Food security and nutrition: Challenges for agriculture and the hidden potential of soil

A Report to the G20 Agriculture Deputies

Food and Agriculture Organization of the United Nations (FAO), and

Organization of Economic Cooperation and Development (OECD)

with inputs from

International Fund for Agricultural Development (IFAD)

International Food Policy Research Institute (IFPRI)

The World Bank Group

World Trade Organization (WTO)

1. Introduction

1. Today, agriculture faces a triple challenge. The production of safe and nutritious food will need to increase to meet the growing demand and ensure food security for all. The sector has to generate jobs and incomes and contribute to poverty eradication and rural economic growth. Furthermore, it has a major role to play in ensuring the sustainability of natural resources and in combating climate change.

2. This report, prepared by FAO and the OECD with inputs from IFPRI, IFAD, the World Bank and WTO, is submitted to the G20 Argentinian Presidency in response to the Presidency's request for information on future trends and challenges faced by global agriculture, with a special focus on the role of soils in promoting food security and the measures that could be undertaken to facilitate sustainable soil management.

3. Section 2 of the report discusses a number of global trends that are affecting agriculture and food security, and the challenges they pose. The section also maps the G20 initiatives and actions that address these trends and challenges and, in conjunction with the information provided by Stock-taking exercise of G20 initiatives, provides a comprehensive account of collective action to date. Section 3 focuses on soils and sustainable soil management. It discusses the status of global soils and identifies the most important threats. It presents sustainable soil practices, discusses the international fora that focus specifically on soil resources. Finally, the section provides a number of recommendations for consideration by the G20 Agriculture Deputies.

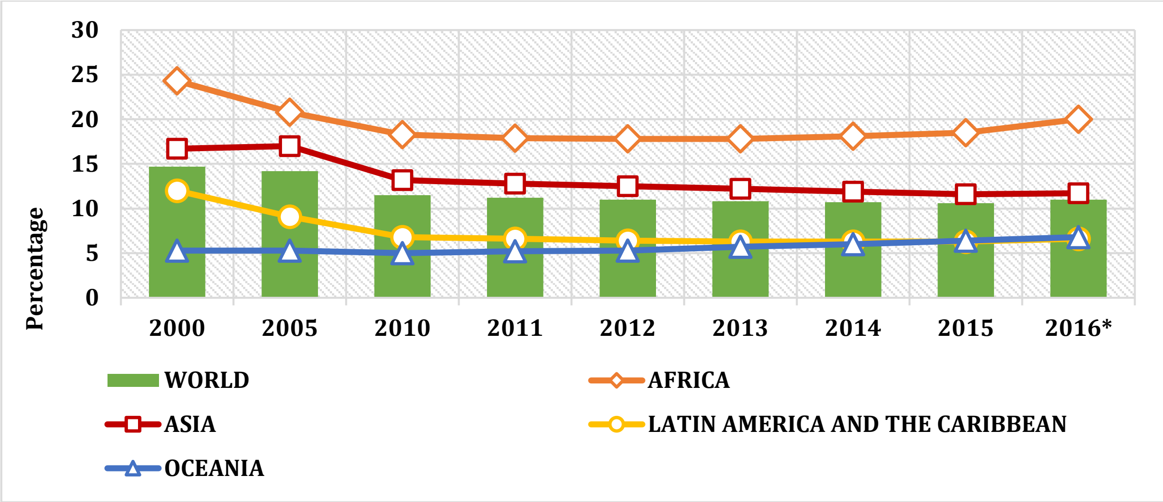
2. Trends and Challenges

2.1. Food security and nutrition

4. The global rate of undernourishment significantly decreased from 14.7% in 2000 to 10.8% in 2013. After this prolonged decline, the rate of reduction in world hunger appears to have slowed in the past few years, coming to a virtual halt between 2013 and 2015. Most worryingly, recent estimates for 2016[1] indicate that the global prevalence of undernourishment may have risen slightly to 11 percent, affecting a total of 815 million people, up from 777 million in 2015, and suggesting a possible reversal of the downward trend seen in recent decades. (Figure 1). Sub-Saharan Africa remains the region with the highest rate of undernourishment, affecting 22.7 percent of the population in 2016. The situation is especially urgent in Eastern Africa, where one-third of the population is estimated to be undernourished. By contrast, undernourishment remains low in Latin America, although there are signs that the situation may be changing, especially in South America, where the levels rose from 5 percent in 2015 to 5.6 percent in 2016.

[1] FAO, IFAD, UNICEF, WFP and WHO. 2017. *The State of Food Security and Nutrition in the World 2017.Building resilience for peace and food security*. Rome, FAO. http://www.fao.org/3/a-I7695e.pdf

Figure 1. Prevalence of Undernourishment by region, 2000-2016



*Projected values
Source: FAO, IFAD, UNICEF, WFP and WHO, 2017.[2]

5. Estimates of the severity of food insecurity, based on an experience scale3, and the differences in these estimates across continents, largely reflect those for undernourishment. Africa has the highest levels of severe food insecurity, reaching 27.4 percent of the population in 2016, almost four times the level of any other region. It is also one of the regions where food insecurity is on the rise, particularly in sub-Saharan Africa. Higher food insecurity was also observed in Latin America between 2014 and 2016, rising from 4.7 percent to 6.4 percent, while in Asia it decreased slightly over the same period, from 7.7 percent to 7.0 percent overall.

6. The observed increases in undernourishment and severe food insecurity are most notable in situations of conflict and political instability, both of which hinder growth and represent major drivers of poverty. For example, conflict, compounded by severe weather events, has resulted in an unprecedented situation of severe food insecurity in South Sudan, Somalia, North-Eastern Nigeria and Yemen. These countries together account for 108 million people on the brink of famine.

7. The worrisome reversal of the downward trend in undernourishment is, however, not yet reflected in nutritional outcomes. Evidence points to continuous decreases in the prevalence of stunting among children under the age of five years from 29.5 percent to 22.9 percent between 2005 and 2016. Nevertheless, stunting still affects 155 million children under the age of five years, increasing their risk of impaired cognitive ability, weakened performance at school, and dying from infections. Wasting affected one in twelve (52 million) of all children under five years of age in 2016, more than half of whom (27.6 million) live in Southern Asia. Anaemia, a condition arising from micronutrient deficiency with significant adverse health consequences for women and their offspring, affects 33 percent of women of reproductive age globally (about 613 million).[4]

---

[2] FAO, IFAD, UNICEF, WFP and WHO. 2017. The State of Food Security and Nutrition in the World 2017.Building resilience for peace and food security. Rome. http://www.fao.org/3/a-I7695e.pdf

[3]Measured using the Food Insecurity Experience Scale (FIES), an experience-based metric of the severity of food insecurity, relying on direct yes/no responses to eight questions regarding access to adequate food. A full description can be found in FAO, IFAD, UNICEF, WFP and WHO. 2017. *The State of Food Security and Nutrition in the World 2017.Building resilience for peace and food security*. Rome, FAO. http://www.fao.org/3/a-I7695e.pdf

[4] FAO, IFAD, UNICEF, WFP and WHO. 2017. The State of Food Security and Nutrition in the World 2017.Building resilience for peace and food security. Rome. Development Initiatives (2017). Global Nutrition Report 2017: Nourishing the SDGs. Bristol, UK: Development Initiatives.

8. At the same time, overweight among children under five is becoming more of a problem in most regions, and adult obesity continues to rise in all regions. Multiple forms of malnutrition therefore coexist, with countries experiencing simultaneously high rates of child undernutrition and adult obesity. The global prevalence of overweight has been increasing stands at about 39 percent for women and 37 percent for men, with about 1.9 billion people worldwide considered overweight.[5] Obesity more than doubled between 1980 and 2014. In 2014, more than 600 million adults were obese, representing about 13 percent of the world's adult population. It is also observed that the prevalence of obesity is, on average, higher among women (15 percent) than among men (11 percent).

9. In monitoring the progress towards the second Sustainable Development Goal (SDG 2), which calls on countries to "*end hunger, achieve food security and improved nutrition and promote sustainable agriculture*" by 2030, these estimates are concerning. They confirm the increased need for the international community to work together in promoting integrated policy approaches and actions. The ambition of a world without hunger and malnutrition by 2030 will be challenging, and achieving it will require renewed efforts. The G20 add value to these efforts by providing international leadership and encouraging international cooperation and policy coherence as set out in the G20 Food Security and Nutrition (FSN) Framework.

Box 1. A global response to Antimicrobial Resistance (AMR)

Increased human health risks are caused by the misuse of antimicrobial drugs, including antibiotics, in livestock, aquaculture and crop production. Evidence is growing that animal-to-human spread of microbial-resistant bacteria reduces the human body's responsiveness to antibiotics (Marshall and Levy, 2011). Antimicrobial resistance (AMR) – where antimicrobial drugs, including antibiotics, no longer treat infections the way they are supposed to – has the potential to cause large global economic damage. It could cause low income countries to lose more than 5% of their GDP and push up to 28 million people, mostly in developing countries, into poverty by 2050 (World Bank 2017). The Global Action Plan on Antimicrobial Resistance, published by WHO in collaboration with OIE and FAO, spells out country-level actions needed to improve awareness and understanding on antimicrobial resistance, strengthen knowledge and the evidence base, reduce the incidence of infection, and optimize the use of antimicrobial medicines in human and animal health and the corresponding investment (WHO, 2015). The G20 Agriculture Ministers have already proposed to containing the development and spread of antimicrobial resistance in line with the "one health approach" (G20 Agricultural Ministers Declaration 2017), welcoming the work by the G20 Health Working Group supported by OECD, WHO, FAO and the OIE.

Sources: Marshall, B.M. and S.B. Levy (2011), WHO. (2015), World Bank. (2017).[6]

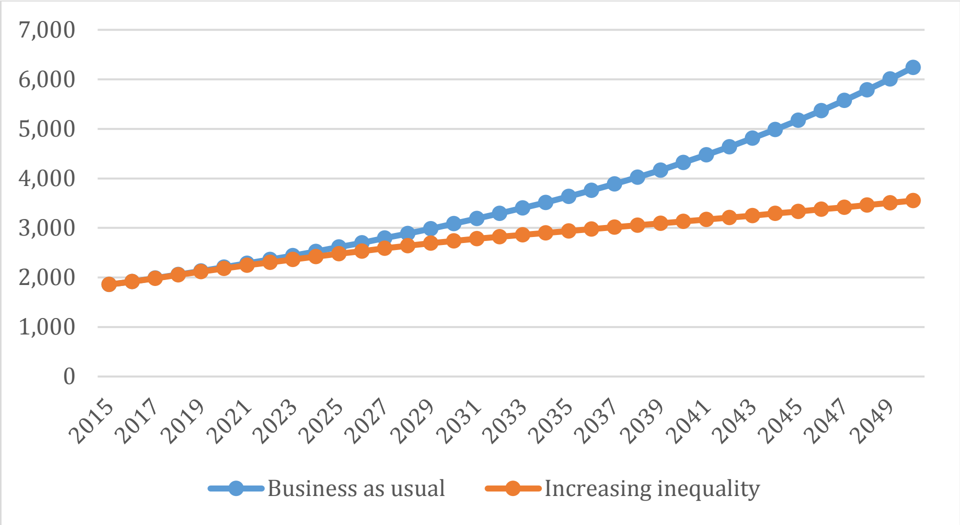
[5] Overweight is defined as Body Mass Index (BMI) $\geqslant 25$. For obesity BMI$\geqslant 30$.
[6] Marshall, B.M. and S.B. Levy (2011). Food Animals and Antimicrobials: Impacts on Human Health. Clinical Microbiology Reviews, 24-4.; World Bank. (2017). Drug-resistant Infections. A Threat to Our Economic Future. World Bank. Washington D.C.; WHO. (2015). Global Action Plan on Antimicrobial Resistance. (Geneva: WHO).

2.2. Demand for food

10. Demand for food and other agricultural products is projected to increase driven by population growth, increasing per capita incomes and changes in diets. Developing countries will contribute the most to these trends and changes.

11. The world's economy almost doubled in size between 1990 and 2014, growing at a rate of 2.6 percent a year. During that period, global economic growth was driven mainly by low- and middle-income countries, whose gross domestic product (GDP) grew, on average, by some 5.1 percent annually. There were, however, marked divergences in growth patterns by region. For example, per capita income in East Asia and the Pacific increased by 7.4 percent a year, while sub-Saharan Africa saw an increase in per capita income of only 1.1 percent a year. In terms of future economic growth, projections suggest that, under a business-as-usual scenario, by 2050 world GDP per capita will triple. Under a different scenario that assumes increasing within- and between-country inequality, GDP per capita will grow much slower (Figure 2).[7]

Figure 2. GDP per capita projection to 2050 (in 2012 US$)



Source: FAO (2017)[8]

12. The world's population is expected to grow to almost 10 billion by 2050, with the majority of growth being in Asia and Africa (Figure 3). Asia, the most populous continent, would reach its population peak between 2050 and 2060. In Africa, the maximum population size will not be reached within this century. Its population is set to continue to expand beyond the end of the century and is expected to reach more than 2.2 billion by 2050 and more than 4 billion by 2100.

