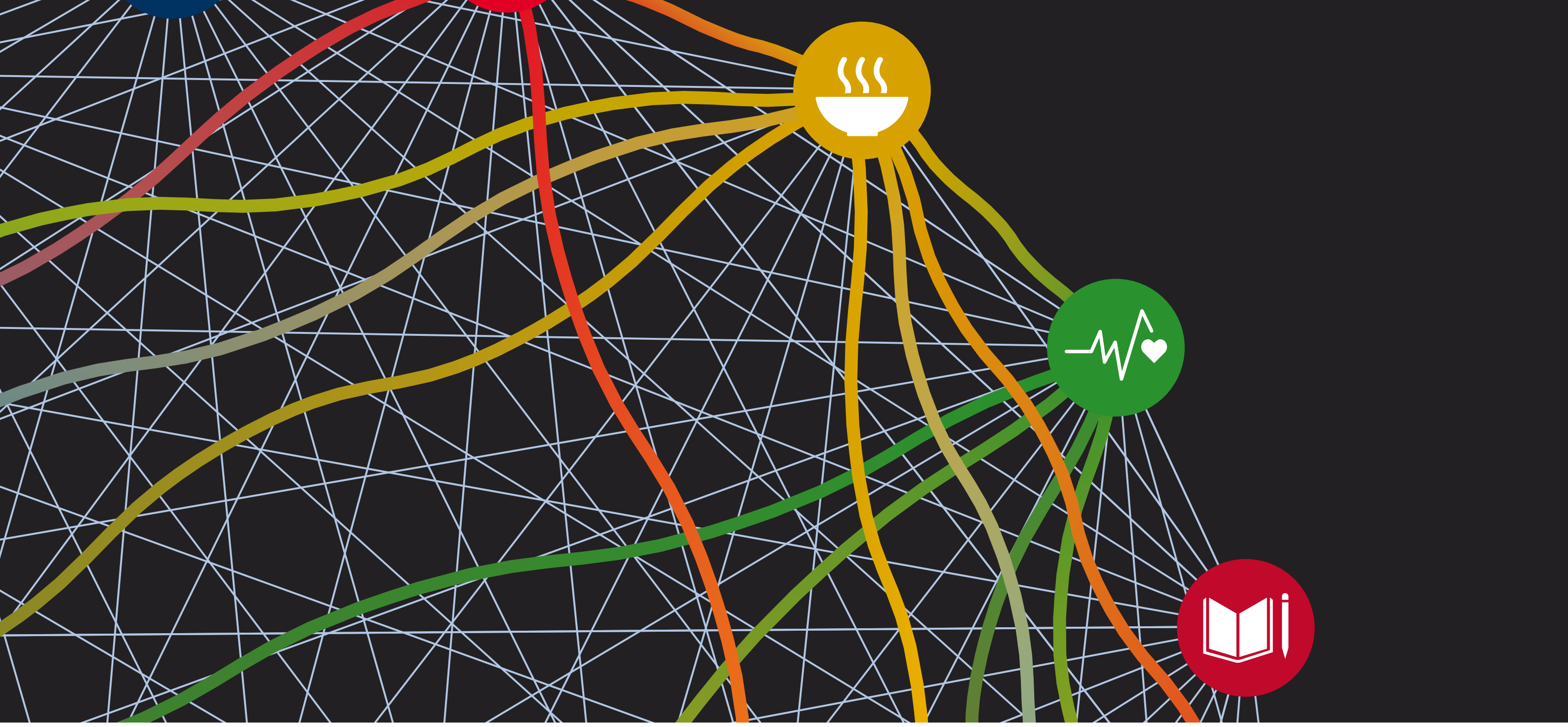

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SDG INTERACTIONS:
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TO IMPLEMENTATION

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