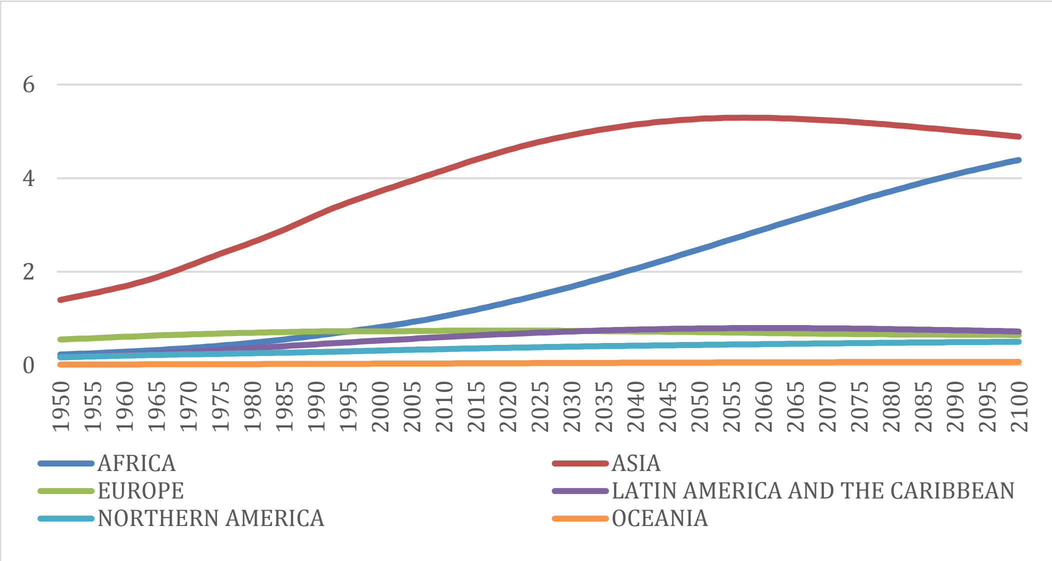
13. Many countries in sub-Saharan Africa are expected to experience fast population growth between 2015 and 2030. For example, in Niger annual population growth is projected at 3.75 percent. Annual growth rates of more than 2.5 percent to 2050 are also projected for Angola, Burundi, Chad, the Democratic Republic of the Congo, Gambia, Malawi, Mali, Senegal, Somalia, the United Republic of Tanzania, Uganda and Zambia. As all of these countries rely significantly on agriculture for employment and income generation, it would also hamper prospects for improving food security and nutrition.

[7] These scenarios, called Shared Socioeconomic Pathways' (SSPs), are developed for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Each scenario depicts a possible alternative future. In this report two (out of five) scenarios are presented: the business-as-usual or middle of the road (SSP2) and the international fragmentation (SSP4).

[8] FAO (2017). The Future of Food and Agriculture: Trends and Challenges. Rome. Based on the United Nations System of National Accounts.

14. In line with these population projections, and under a business-as-usual economic growth scenario, to meet demand, agriculture in 2050 will need to produce almost 50 percent more food, feed and biofuel than in 2012. In sub- Saharan Africa and South Asia, agricultural output would need to more than double by 2050 to meet increased demand. [9] Producing more with less, while preserving natural resources and enhancing the livelihoods of small-scale and family farmers, is a key challenge for the future.

Figure 3. Population growth by region, 1950-2100 (Billions)



Source: FAO (2017)[10]

15. An additional effect will come through growing incomes in low- and middle-income countries. This is expected to hasten a dietary transition towards higher consumption of meat, fruits and vegetables, relative to that of cereals, requiring corresponding shifts in output and adding furthermore pressure on natural resources. In the medium-term, significant increases in per capita calorie availability are expected in developing countries. Nonetheless, food insecurity is expected to remain a critical global concern, and with consumption of some products, notably quantities of vegetable oils and sugar in food intake exceeding levels consistent with healthy diets, the co–existence of malnutrition in its various forms may continue to pose challenges in many countries.

16. Policies will need to address these increasing and multiple challenges while ensuring inclusive growth. Economic growth is a necessary but not sufficient condition in reducing poverty and eradicating hunger. Making growth work for the poor is a significant task. The hungry are the poorest of the poor whose lives are circumscribed by self-reinforcing traps, which are subsequently passed onto their children in an intergenerational cycle of poverty. Their main asset is labour and, in this regard, sustainable productivity growth in agriculture, in particular, can play a key role in poverty reduction. However, hunger reduces their capacity to be productive and increases the risk of disease. Ensuring pro-poor growth requires a twin-track approach. Policies need to combine immediate hunger relief interventions with long-term actions for sustainable agricultural growth. Social protection strategies, in particular, can target the poorest and most vulnerable and aim to ease inequality.

[9] FAO (2017). The Future of Food and Agriculture: Trends and Challenges. Rome.
[10] FAO (2017). The Future of Food and Agriculture: Trends and Challenges. Rome (based on United Nations Population Division projections).

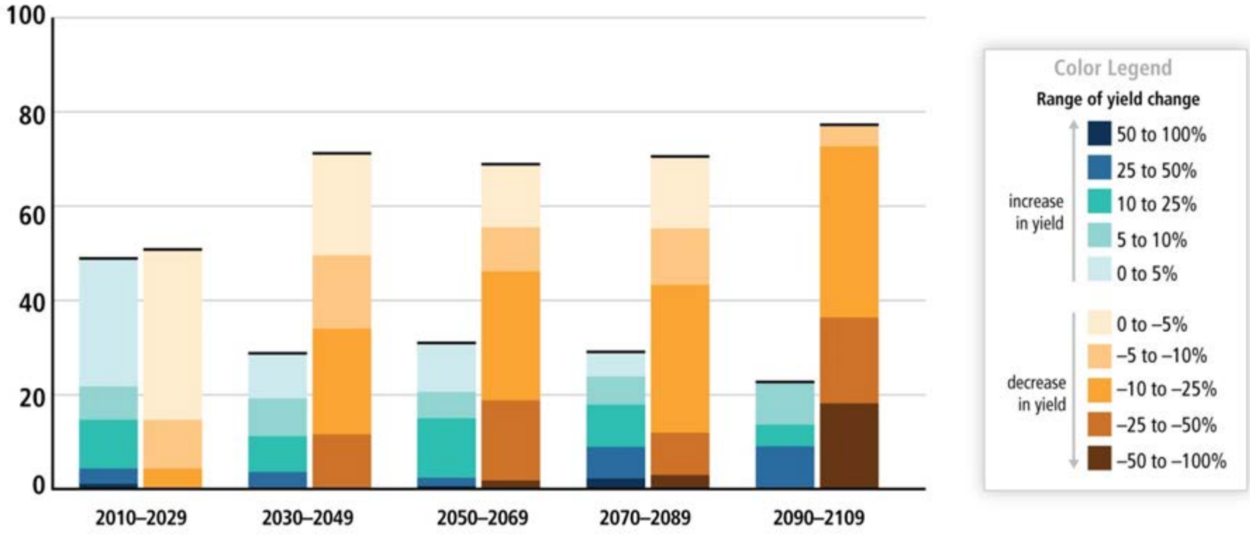
2.3.Climate change

17. Climate change disproportionately affects food-insecure regions and exacerbates the food security challenges they already experience. In the long run, rising temperatures may significantly affect crop and livestock production through yield reductions, especially in tropical areas, and will have a negative impact on food availability, rural incomes and subsequently on access to food. Rising temperatures will also negatively impact fisheries and aquaculture, which provide at least 50 percent of animal protein to millions of people in low-income countries and are already under multiple stresses. In many regions, agricultural production is already being adversely affected by rising temperatures, increased temperature variability, changes in levels and frequency of precipitation, the increasing intensity of extreme weather events, rising sea levels and increases in vector-borne diseases.

18. Up to a certain point, warmer temperatures may benefit the growth of certain crops in some parts of the world. However, if temperatures exceed a crop's optimal level, or if sufficient water and nutrients are not available, yields are likely to fall. Impacts will also vary strongly across crops and regions. Numerous studies, mostly on the major crops, have examined the potential impact of climate change on yields. In general, higher latitudes will tend to see smaller yield losses, or even yield gains, while yield losses in lower latitude regions are expected to be greater. However, impacts will be location specific and vary strongly across crops and regions (Figure 4). In addition, some studies indicate that the nutritional quality of key food crops could suffer because of climate change.

Figure 4. Projected changes in crop yields for all locations owing to climate change

(% of yields projections, number of studies=1,090)[11]



Source: FAO (2016)[12]

[11] The chart shows results of 1,090 studies on the impact of climate change yields on various regions of the world. Studies show both positive and negative impacts as some regions benefit (blue shade) while others suffer from yield decreases (orange shade). The bars show the percentage of studies that project yield changes. Some studies project increases between 50-100% (deep blue). Others show declines between 50-100% (deep orange). The time scale of these studies is shown on the horizontal axis. The studies point to a prevalence of negative outcomes in the longer run. Until about 2030, the positive and negative effects of climate change on yields are projected to offset each other. From 2030 onwards the impacts are increasingly negative as climate change accelerates.

[12] FAO (2016). The State of Food and Agriculture: Climate Change, Agriculture and Food Security. Based on Challinor, A.J., Watson, J., Lobell, D.B., Howden, S.M., Smith, D.R. & Chhetri, N. (2014). A meta-analysis of crop yield under climate change and adaptation. Nature Climate Change, 4: 287–291. Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., Iqbal, M.M., Lobell, D.B. & Travasso, M.I. (2014). Food

19. Meeting the growing demand for food with existing farming practices is likely to lead to more intense competition for natural resources, increased greenhouse gas emissions, and further deforestation and land degradation. In the current context of massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, high-input, resource-intensive farming systems cannot deliver sustainable food and agricultural production. Innovative systems that protect and enhance the natural resource base, while increasing productivity are needed. Farming methods will need to embrace technological improvements and production systems that use fewer inputs to achieve a given output and move towards 'holistic' approaches that can contribute to sustainable productivity growth, such as agroecology, agro-forestry, climate-smart agriculture and conservation agriculture, which also build upon indigenous and traditional knowledge.

20. Climate change has become a source of uncertainty and often also of significant additional risks for agriculture and food systems. Increased climate variability and extreme weather events will affect stability and price volatility. Climatic events that lead to production losses and infrastructure damage can result in significant increases in the price of food, which will affect millions of poor people. Agricultural Risk Management (ARM) can play an important role in building resilience of stakeholders in the face of unpredictability and in the transition to climate-smart agriculture systems. Initiatives such as the Platform for Agricultural Risk Management (PARM),[13] an outcome of G20 discussions on food security and agricultural growth, are vital in this regard. PARM strengthens ARM strategies in selected developing countries, in a holistic manner and on a demand-driven basis and supports countries in incorporating such strategies into public policies, private sector practices, and agricultural investment programmes.

security and food production systems. In: C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel.

[13] The IFAD-hosted Platform for Agricultural Risk Management's official website is: http://p4arm.org/

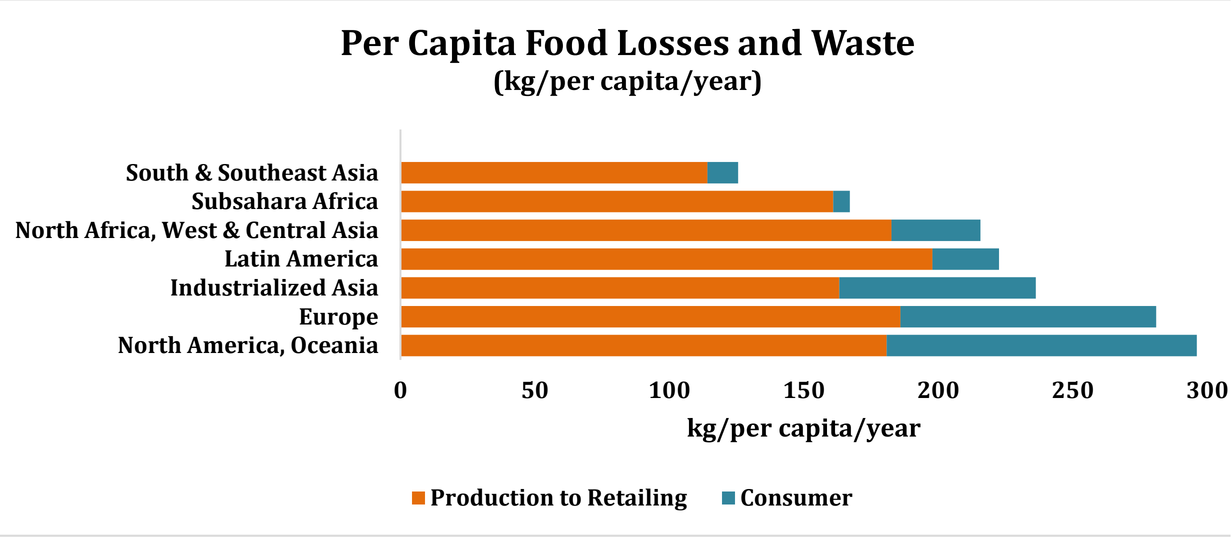
Box 2. Understanding the magnitude and causes of Food Loss and Waste (FLW)

Each year, an estimated one-third of all food produced for human consumption is lost or wasted world-wide. Food loss and waste (FLW)[1] occurs throughout the supply chains: from primary production to final household consumption. It has direct and significant implications for food availability and nutrition, natural resources, and climate change.

In middle- and high-income countries, food is wasted and lost mainly at later stages in the supply chain, with more than 40% of this waste occurring at retail and consumer levels. Food waste is recognised as a distinct part of food loss because the drivers that generate it, and therefore the approaches to tackling it, are quite different. Solutions should focus on raising awareness among industries, retailers and consumers as well as finding beneficial use for food that is presently not consumed.

In low-income countries, FLW occurs mainly at the early and middle stages of the food supply chain with lower levels of waste at consumer level. FLW can be traced back to financial, managerial and technical constraints in harvesting techniques as well as storage and cooling facilities, with an estimated 40% of losses occurring at post-harvest and processing levels. These translate into lost income for small farmers and higher prices for poor consumers. Strengthening the supply chain through investments in infrastructure, transportation and farmers' capacities, as well as in an expansion of the food and packaging industry could help to reduce losses. In addition, pests and diseases, lack of rainfall, and lack of appropriate harvesting techniques are also important causes of post-harvest losses at the farm level (Delgado et al., 2018). Promoting improved and climate-smart farming practices techniques therefore will also be important to reducing food loss.

As a basis for public action, a clearer understanding of the magnitude and causes of food loss and waste across all stages of the food supply chains is necessary. Reducing FLW will require improvements in handling, processing, transportation, and consumer habits. In response to this challenge, in 2015, the G20 members, who provide impetus on global actions to reduce food loss and waste, requested the establishment of a platform to improve FLW measurement and to facilitate knowledge sharing on this topic, with a special focus on post-harvest loss reductions in low-income countries. The Technical Platform on the Measurement and Reduction of Food Loss and Waste (TPFLW)[2] was established to improve coherence and consistency in the measurement of FWL, raise awareness, and promote approaches for FLW reduction by sharing successful experiences and best practices, in the context of sustainable food systems. The Platform is supported by the Meeting of Agricultural Chief Scientists of the G20 (MACS-G20) Food Loss and Waste Initiative[3], which aims to share information and experiences relating to agricultural science and technology, in measuring and reducing food loss and waste.



[1] Food loss is defined as "the decrease in quantity or quality of food" (FAO, 2014) and refers to all food produced for human consumption but not eaten by humans. Food waste is part of food loss and refers to discarding or alternative (non-food) use of food that is safe and nutritious for human consumption along the entire food supply chain, from primary production to end household consumer level.

[2] http://www.fao.org/platform-food-loss-waste/en/

[3] https://www.global-flw-research.org//

Box 3. Smallholder agriculture remains central to poverty reduction

Many of the challenges faced by agriculture, especially in developing countries, can be met by successful structural transformation, including rural transformation. Labour productivity increases in agriculture promote food security, lead to higher wages, especially for the unskilled in the rural areas, and contribute towards the eradication of extreme poverty. As structural and rural transformation proceed, agriculture contributes to economic growth in other sectors and the wider economy, and entrepreneurial and job opportunities are created all along agricultural supply chains. Farmers become more competitive, more nutritious food results in higher non-farm productivity, and as rural households invest in human capital, they further raise their own productivity and diversify their income sources with some family members leaving the farm for other economic opportunities. Increasing agricultural productivity of small-scale food producers is a specific goal (SDG 2.3) of the 2030 Agenda.

The evolution of the smallholder farm is intrinsically linked to structural transformation and to economic growth. There are more than 570 million farms in the world. More than 90 percent of farms are run by an individual or a family and rely primarily on family labour. Family farms are by far the most prevalent form of agriculture in the world. Estimates suggest that they occupy around 70 – 80 percent of farm land and produce more than 80 percent of the world's food in value terms.

Worldwide, farms of less than 1 hectare account for 72 percent of all farms but control only 8 percent of all agricultural land. Slightly larger farms between 1 and 2 hectares account for 12 percent of all farms and control 4 percent of the land, while farms in the range of 2 to 5 hectares account for 10 percent of all farms and control 7 percent of the land. In contrast, only 1 percent of all farms in the world are larger than 50 hectares. In some developing countries in Asia and Africa further fragmentation of small farm holdings is taking place, raising questions about their viability.

Small farms are key in promoting food security and poverty reduction, but they have an important role to play within the broader context of development: smallholder farmers have more favourable expenditure patterns to promote rural development than their larger counterparts. Transformation will also affect both the evolution of the smallholder family and the farm size. With well-functioning factor markets, productivity growth allows wages to rise, and rural household members diversify their income sources by obtaining better-paid off-farm work. As people leave agriculture for other economic opportunities, the share of agriculture in GDP and employment declines, together with poverty.

Today, smallholder gains from globalization appear to be limited. Providing an enabling environment is required to increase their sustainable production and integrate to markets through improvements in infrastructure, technology adoption and efficient input use. A better investment climate will contribute towards sustainable productivity growth and facilitate transformation and rural development.

The development of small-scale agriculture has been a focus of the G20 since 2011, when Agriculture Ministers committed to implementing a broad scope of actions to boost agricultural growth, giving special attention to smallholders, women and young farmers, in particular in developing countries. G20 members encourage the promotion of national enabling environments for investment, including infrastructure and policies conducive to well-functioning markets, the integration of smallholders and women into those markets, inclusive financing institutions, secure tenure of land, social protection, the management of risk and measures to limit the adverse impacts of excessive price volatility.

Sources:
International Fund for Agricultural Development (IFAD). 2016. *Rural Development Report 2016: fostering inclusive rural transformation*. Rome, Italy: International Fund for Agricultural Development (IFAD).
World Bank and IFAD (2017), Rural Youth Employment: A Synthesis Study. BMZ.
FAO (2014), The State of Food and Agriculture: Innovation in Family Farming. Rome.

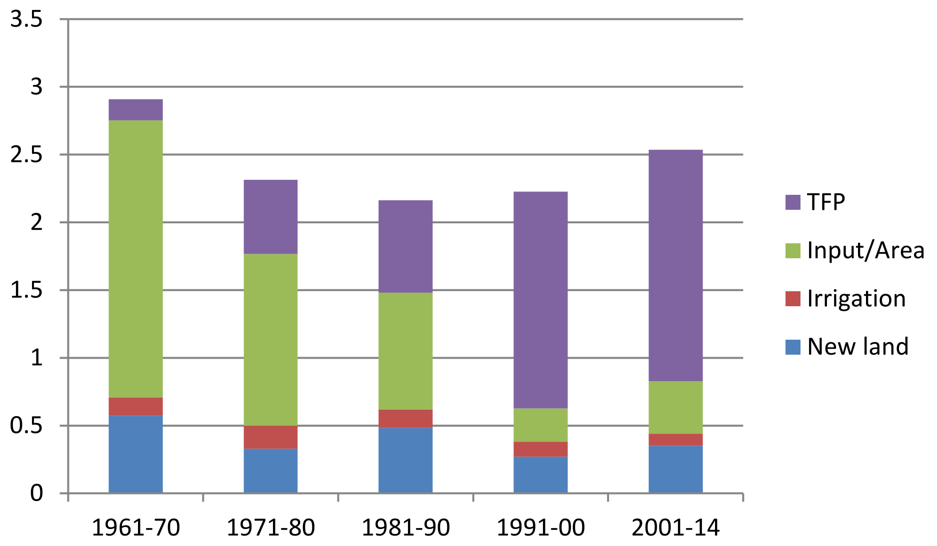
2.4. Sustainable agricultural productivity growth

21. Addressing global food security objectives is a multidimensional global challenge. The core contribution of agriculture can be encapsulated in the goal of achieving sustainable productivity growth, protecting the natural resource base and enabling future growth. Finding the appropriate policy tools to enhance the capacity of the food and agriculture sector to grow sustainably is a challenge for all governments and a target for the international community as established in SDG 2.4 of the 2030 Agenda for Sustainable Development. Responding to this challenge has the potential of delivering the required increases in production, with improvements in farming returns and rural incomes, while assuring the sustainability of the natural resources.

22. Average annual growth in global agricultural production has slowed down from 2.9% in the 1960s to 2.1% in the 1980s and 2.5% in the 2000s. In the 1960s and 70s most of this growth came from intensification of input use per hectare, such as labour, capital and other inputs (Figure 5). Despite the slowdown in the rate of growth in the use of these input factors in the last two decades, output has continued to grow thanks to gains in Total Factor Productivity (TFP).[14] Since the 1990s, most of the global agricultural production growth is due to increases in TFP. This means using better farming practices to combine the different factors of production (technical efficiency), and innovating with new technologies that expand the production frontier. A significant part of the TFP growth is due to the adoption of labour saving practices.

23. In the period 2001-14, agricultural production had grown faster in low- and middle-income countries than in high income countries. In low-income countries, however, agricultural growth has been primarily driven by increased input and land use rather than by productivity gains. Despite these significant differences among countries, even in the low-income group, TFP growth outstripped the use of more variable inputs per hectare as a source of agricultural growth. In the future, most of the increases in global agricultural production are expected to result from applying further existing or new technologies and practices.

Figure 5. Sources of Growth on Global Agricultural output



Source: USDA, Economic Research Service, *International Agricultural Productivity* data product, as of October 2017

[14] Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production. As such, its level is determined by how efficiently and intensely the inputs are utilized in production.

24. As TFP drives the increase in production, its growth also translates into increasing the efficiency and competitiveness of the agricultural sector and, consequently, increasing returns to the factors of production, including land and labour, and thus the incomes of farm and rural households. In order to realise these potential gains, innovation in the wide sense is required, combining adapted technologies with improved farm management practices. There is evidence of high rates of return to research and development accompanied with extension, albeit with long time lags.[15] Moreover, the realization of increased opportunities within agriculture and in other sectors goes hand-in-hand with the agricultural transformation.

25. Sustainable productivity growth is also key to rural growth and development, as it tends to translate in income increases for farmers. As such it can open opportunities for the rural areas where most of the poor are located, driving agricultural (structural) transformation. It is important that these improvements in productivity reach poor farmers in low income countries.

26. Along the path of agricultural transformation, farmers become more competitive, households diversify their income sources (for example by a family member obtaining off-farm work) and people – often sons and daughters – leave the farm for other economic opportunities. In the aggregate, sustainable TFP growth facilitates the release of labour from the sector, but also changes the nature of the work and upgrades the skills required for those employed in the sector, making the sector more attractive for younger people. The challenge is to generate balanced development so that labour is "pulled" out of agriculture via rising opportunities, rather than simply "pushed" out by improvements in labour productivity.

Increasing agricultural production sustainably

27. TFP growth is sustainable if it is compatible with the preservation of natural capital, conserving and enhancing natural resources required for agriculture, such as water and soil. Like physical capital, natural capital needs investment and maintenance to retain its productivity in the long run. To be sustainable, productivity growth will also need to account for the projected impacts of climate change, the associated adaptation responses, and the potential role of agriculture in the global greenhouse gas mitigation effort. There is evidence that it is possible to dissociate (or "decouple") the growth in TFP from the use of additional natural resources. For instance, water use and pesticides have been decoupled from increased output in Australia, the United States and Korea (Table 1).

[15] Bioversity, CGIAR Consortium, FAO, IFAD, IFPRI, IICA, OECD, UNCTAD, Coordination team of UN High Level Task Force on the Food Security Crisis, WFP, World Bank, and WTO (2012). Sustainable agricultural productivity growth and bridging the gap for small-family farms. Interagency Report to the Mexican G20 Presidency.

Table 1. Decoupling agriculture productivity from resource and environmental pressure: observed trends among selected countries, between the 1990s and the period since 2000

	Resource use	Environmental impacts
Absolute decoupling	**Water use**: Australia, Netherlands, Estonia, Korea **Land use**: Netherlands, Korea	**N and P balance**: Estonia, Korea, Sweden, USA, Turkey **Ammonia**: Netherlands, Sweden, USA **GHG emissions**: Netherlands, Turkey **Pesticide use**: Netherlands, USA, Korea
Relative decoupling	**Water use**: China, Turkey, USA **Energy use**: USA, Estonia	**GHG emissions**: USA, Estonia
Deterioration	**Energy use**: Turkey	**Pesticide use**: Turkey; **GHG emissions**: Korea

Note: Absolute decoupling refers to a situation in which resource use and environmental impacts decline in absolute terms while TFP increases. Relative decoupling refers to a decline in the ecological intensity per unit of economic output. Deterioration refers to a situation of increases in resource use or environmental impact beyond the increase in TFP. Time periods correspond the most recent decade for which there is information available, which is not identical for each country; more recent date on agri-environmental indicators might alter this assessment. This table is subject the existing limitations in the information and methods to evaluate the joint productivity and sustainability performance.

Source: Adapted from OECD country reviews. http://www.oecd.org/tad/agricultural-policies/innovation-food-agriculture.htm based on TFP data and OECD Agri-environmental indicators

Innovation and R&D in food and agriculture

28. Productivity and sustainability outcomes depend also in other important drivers: innovation and structural change. Productivity can be improved through economies of scale and the adoption of more efficient existent technologies and practices. But the long term sustainable productivity growth depends on a continuous process of technical progress and social and business innovations. Innovation should increasingly move from a linear (lab-to-field) approach to a demand driven network connecting farmers, industry, consumers and research, which requires good governance, interactions and collaboration among national actors and across countries, and mechanisms to facilitate adoption.

29. Evidence gathered in country reviews confirms that innovation is a major driver of both productivity growth and sustainability in many cases. Examples are the adoption of input-saving technology and production practices, such as low-tillage, modern buildings allowing energy savings, machineries for precision agriculture, genetic improvement, better management of risks, and changes in marketing practices. Information and Communication Technologies (ICT) contribute to reducing input use (labour, energy, fertiliser and pesticides through precision agriculture) and thus improving productivity and sustainability performances. ICTs also facilitate sharing of information, participation and traceability along the global value chains and increasingly connect small farmers to markets, reducing transaction costs, and potentially raising food system efficiencies, sustainability and inclusion.[16]

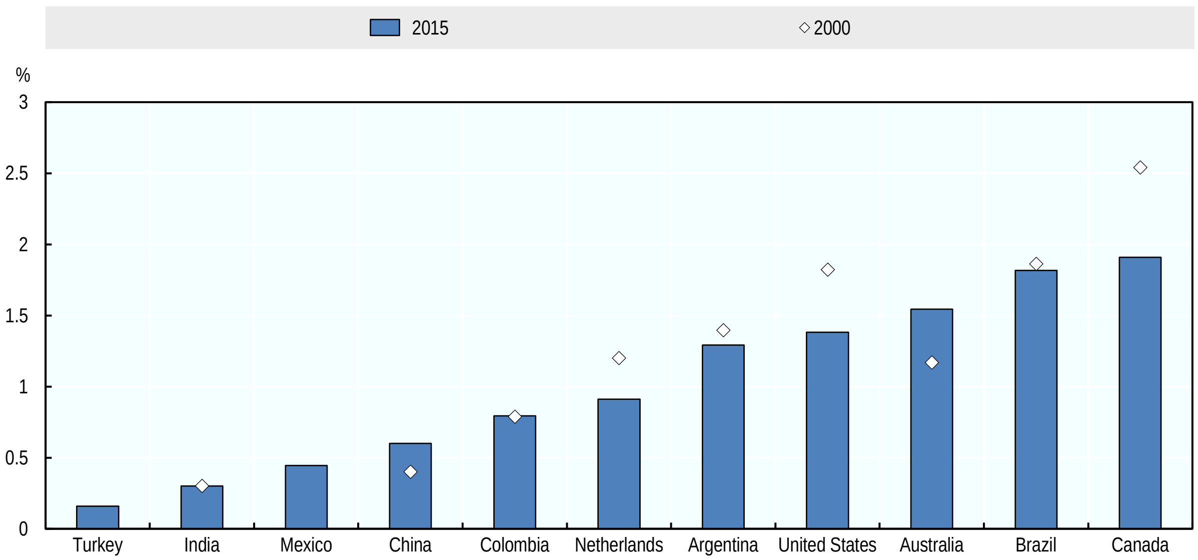
30. More generally, new technology is already shaping how agricultural value chains are organized, offering potential to accelerate innovation and new opportunities for income gains, entrepreneurship, and higher skilled jobs in the food system. Emerging technologies driven by the Fourth Industrial Revolution include big data and artificial intelligence; new physical systems such as automation, robotics, and additive manufacturing; and advances in science such as new energy

[16] FAO with inputs from IFPRI and OECD (2017). Information and Communication Technology (ICT) in Agriculture, A Report to the G20 Agriculture Deputies.

technologies and next generation biotechnologies and genomics offer significant opportunities for the food system.[17] Solar power is providing new job opportunities for agro-processing in off-grid areas. Remote sensing technologies are being used to offer mechanized and extension services in some African countries. Digital finance is increasing financial inclusion in many regions and facilitating micro-entrepreneurship. E-commerce platforms are linking small entrepreneurs in rural areas with national and global markets.

31. The budget expenditure on agricultural R&D is an indicator of the innovation effort by the governments. In the period 2000-15 R&D expenditure has been reduced in some major exporting countries as a percentage of the agricultural value added (Figure 6). Although research intensity has increased in several developed countries and emerging economies, agricultural research investment levels in most low- and middle-income countries fall well below 1 percent of agricultural gross domestic product. Agricultural research investment returns can take decades from the inception of research to the adoption of a new technology or a new variety, requiring sustained and stable research funding.[18]

Figure 6. Share of budget expenditures on agriculture R&D as a percentage of agricultural value-added, 2000 and 2015



Note: No information available for Turkey and Mexico in 2000.

Source: OECD (2017), OECD statistics [Research and Development, OECD National Accounts], http://stats.oecd.org/; and ASTI (2017) for Brazil, China, and Colombia.

[17] World Economic Forum (2018). Innovation with a Purpose: The Role of Technology Innovation in Accelerating Food System Transformation. Prepared in collaboration with McKinsey & Company. (New York: World Economic Forum).
[18] ASTI (2017): Food Policy Indicators: Tracking Change: Agricultural Science And Technology Indicators. Alston, J. (2010), "The Benefits from Agricultural Research and Development, Innovation, and Productivity Growth", OECD Food, Agriculture and Fisheries Papers, No. 31, OECD Publishing, Paris.

32. Despite the diversity of situations between them, countries face common opportunities and challenges for improving agricultural productivity sustainably. Governments remain major funders of agriculture R&D but face budget constraints and need to be selective in their investments, redirecting the resources for agricultural interventions towards measures that are well targeted to strengthen the productivity and sustainability of the sector. The public sector plays a major role in the provision of knowledge infrastructure and the financing of basic research or research on long-term and public good aspects not taken by the private sector such as natural resource management.[19] Governments should also encourage innovation activities in the private sector, fostering knowledge markets through Intellectual Property Rights protection and exploiting synergies and complementarities with formal public-private partnerships (PPPs) when appropriate.[20] Agricultural Innovation Systems (AIS) need strategic focus and be inserted in regional or international initiatives.

Investment and enhancing international exchange on R&D and innovation

33. Investment in agriculture is essential to materialize the potential productivity and sustainability gains derived from R&D and innovation. International initiatives like the Principles for Responsible Investment in Agriculture and Food Systems (CFS-RAI), the Policy Framework for Investment in Agriculture PFIA[21] and the Guidance for Responsible Agricultural Supply Chains[22] define how responsible investment in agriculture and food systems can contribute to food security and nutrition and how to create an attractive investment environment for all investors, private or public, domestic or foreign, small or large.

34. Improving cross country supply of innovations and cross border technology transfer is crucial to increase productivity growth and address transboundary issues such as contagious diseases, climate change mitigation and adaptation, and the sustainability of water resources. The international R&D architecture and good coordination between national, international and regional research networks is important in particular for low-income countries. Increases in the effectiveness and spill overs of R&D and technology adoption, can be enhanced by international organizations such as the CGIAR and its on-the-ground research centres. Other global initiatives on R&D cooperation include the Global Forum for Agricultural Research, the Global Soil Partnership and the Global Research Alliance on Agricultural Greenhouse Gases.

35. The G20 has launched several initiatives aligned with its comparative advantage on the long term strategic approaches to provide public goods and policy dialogue. In 2012 the G20 Presidency of Mexico established the Meetings of Agricultural Chief Scientists of G20 (MACS).[23] MACS purpose is to address central science and research questions in the fields of agriculture and nutrition that are too great to be solved with only national efforts, to better coordinate agricultural research systems and to seek and apply common solutions strategies. MACS has been active in sharing research priorities and prioritization models and in specific research areas such as food losses and waste.

[19] OECD (2015a), Analysing policies to improve agricultural productivity growth, sustainably: Draft Framework, May,
[20] Moreddu, C. (2016), "Public-Private Partnerships for Agricultural Innovation: Lessons From Recent Experiences", OECD Food, Agriculture and Fisheries Papers, No. 92, OECD Publishing, Paris.
[21] OECD (2014), Policy Framework for Investment in Agriculture, OECD Publishing, Paris
[22] OECD and FAO (2016). OECD-FAO Guidance for Responsible Agricultural Supply Chains
[23] MACS-G20 website: www.macs-g20.org.

36. In 2012, the G20 also proposed to develop the Framework for Improving Sustainable Productivity Growth, an analytical tool for improving agricultural productivity and sustainability to analyse the policy experiences in achieving sustainable productivity growth. The framework has been developed and applied to a selection of G20 and OECD countries (Australia, Brazil, Canada, Netherlands, Turkey, United States, China, Estonia, Korea and Sweden).[24]

37. Several G20 initiatives are directly focused on improving innovation and contributing to global food security: the Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM),[25] the International Research Initiative for Wheat Improvement (IRIWI),[26] and the Tropical Agricultural Platform (TAP)[27] that aims at building AIS capacity in developing countries. More recent G20 proposals focused on innovation and sustainability, including the assessment and exchange of experience of ICT technologies for agriculture proposed under the Presidency of China in 2016 and the Agricultural Ministers Action Plan on water under the German presidency in 2017.

38. Despite on-going efforts to improve the measurement of sustainable productivity and its drivers, such as structural change and innovation, on a comparable basis across countries (e.g. agri-environmental indicators, agricultural total factor productivity, farm-level productivity and activities of different policy initiatives[28]), information on the joint performance of productivity and sustainability is often limited and difficult to compare. MACS has reflected this concern both in their Communiqués of 2015 and 2016, and in a white paper on the "Metrics of Sustainable Agricultural Productivity". Monitoring developments on sustainable productivity growth across countries requires further investment on methods and analytical frameworks that would allow international benchmarking of productivity and sustainability performance of agriculture.

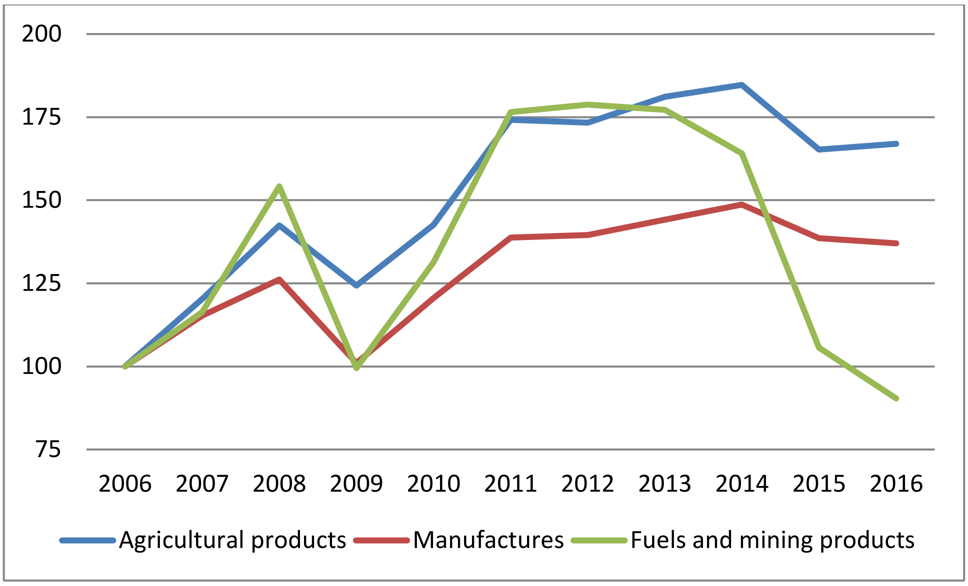
2.5.Trade and transparency in food markets

39. Trade has an important role to play in raising agricultural production and farmers' incomes. It enables production to be located in areas that can use resources more efficiently and allows food to move from surplus to deficit areas, thus contributing to food security and nutrition. Growth in global trade has underpinned the improved availability of food. Agricultural and total merchandise trade have both experienced several decades of high growth rates, in particular during the first years of the 21st century, during 2000-06. The global trade slowdown of 2008-09 implied a significant reduction in global trade affecting all products (Figure 7). Nevertheless agriculture was less negatively affected than other sectors and in 2016 world agricultural exports were 70% higher than in 2006. The most recent indicators for 2017 suggest a strong annual rate of 2.4% of global trade growth compared to 1.3% in 2016.[29]

---

[24] OECD (2013), Agricultural Innovation Systems: A Framework for Analysing the Role of the Government, OECD Publishing. OECD (2015a), Analysing policies to improve agricultural productivity growth, sustainably: Draft Framework, May.
[25] https://cropmonitor.org
[26] http://www.wheatinitiative.org
[27] http://www.fao.org/in-action/tropical-agriculture-platform/en/
[28] The OECD Networks on Agriculture Total Factor Productivity and the Environment http://www.oecd.org/tad/events/oecdnetworkonagriculturaltotalfactorproductivityandtheenvironment.htm and the Farm Level Analysis Network (https://www.oecd.org/agriculture/farm-level-analysis-network/). An important part of the former focusses on developing methodological guidelines that countries can use to construct productivity accounts for the measurement of TFP and environmentally adjusted TFP trends.
[29] WTO (2017): World Trade Statistics Review 2017

Figure 7. World merchandise trade by major product grouping, 2006-2016 (Index 2006=100)



Note: World trade is calculated as an average of exports and imports of merchandise trade
Source: WTO (2017). World trade as an average of exports and imports of merchandise trade.

40. The relative share of agricultural trade in domestic consumption remains small, in the range of 0-20% for many countries. The export shares of production have not dramatically changed in the last decades for most agricultural commodities. Only some countries, such as Argentina, Australia and the United States have net exports that reach 50% of their domestic supply.[30] On the import side, only a few countries from the Near East and North Africa have net imports that reach 50% of their domestic food supply. However, responsive world markets and access to trade remain decisive to ensure that food is available in a timely manner.

41. In the context of climate change and the resulting negative effect on agricultural productivity in low latitude regions, international trade could be a potentially powerful adaptation instrument to even out supply fluctuations across the globe, and to reduce market instability. To fulfil this beneficial pooling function to the maximum degree, trade has to be able to flow smoothly between nations. Furthermore, from a risk management perspective, there is evidence that trade restrictive policies have significant negative impacts on food security in scenarios of domestic shocks, such as a crop failure or a natural disaster.[31] Open and predictable trade policies have the potential to reduce the negative impacts on food security across diverse scenarios and represent a good risk management strategy to ensure the stability of markets.

Global trends in market demand have reduced pressures on prices

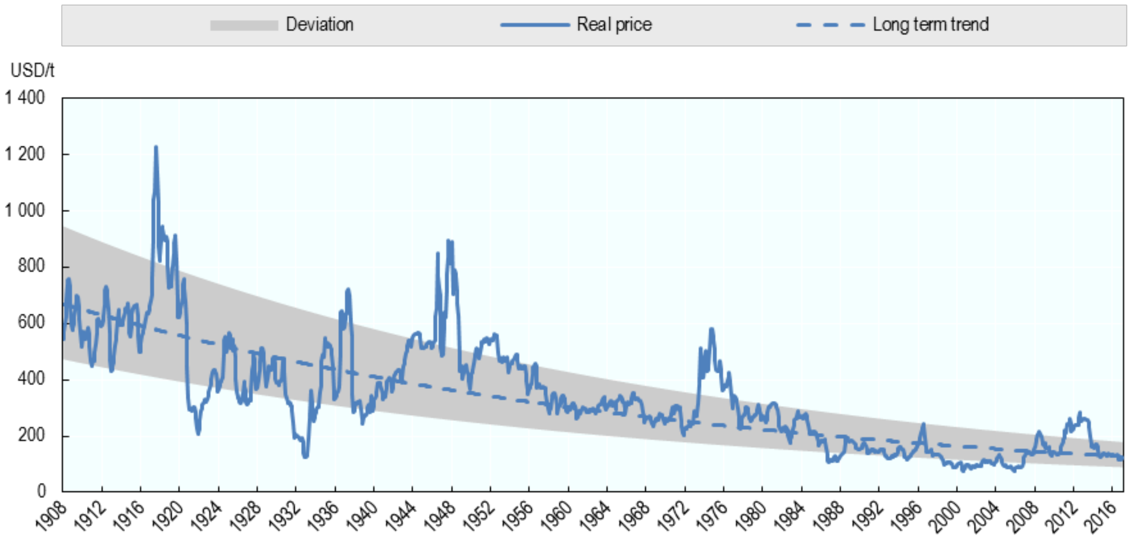
42. Agricultural world price formation depends on the relative forces of demand and supply in world markets, that is on the imports and exports from all countries. In 2016, record production and abundant stocks of most commodities, kept prices of the main agricultural commodities well below the peaks experienced in the last decade, in particular in 2008-12. Average prices of cereals, meats and dairy products continued to decline, while prices of oilseeds, vegetable oils, and sugar saw a slight rebound in 2016.

[30] FAO (2017). The future of food and agriculture – Trends and challenges. Rome.
[31] OECD (2015): Managing Food Insecurity Risk: Analytical Framework and Application to Indonesia.

43. In the medium term, between 2017 and 2026, demand growth is projected to slow considerably, and global agricultural market prices (in real terms) are projected to follow a slightly declining trend.[32] Rising meat demand from China, additional feedstock inputs for biofuels and the replenishment of cereal stocks, that have been the primary sources of demand growth in the last decade, are not anticipated to support markets in the same way over the medium term. Therefore, growth in food demand for virtually all commodities is anticipated to be slower than in the previous decade and, globally, per capita food demand for cereals is anticipated to be largely flat, with growth only expected in least developed countries.

44. Currently, both historical and implied volatility in the world markets of the main commodities have declined from their peaks of 2008 and were at the end of 2016, at the lower end of their historical ranges.[33] Nevertheless, climate change and the potential increase in the frequency and intensity of weather events may disrupt markets and result in significant price volatility and considerable variation around the prices' projected levels.

Figure 8. World market prices of maize, 1908-2016 (real terms)



Source: OECD-FAO Agricultural Outlook 2017-26

45. Price volatility matters because it can be harmful for poor consumers and for farmers. Sudden higher prices can be disastrous for the poor, especially in developing countries where a high share of their total income is spent on food. Low and volatile prices pose significant problems to farmers and other agents in the value chains, adding risk and uncertainty to their returns, and creating disincentives for investment. Increasing market transparency and applying sensible, more open and predictable trade policies are key elements of any policy strategy to reduce price volatility.[34]

46. The Agricultural Market Information System (AMIS) was created in 2011 to enhance food market transparency and encourage international policy coordination in times of crisis. Countries participating in AMIS encompass the main producing and consuming countries of major food crops covered by the initiative: wheat, maize, rice and soybeans. The AMIS Secretariat (composed of 11 international organizations), the Global Food Market Information Group and the Rapid Response

[32] OECD-FAO (2017) Agricultural Outlook 2017-26.
[33] Agricultural Markets Information System (AMIS) Market Monitor No 57. November 2017.
[34] FAO, IFAD, IMF, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF (2011). Price volatility in Food and Agricultural Markets: Policy Responses. Interagency policy report for the G20.

Forum have been meeting regularly, producing and publicly disseminating market and policy information to all agents.

47. Global food trade can be vulnerable to physical points along trade routes that handle high volumes of important commodities. These are maritime chokepoints (straits and canals), coastal chokepoints (ports) and inland chokepoints (roads, railways and waterways).[35] As climate change takes hold, the risk of disruption to food trade chokepoints may increase. Current assessments focus on conditions and policies that influence exposure to supply or price shocks and data on patterns of transportation of food, and analysis of the systemic importance of trade chokepoints to food markets are lacking. Against this background, the Secretariat of the Agricultural Market Information System (AMIS) is currently considering to expand its activities to include the assessment of chokepoint disruption risk, and to monitor chokepoint performance by collating data on throughput, congestion and climate resilience.[36]

[35] Bailey, R., and L. Wellesley (2017). Chokepoints and Vulnerabilities in Global Food Trade. Chatham House Report, Royal Institute of International Affairs.

[36] Chatham House (2018). An analysis and proposal of how the monitoring of food trade chokepoints can be incorporated into the work programme of the Agricultural Market Information System (AMIS), prepared for the 7th session of the AMIS Rapid Response Forum, Rosario: Argentina, 15 March 2018.

3. Soils: a hidden potential if well managed

48. Increasing population and economic growth are estimated to result in a 50 percent increase in the demand for food by 2050. There is little scope to expand the agricultural area, except in some parts of Africa and South America. Much of the additional available land is not suitable for agriculture, and the ecological, social and economic costs of bringing it into production will be very high.[37] In addition, approximately 33% of the world's soil resources are moderately to highly degraded.[38]

49. Soils are the foundation of food production and many essential ecosystem services. Indeed, the 2030 Agenda and the Sustainable Development Goals identify the need to restore degraded soils and improve soil health. Unlocking the full potential of soils will not only support food security and nutrition, but will also contribute towards storing and supplying more clean water, maintaining biodiversity, sequestering carbon, and increasing resilience in a changing climate.

50. The current situation is expected to worsen unless intensive actions are taken to mitigate soil threats. With the urgent need to eliminate hunger and ensure food security and nutrition, it is crucial not only to understand, but also actively work towards management practices that respect the importance of the role of soils in food production, and are tailored to their diverse chemical, physical and biological properties. Sustainable soil management (SSM)[39] embodies such an approach and has the potential to aid climate change mitigation and adaptation.

3.1. Status of global soils

51. A number of global soil threats have been identified with soil erosion, soil organic carbon (SOC) change, and nutrient imbalance having the largest impact at the global level. [40] Other threats, that tend to be more country or region specific, include soil salinisation and sodification, soil sealing and land take, loss of biodiversity, soil contamination, acidification, compaction and waterlogging. Unsustainable practices, including land use/cover change (LUCC), are among the main drivers behind these threats.

Soil erosion

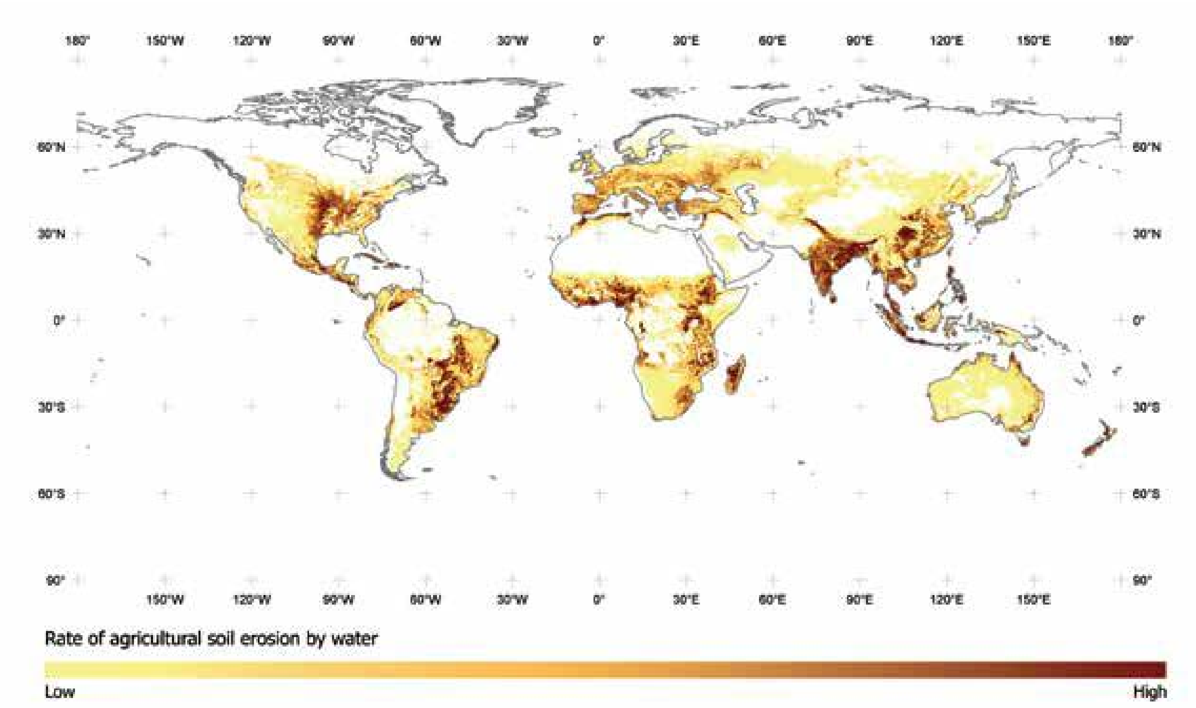
52. Soil erosion, or the accelerated loss of topsoil from the land surface through different mechanisms, such as air and water, has direct and negative impacts on global agriculture. In the long-term, the loss of topsoil can result in the reduction of the soil's capacity to provide rooting space and to store and cycle water. Erosion, specifically water erosion, leads to nutrient losses, which then need to be replaced through fertilization, often, at a significant cost. In some cases, when the nutrients are not replaced, crop yields can be greatly affected. Soil erosion also has

[37] Available land is assessed through the Global Agro-Ecological Zones (GAEZ v3.0) analysis. The GAEZ, combining soil, terrain and climate characteristics with crop production requirements, estimates the suitability for crop production. See also Alexandratos, N. and J. Bruinsma. 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working paper No. 12-03. Rome, FAO.
[38] FAO-ITPS. (2015) Status of the World's Soil Resources. Rome, Italy.
[39] According to the definition of Sustainable Soil Management (SSM) by the Intergovernmental Technical Panel on Soils (ITPS), soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soils are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity. The balance between the supporting and provisioning services for plant production and the regulating services the soil provides for water quality and availability and for atmospheric greenhouse gas composition is a particular concern. Supporting services include primary production, nutrient cycling and soil formation; Provisioning services comprise the supply of food, fibre, fuel, timber and water; raw earth material; surface stability; habitat and genetic resources; Regulating services imply the regulation of aspects such as water supply and quality, carbon sequestration, climate regulation, control of floods and erosion; and Cultural services denote the aesthetic and cultural benefits derived from soil use.
[40] FAO-ITPS. (2015) Status of the World's Soil Resources. Rome, Italy.

negative impacts on water quality as the sediments and nutrients from erosion are deposed in water bodies.

53. Soil erosion by water is problematic in much of the hilly areas that are used as croplands on all continents. The highest rates of soil erosion by water, mainly occur on cropland in tropical areas. Rangelands and pasturelands in hilly tropical and sub-tropical areas may also suffer similar erosion rates. In temperate areas, soil erosion can also be significant, even where there have been conservation efforts, as in the Mid-West of United States. Cropland in Europe is characterized by somewhat lower, yet still significant soil erosion rates (Figure 9).

Figure 9. Spatial variation of soil erosion by water.



Source: The map is derived from Van Oost et al., 2007[41] using a quantile classification. FAO and ITPS, 2015[42]

54. The effect of soil erosion on individual soil properties related to crop production is well documented, but the aggregate effect of soil loss on crop yields themselves is less firmly established. According to the integrative studies[43] that have been undertaken, the range of estimates of annual crop loss due to erosion ranges from 0.1 percent to 0.4 percent, with two studies estimating 0.3 percent yield reduction.

[41] Van Oost, K., Quine, T.A., Govers, G., De Gryze, S., Six, J., Harden, J.W., Ritchie, J.C., McCarty, G.W., Heckrath, G., Kosmas, C., Giraldez, J.V., Marques da Silva, J.R. & Merckx, R. 2007. The impact of agricultural soil erosion on the global carbon cycle. Science, 318(5850): 626-629

[42] FAO-ITPS. (2015) Status of the World's Soil Resources report. Rome, Italy.

[43] Crosson, P. (2003). Global consequences of land degradation: An economic perspective. In K. Wiebe, ed. *Land Quality, Agricultural Productivity, and Food Security*. pp. 36-46. UK, Cheltenham, Edward Elgar.;
Scherr, S.J. (2003). Productivity-related economic impacts of soil degradation in developing countries: an evaluation of regional experience. *In* K. Wiebe, ed. *Land Quality, Agricultural Productivity, and Food Security*. pp. 223-261. UK, Cheltenham, Edward Elgar.;
Den Biggelaar, C., Lal, R., Eswaran, H., Breneman, V.E. & Reich, P.F. (2003). Crop losses to soil erosion at regional and global scales: evidence from plot-level and GIS data. In K. Wiebe, ed. *Land Quality, Agricultural*;
Bakker, M.M., Govers, G. & Rounsevell, M.D.A. 2004. The crop productivity-erosion relationship: an analysis based on experimental work. *Catena*, 57(1): 55-76; *in* FAO-ITPS (2015) Status of the World's Soil Resources.

55. If the median value of 0.3 percent annual crop loss is valid for the period from 2015 to 2050, a total reduction of 10.25 percent could be projected to 2050 (assuming no other changes such as the adoption of additional conservation measures by farmers). Such a loss of 10.25 percent of yield due to erosion would be equivalent to the removal of 150 million hectares from crop production from a total of 1.53 billion hectares globally (equivalent to 4.5 million hectares per year.)[44]

Soil organic carbon (SOC) loss

56. Soil organic carbon (SOC) loss takes place when soil carbon is converted to greenhouse gases: carbon dioxide (CO_2) or methane (CH_4). Soils constitute the largest terrestrial carbon pool and play crucial roles in the global carbon balance by regulating dynamic biogeochemical processes and the exchange of greenhouse gases (GHGs) with the atmosphere. Declines of organic carbon stock negatively affect the soil's fertility and climate change regulation capacity. SOC stocks are especially sensitive and responsive to changes in land use (LUCC), for example, from a natural state to an agricultural ecosystem or from forest to cropland.

57. In sub-Saharan Africa, SOC loss generally occurs as a result of the replacement of the natural vegetation, complete crop biomass removal from farmlands and by the high rate of organic matter decomposition by microbial communities, a risk that is increased by higher temperatures. In Asia, it is due to the usage of crop residues as fuel or fodder as opposed to being returned to the soil, and to the degradation of grasslands. In Europe and Eurasia, drainage of peatland has led to organic carbon loss. In Latin America and the Caribbean, it occurs as a result of deforestation, the ploughing of grasslands and monoculture. In the Near East and North Africa region, it is mostly the high temperature which causes a high turnover of SOC, and the changes to soil management practices which result in SOC losses. In North America, the main concern is the loss of SOC from northern and arctic soils due to climate change. Lastly, in the Southwest Pacific, it is mostly the conversion of land for agricultural uses that has caused the largest losses. (Figure 10)

Nutrient imbalance

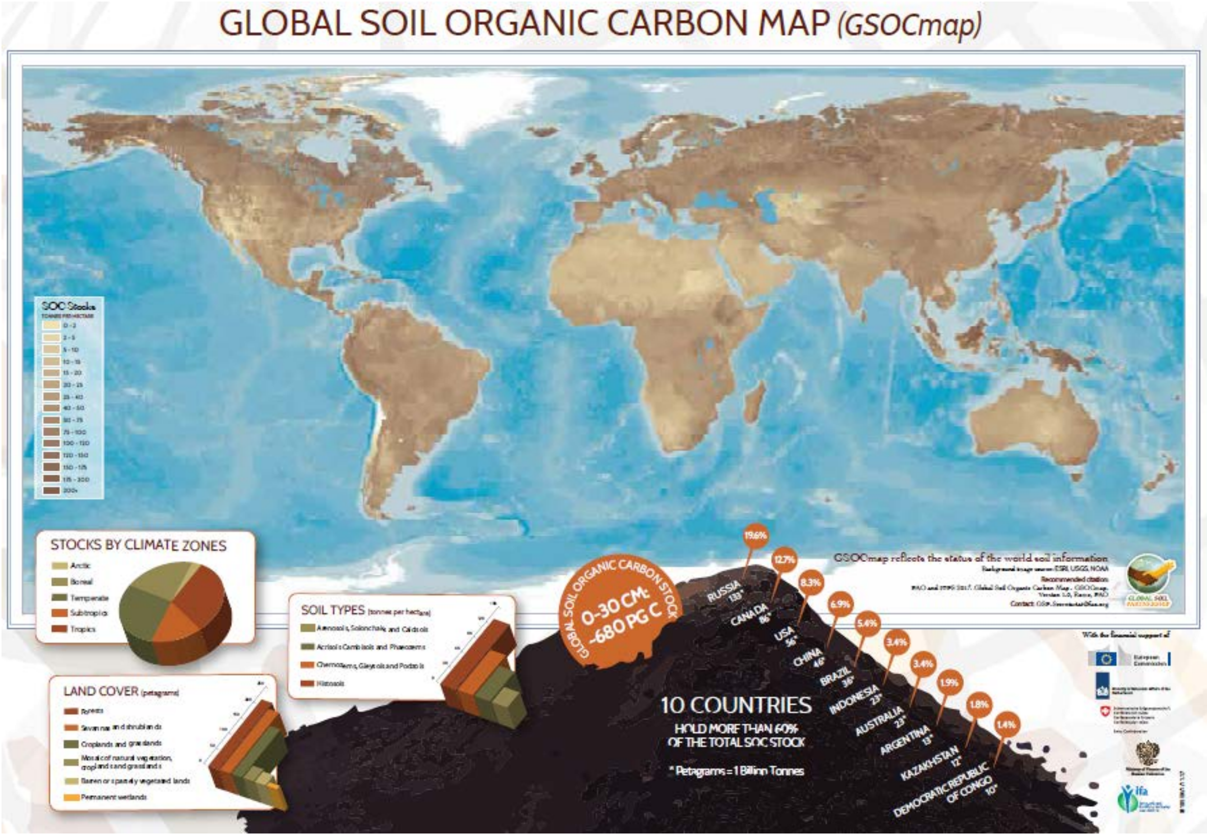
58. Finally, the last major global threat, nutrient imbalance, is when nutrient inputs or additions in the soil are either insufficient or in excess. On a global scale, soil nutrient balances for nitrogen (N) and phosphorus (P) are positive for all continents except for Antarctica.[45] Positive nutrient balances are representative of inefficient natural resource use and can lead to crop failure, as well as water and atmospheric pollution.

---

[44] FAO-ITPS (2015). Status of the World's Soil Resources.

[45] Bouwman, A. F., Beusen, A. H. W., & Billen, G. (2009). Human alteration of the global nitrogen and phosphorus soil balances for the period 1970-2050. Global Biogeochemical Cycles, 23(4), 1-16;
Bouwman,L. Kees Klein Goldewijk, Klaas W. Van Der Hoek, Arthur H. W. Beusen, Detlef P. Van Vuuren, Jaap Willems, Mariana C. Rufino, and Elke Stehfest, (2013), Exploring global changes in nitrogen and phosphorus cycles in agriculture induced by livestock production over the 1900–2050 period.

Figure 10: Spatial variation of soil organic carbon in the first 30 cm.

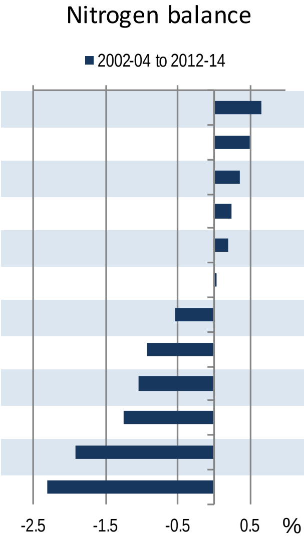


Source: FAO-ITPS (2018). Global Soil organic Carbon Map. Rome, Italy. The map was prepared by member countries under standard technical specifications.

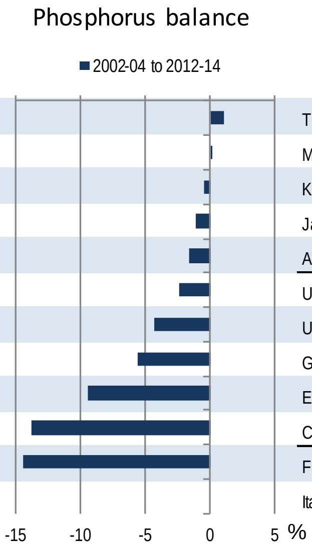
59. Phosphorus balances have been declining in developed countries. Historically, most of these countries have maintained high phosphorus surplus levels, so reductions are not affecting yields (Figure 11). Nitrogen is more mobile, therefore, reducing its application rate is challenging. This is reflected in the mixed results across countries and lower declining rates. Nitrogen surplus reductions in European countries have mainly been done by reducing N fertilizer use, while in Canada and the United States reductions come mainly from crop mix and livestock composition changes.

60. A negative nutrient balance, on the other hand, can adversely impact plant growth and crop nutritional value, as well as reduce the provisioning of ecosystem services that rely on nutrients for their completion. The main regions affected by nutrient depletion are located in Africa, Asia and South America. In Africa, all but three countries extract more nutrients from the soil each year than are returned through use of fertilizer, crop residues, manure, and other organic matter. Nutrient imbalance contributes to food insecurity, as insufficient nutrients hinder crop development and yield growth, and to water and atmospheric pollution, through losses of these nutrients to the environment.

Figure 11. Nitrogen and phosphorus balance per hectare of agricultural land, selected G20 countries: 2002-2014



	Average (kg nitrogen/ha) 2002-04	Average (kg nitrogen/ha) 2012-14	Average annual % change 2002-04 to 2012-14
Turkey	24	25	0.6
Australia	18	19	0.5
Korea	240	249	0.4
Mexico	23	23	0.2
Japan	173	176	0.2
Italy	72	72	0.0
Canada	30	28	-0.5
United Kingdom	71	65	-0.9
Germany	100	91	-1.0
United States	35	31	-1.2
EU15	85	70	-1.9
France	61	48	-2.3



	Average (kg phosphorus/ha) 2002-04	Average (kg phosphorus/ha) 2012-14	Average annual % change 2002-04 to 2012-14
Turkey	6	7	1.1
Mexico	2	2	0.2
Korea	49	47	-0.4
Japan	66	60	-1.0
Australia	1	1	-1.6
United States	4	3	-2.4
United Kingdom	6	4	-4.3
Germany	3	2	-5.5
EU15 (1)	7	3	-9.4
Canada	3	1	-13.7
France	6	1	-14.4
Italy	4	-2	n.c.

Note: n.c.: not calculated. Balance (surplus or deficit) expressed as kg nitrogen or phosphorus per hectare of total agricultural land. Countries are ranked in descending order according to average annual percentage change 2002-04 to 2012-14. The EU15 total excludes Luxembourg.
Source: OECD Agri-Environmental indicators: Nutrients http://stats.oecd.org//Index.aspx?QueryId=79764&lang=en

3.2. Impacts of soil degradation

61. Soil degradation, and the resulting effect on agricultural productivity and ecosystem services, has a major impact on food security and nutrition. In sub-Saharan Africa, in particular, it is considered a key driver of stagnating and declining agricultural productivity. A continuing decline in soil productivity, presents a significant socio-economic risk that could impact the economies of low-income countries and the lives of millions of rural households that are dependent on agriculture for their livelihood needs.

62. As population and, subsequently, food demand rises, agricultural productivity growth requires the sustainable management of natural resources and, in particular, soils and fertile land. Availability of new land in many countries is limited to that of marginal quality, with resulting low productivity. Local mineral deficiencies in soils produce deficiencies in food systems, which clinically impacts populations. Over 2 billion people suffer from micronutrient deficiencies and soils are an important factor: most essential nutrients and minerals (e.g. zinc, iron, iodine) cannot be derived from biosynthesis and must be obtained by plants from soils, in turn, these are acquired by humans through the food they consume. Soil degradation leads to large losses of productivity and fertile land, further compounding the challenge of soil quality, land availability and food security. Often, there are also negative impacts on water quality as the sediments and nutrients from erosion are deposed in water bodies, with this increased pollution causing declines in fish and other species.

63. In addition to the impacts that soils can have on food security, they also hold an important role in climate processes as they regulate greenhouse gas emissions (carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4)). Being a major terrestrial reservoir of carbon, they can have a huge influence on the concentration of greenhouse gases in the atmosphere and, if managed properly, certain soils can act as carbon sinks. However, if mismanaged, soils can also release carbon dioxide into the atmosphere as a result of, for example, land use change and poor soil management practices. Rising global temperatures are also increasing the amounts released, as warmer soils release more carbon.

64. The effects of climate change itself, such as higher temperatures and related extreme weather events (droughts, floods, storms), impact on soil quantity and fertility, being further drivers of soil change. The interactions and sensitivities between the climate system and soil processes are evident. Considering the growing demands on land area, and the expected increased degradation of soils as a result of climate change, sustainable soil management practices will be key in fostering carbon sequestration and improving soil health (such practices include cover crops, improved fallow plant species and reduced or no-tillage practices to ensure the soil has a sufficient organic cover).

65. The annual cost of land degradation due to land use and cover change (LUCC), including that of land degrading management practices on static cropland and grazing land, is estimated to be about US$300 billion.[46] This does not, however, include the impact on ecosystem services which would increase costs significantly. The investments needed to completely rehabilitate land degradation due to LUCC in all world regions are estimated at US$4.6 trillion over 6 years. During the same period, if action is not taken to rehabilitate degraded lands, the world will incur a loss of US$14 trillion, all of which suggests that the investment has a very positive return. A main question then is how to mobilize the resources needed to finance those investments.

3.3. Sustainable soil management practices

66. Food production relies on soils as a key natural resource: nutritious and quality food and animal fodder can only be produced if our soils are healthy. A healthy living soil is therefore a crucial ally to food security and nutrition. Numerous and diverse farming approaches promote some principles of sustainable soil management with the goal of improving productivity and protecting soils and the environment, for instance: agroecology, conservation agriculture, organic farming, minimum/zero tillage farming and agroforestry.

67. **Agroecology** uses ecological theory to study and manage agricultural systems in order to make them both more productive and better at conserving natural resources. This whole systems approach to agriculture and food systems development is based on a wide variety of technologies, practices and innovations, including local and traditional knowledge as well as modern science. By understanding and working with the interactions between plants, animals, humans and the environment within agricultural systems, agroecology encompasses multiple dimensions of the food system, including ecological, economic and social.

[46] Nkonya, E., A. Mirzabaev and J. von Braun (eds), 2016 Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development. International Food Policy Research Institute (IFPRI) and Center for Development Research (ZEF), University of Bonn. Springer Open. Springer International Publishing AG Switzerland.

68. **Organic farming** is agricultural production without the use of synthetic chemicals or genetically modified organisms, growth regulators, and livestock feed additives. It also emphasises a holistic farm management approach, where rotations and animals play an integral role to the system. Soil fertility is the cornerstone of organic management. Because organic farmers do not use synthetic nutrients to restore degraded soil, they must concentrate on building and maintaining soil fertility primarily through their basic farming practices. Evidence from research, field trials and farm experience shows that organic farming is, overall, more environmentally friendly than conventional agriculture, but its economic performance is more uncertain.

69. **Conservation agriculture practices** have significantly improved soil conditions, reduced land degradation and boosted yields in many parts of the world by following three principles: minimal soil disturbance, permanent soil cover and crop rotations. To be sustainable in the long term, the loss of organic matter in any agricultural system must never exceed the rate of soil formation. In most agro-ecosystems, that is not possible if the soil is mechanically disturbed. Therefore, one of the tenets of conservation agriculture is limiting the use of mechanical soil disturbance, or tilling, in the farming process. The economic attractiveness of soil conservation is highly site-specific, but brings positive environmental impacts.[47]

70. **Zero tillage** is one of a set of techniques used in conservation agriculture. Essentially, it maintains a permanent or semi-permanent organic soil cover (e.g. a growing crop or dead mulch) that protects the soil from sun, rain and wind and allows soil microorganisms and fauna to take on the task of "tilling" and soil nutrient balancing - natural processes that are disturbed by mechanical tillage. The application of modern biotechnology in agriculture has resulted in facilitation of zero-tillage systems for some crops. However, environmental benefits are context-specific and heavily dependent on thoughtful management practices as the use of herbicides on herbicide-tolerant varieties may compromise soil biodiversity.

71. **Agroforestry** systems include both traditional and modern land-use systems where trees are managed together with crops and/or animal production systems in agricultural settings. The combination of trees, crops and livestock mitigates environmental risk, creates a permanent soil cover against erosion, minimises damage from flooding and acts as water storage, benefitting crops and pastures.

72. **Integrated soil fertility management (ISFM)** is a combination of a judicious amount of inorganic fertilizer with organic inputs.[48] ISFM has been shown to be more profitable and sustainable than both organic farming and the application of inorganic fertilizer alone at recommended or higher rates.[49]

---

[47] OECD (2016), Farm Management Practices to Foster Green Growth, OECD Green Growth Studies, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264238657-en

[48] Vanlauwe, B., A. B. Bationo, J. N. Chianu, K. E. Giller, R. Merckx, U. Mokwunye, O. Ohiokpehai, et al.,. 2010. "Integrated Soil Fertility Management Operational Definition and Consequences for Implementation and Dissemination." Outlook on Agriculture 39 (1): 17–24.

[49] Nkonya E. and J. Koo. 2017. The Unholy Cross: Profitability and Adoption of Climate-Smart Agriculture Practices in Africa South of the Sahara. In De Pinto, A., and J. M. Ulimwengu (Eds). 2017. A Thriving Agricultural Sector in a Changing Climate: Meeting Malabo Declaration Goals through Climate-Smart Agriculture. ReSAKSS Annual Trends and Outlook Report 2016. Washington, DC: International Food Policy Research Institute: 103-113.

Box 4: Soil Management Programmes

There are currently a number of successful development programmes, in various regions and countries, with a specific focus on sustainable soil management.

In Africa, the AGRA Soil Health Programme aims to increase income and food security by promoting the wide adoption of integrated soil fertility management (ISFM) practices among smallholder farmers. The objective is to improve supply and access to appropriate fertilizers, as well as access to knowledge on ISFM. Currently 1.8 million smallholders are reported to be using ISFM, including fertilizer micro-dosing, manure and legumes in crop rotations, with yields in the Sahel up three to fourfold in good seasons.

The AgWaterSolutions Project, another initiative in Africa, promotes small-scale distributed irrigation systems that rely primarily on groundwater. The project has a lot of potential in countries such as Burkina Faso and is helping to shift the attention of policy makers and planners away from large scale irrigation developments.

In the Near East and North Africa (NENA) region, considered to be the most arid region in the world, MENARID (Integrated Natural Resources Management in the Middle East and North Africa) is a partnership working for improvement of the governance of natural resources, including water. The programme aims to improve the livelihoods of target communities through the restoration of degraded natural resources, including land and soils.

The regions with the largest challenges in relation to soil degradation are often those facing many other difficulties, including, rapid population growth, conflict and political unrest and high vulnerability to climate variability. Implementing such programmes can be especially difficult, but also extremely important as these are the regions that also face the biggest challenges with relation to food security and nutrition.

In the United States a number of agri-environmental programmes are in place, among them: i), Working-land programmes like the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP) provide financial assistance to farmers who adopt, install, or maintain conservation practices such as conservation tillage, nutrient management, integrated pest management, etc.) on land in production; ii) Land retirement programmes like the Conservation Reserve Program (CRP) remove land from agricultural production for at least 10 years and support high-priority, partial-field practices such as field-edge filter strips and grass waterways. Cross compliance approaches are also used to control soil erosion.

In the European Union, member states have the freedom to implement policies to protect soils according to the needs and specific geo-climatic and farming conditions in their territories. Agricultural soil protection is at the interface of several EU main policy packages. In the EU Common Agricultural Policy (CAP) aspects of soil protection have been an integral part of Good Agricultural and Environmental Conditions (GAEC) since the introduction of cross compliance in 2003, and several of agri-environmental measures cover actions to conserve soils. In addition, the Soil Thematic Strategy was introduced in 2014 and soil management is also affected by a number of environmental policies such as the Nitrates and Water Directives.

73. The provision of ecosystem services, including through environmental payments and regulations, can facilitate the adoption of sustainable soil practices (see Box 4). Governments should promote the creation and dissemination of credible, science-based information on farmer- and science-led farm management practices. The key ingredients for persuading and enabling farmers to adopt SSM practices are credible, relevant and up-to-date business-acumen advice, training and extension.[50]

74. Payments under environmental programmes are voluntary for farmers. For compliance with the WTO they must meet specific criteria. Often the adoption of such sustainable practices may lead to an initial loss of productivity and income. To qualify as environmental programme consistent with the requirements specified in the WTO Agreement on Agriculture (AoA), one important criterion is that the amount of the payment must be limited to the "extra costs or loss of income involved with complying with the government programme" (paragraph 12(b) of Annex 2 of the AoA).

75. In the United States and other countries such cost-share programs for establishing conservation practices on agricultural land have supported implementation of farming practices and structures that reduce loss of fertility through soil erosion; facilitate improved drainage, water storage, and more efficient irrigation; and, provide manure storage and assistance with meeting nutrient management regulations.[51] The effectiveness and efficiency of voluntary payment programmes are difficult to assess. Environmental benefits will be realised only if payments made to farmers leverage the adoption of conservation practices that would not have been adopted otherwise.[52]

76. The cost effectiveness of agri-environmental payments to promote soil management could be improved by directly linking incentives to environmental outcomes.[53] This can be done through using proxies, like an environmental benefit index, wherever data availability allows this. In the case that multiple policy instruments are combined, they should complement and do not conflict with each other.

77. In some countries, the provision of payments to farmers is conditional on producers following specified farm management practices. This environmental cross-compliance is required, with the policy acting as compensation to meet regulatory requirements. In the EU, for example, the scope of environmental cross compliance includes water pollution, soil quality and soil erosion, protection of landscape features and avoiding abandonment of land. In the United States it includes soil erosion, wetland preservation, and in Switzerland it includes environmentally sustainable use of land for farming, biodiversity and animal welfare.[54] Other things being equal, with respect to furthering environmental objectives, targeted measures are likely to be more efficient and cost effective in achieving specific environmental aims than cross-compliance approaches.[55]

---

[50] OECD (2015), Fostering Green Growth in Agriculture: The Role of Training, Advisory Services and Extension Initiatives, OECD Green Growth Studies, OECD Publishing, Paris

[51] Claassen, R. Duquette, E., Horowitz J. (2013) Additionality in agricultural conservation payment programs. Journal of soil and water conservation 68 (3), 74A-78A

[52] Claassen, R. (2012), "Additionality in US agri-environmental programmes for working land: A preliminary look at new data", in OECD (2012), OECD (2012), Evaluation of Agri-Environmental Policies: Selected Methodological Issues and Case Studies, OECD Publishing. http://dx.doi.org/10.1787/9789264179332-en

[53] OECD (2010), Environmental Cross Compliance in Agriculture, http://www.oecd.org/tad/sustainable-agriculture/44737935.pdf, Paris. OECD (2012), Evaluation of Agri-Environmental Policies: Selected Methodological Issues and Case Studies, OECD Publishing. http://dx.doi.org/10.1787/9789264179332-en

[54] OECD (2010), Environmental Cross Compliance in Agriculture, http://www.oecd.org/tad/sustainable-agriculture/44737935.pdf, Paris.

[55] OECD (2013b): Global Food Security: Challenges for the Food and Agriculture System

3.4. Role of Information Communication Technology (ICT)

78. In addition to, or complementing, sustainable soil management practices, many existing and important tools can be used for soil conservation, such as Information and Communication Technology (ICT). In the context of increasing digitalization of the economy and the society, ICTs are crucial in assessing natural resources and providing information to tackle climate change.

79. Over the last twenty years, farmers in developed countries have already been using ICTs in large scale farming for Precision Agriculture (PA)[56] including in soil analysis, irrigation, farming equipment, weather forecasting, and more. The fast pace of technological development, which allows for increasing data storage and analytics and progressively lower costs has helped support these farming advances.

80. While the main incentive to adopt Precision Agriculture (PA) methods is to maximise profitability, it can also reduce environmental impacts of farming practices. The approach is currently used mainly by large arable farms in Central and Northern Europe, the USA, Canada and Australia, and it has the potential to expand into emerging economies like India. A successful example of the application of this method is the use of Controlled Traffic Farming, which reduces crop damage and soil compaction as it confines field vehicles to the minimal area of permanent traffic lanes with the aid of GNSS technology and decision support systems. Farmers in Australia and the UK have been able to reduce machinery and input costs and increase crop yields.

81. In many developing countries, however, the digital divide is nowhere more evident than in agriculture. This is not only due to the different extent to which digital technologies have penetrated rural areas across the developed economies and the developing world, but also due to different farm structures. Open access resources, particularly mobile phone applications, are vital in the provision of information and knowledge. For example, the application *Open Foris*[57] allows even a smallholder equipped with a smartphone to better measure and monitor a piece of land no bigger than an acre. Other applications, such as the recently launched *Soil Organic Carbon App*[58], allow investors to assess to what extent planned efforts to restore degraded land will bind organic carbon in soil and mitigate climate change.

82. Technologies such as Digital Soil Mapping (DSM) and soil sensors allow for innovative bottom-up approaches to characterise soils. Such technology can be utilised in efficient and precise decision making on the farm, and is key to advancing soil research and providing location specific advice by extension services to adopt best practices. ICTs can also provide digital platforms for cooperation and collaboration between scientists and other stakeholders, which would improve agricultural practices and soil conservation.[59] Finally, the design and implementation of environmental policies can also benefit from these technologies in order to monitor soil erosion, SOC, nutrient balances and other agri-environmental performance indicators, and better targeting policy and legislation on environmental practices in different locations.

[56] Precision Agriculture (PA) is a whole-farm management approach using information technology, satellite positioning (GNSS) data, remote sensing and proximal data gathering.
[57] http://www.openforis.org/
[58] https://wle.cgiar.org/solutions/soil-organic-carbon-app
[59] Lin, Yu-Pin, et al. (2017) Applications of information and communication technology for improvements of water and soil monitoring and assessments in agricultural areas—A case study in the taoyuan irrigation district. Environments 4.1: 6.

3.5. Ongoing collective responses and international governance

83. In recent years, significant progress has been made in the support of strategies and policies to improve global governance of soil resources. In order to meet the need for a multilateral forum focusing specifically on soil challenges, and to advocate for sustainable soil and land management at global level, the Global Soil Partnership (GSP) was established by the FAO Council in December 2012.

Global Soil Partnership

84. The GSP is an interactive, responsive and voluntary partnership, open to governments, regional organizations, institutions and other stakeholders at various levels. It strives to raise awareness among decision makers on the role of soil resources in relation to food security, climate change, and to build capacities and exchange knowledge and technologies for sustainable management of soil resources.[60]

Table 2. The 5 Pillars of Action of the Global Soil Partnership.

Pillar No.	Action
1	Promote sustainable management of soil resources for soil protection, conservation and sustainable productivity
2	Encourage investment, technical cooperation, policy, education awareness and extension in soil
3	Promote targeted soil research and development focusing on identified gaps and priorities and on synergies with related productive, environmental and social development actions
4	Enhance the quantity and quality of soil data and information: data collection, analysis, validation, reporting, monitoring and integration with other disciplines
5	Harmonize methods, measurements and indicators for the sustainable management and protection of soil resources

85. The Partnership, being a common communication platform incorporating local challenges, allows experiences to be shared among farmers and scientists across countries and regions, and develops global governance guidelines aiming to improved soil protection and sustainable soil productivity, in accordance with the sovereign right of each State over its natural resources. In order to achieve its mandate, the GSP addresses five pillars of action to be implemented in collaboration with its regional soil partnerships. (Table 2).

86. An indication of the emerging priority accorded to soils and a measure of the impact of the GSP was the declaration by the United Nations General Assembly of 2015 as the International Year of Soils and the initiation of the UN World Soil Day.

[60] http://www.fao.org/global-soil-partnership/en/

The Intergovernmental Technical Panel on Soils

87. Technical and scientific guidance is provided by the Intergovernmental Technical Panel on Soils (ITPS).[61] The main function of the ITPS is to provide scientific and technical advice and guidance on global soil issues to the Global Soil Partnership primarily and to specific requests submitted by global or regional institutions. The ITPS advocates for addressing sustainable soil management in the different sustainable development agendas, and complements related scientific advisory panels including the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES), and the UNCCD's Science-Policy Interface (SPI).

88. The ITPS has been key to the development of the Plans of Action for the five pillars of the Global Soil Partnership (Table 2). It has also been engaged in the development of the Sustainable Development Goals and the initiation of formal reporting mechanisms, including the publication of the State of World's Soil Resources.

The revised World Soil Charter

89. The World Soil Charter, adopted in 1981, established a set of broad guiding principles for the use of the world's soil resources, for improvement of their productivity, and for their conservation for future generations. In view of new scientific findings and the rapidly changing environmental and social conditions of the world, including soil pollution and its consequences for the environment, urbanization pressures, and climate change adaptation and mitigation, the Chapter was revised in 2015, by means of extensive consultations organized by the ITPS.[62] The Charter contains a number of key principles and general guidelines and forms a normative instrument for countries to chart the required policy measures and concrete action programmes that promote sustainable management, conservation and restoration of soils.

The Voluntary Guidelines for Sustainable Soil Management

90. The Voluntary Guidelines for Sustainable Soil Management (VGSSM) were developed through an inclusive process within the framework of the Global Soil Partnership. They aim to be a reference providing general technical and policy recommendations on sustainable soil management for a wide range of committed stakeholders, and to contribute to global, regional and national efforts towards the eradication of hunger and poverty due to the importance of soils in sustainable development.

91. The VGSSM are of voluntary nature and are not legally binding. They elaborate the principles outlined in the revised World Soil Charter, and provide guidance on how to translate these principles into practice, taking into account the scientific evidence. The guidelines address technical aspects of SSM including core characteristics of sustainably managed soils, key challenges and potential solutions to address them.

---

[61] The Intergovernmental Technical Panel on Soils (ITPS) was established at the first Plenary Assembly of the Global Soil Partnership held at FAO Headquarters on 11 and 12 of June, 2013. The ITPS is composed of 27 top soil experts representing all the regions of the world.

[62] The revised World Soil Charter was endorsed by the FAO Conference at its 39th session in June 2015. FAO (2015). The Revised World Soil Charter. (http://www.fao.org/3/a-i4965e.pdf)

92. The VGSSM focus mostly on agriculture which is broadly defined as the production of food, fibre, feed, timber and fuel, although many of the principles described have a significant influence on ecosystem services provided by managed and unmanaged soil systems.[63]

Box 5: The SDGs and soil

In 2016, the United Nations adopted 17 Sustainable Development goals, with a view to mobilising efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind. The adoption of the SDG's represented an opportunity for soil-related issues to be included in intergovernmental processes. This was explicitly recognised through the inclusion of Target 15.3 *"By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world"* but the sustainable management of soils also has the potential to contribute directly to areas of importance for additional SDGs, for example:

- Food security and nutrition (SDGs 1, 2 and 3) – Restoration of soil productivity and ecosystem functions through precision agriculture, soil nutrient management and increasing nutrient and water use efficiency can improve food security and nutrition.
- Health (SDG 3) – Soils sustain life by providing not only food and water, but also by being a source of many essential medicines, including certain antibiotics.
- Water security and resources (SDGs 3 and 6) – Soils play a major role in the storing and transmitting water to plants, the atmosphere, groundwater, lakes and rivers. Around 74% of freshwater appropriated by humans is estimated to come from soil.
- Climate change (SDG 13) – Sustainable soil management can assist with climate change mitigation.
- Biodiversity (SDG 15), There is increasing evidence that soil biodiversity is of great importance of biogeochemical cycles, above-ground biodiversity, soil formation, the control of plant, animal, and human pests and diseases, as well as climate regulation.
- Land management (SDGs 2, 13 and 15) – Sustainable land management is important to ensure ecosystem services and soil functions.

To achieve sustainable development, we need to recognize the multiple benefits that sustainable soil management could provide for the realization of the 2030 agenda.

The Global Symposium on Soil Organic Carbon

93. In 2017, FAO together with GSP-ITPS, IPCC, WMO and SPI-UNCCD successfully organized the Global Symposium on Soil Organic Carbon (SOC) in order to set an agenda for action on SOC losses. The recommendations made based on this consultation are aimed at supporting the development of policies and actions to encourage the implementation of soil and land management strategies that foster the protection, sequestration, measurement, mapping, monitoring and reporting of SOC.[64]

4/1000 initiative: Soils for Food Security and Climate

94. France, launched the "4/1000 initiative: soils for food security and climate" in December 2015, as part of the COP21. The initiative aims to foster soil organic carbon sequestration by looking at the annual growth rate of the soil carbon stock and its importance in increasing soil fertility,

---

[63] The guidelines were adopted by the 4th GSP Plenary Assembly (Rome, 25 May 2016), approved by the 25th session of the FAO Committee on Agriculture (Rome, 28 September 2016) and finally endorsed by the 155th session of the FAO Council (Rome, 5 December 2016). FAO and ITPS (2017). Voluntary Guidelines for Sustainable Soil Management. Rome. (http://www.fao.org/3/a-bl813e.pdf).

[64] FAO, Global Soil Partnership, Intergovernmental Panel on Climate Change, Intergovernmental Technical Panel on Soils, Science-Policy Interface of the UNCCD, United Nations Convention to Combat Desertification, World Meteorological Organization (2017) Unlocking the Potential of Soil Organic Carbon: Outcome Document. Rome.

agricultural production, and carbon sequestration. Soil degradation is an issue and potential threat in over 40% of global soils, and the 4/1000 initiative aims at engaging stakeholders in shifting towards sustainable soil management in order to avoid the consequences on agricultural production, food security and climate change. The initiative has already established its forum and consortium and is planning implementation activities with partners.[65]

Global Symposium on Soil Pollution

95. Finally, earlier this year, the United Nations Environment Assembly – 3 (UNEA-3) committed to a pollution-free planet, with resolutions that promise to improve the status of our planet by cleaning up our air, water and land. One of the resolutions adopted focuses on the importance of managing soil pollution, a major step towards sustainable development. In response to this, FAO, GSP, ITPS, UNEP, WHO and the Basel and Rotterdam Conventions are organizing the Global Symposium on Soil Pollution in May 2018 in order to provide a forum for scientific evidence, on an issue that requires joint bold actions.

Box 6: Information and data

Global Soil Information System, including the International Network of Soil Information Institutions

In 2017, GSP partners recognizing the need for comprehensive and reliable soil data to support evidence-based policies, agreed on the establishment of Global Soil Information System (GLOSIS), including the International Network of Soil Information Institutions (INSII).1

GLOSIS will have three primary functions: (i) to provide data on soils at the global level (e.g. the amount of arable land with suitable soil to feed the world); (ii) to provide the global context for more local decisions (e.g. transnational aspects of food security and degradation of natural resources): and, (iii) to supply fundamental soil data for understanding Earth-system processes to support work on major natural resource issues facing the world (e.g. climate change, food security, biodiversity loss).

The Global Soil Organic Carbon Map

The Global Soil Organic Carbon Map (GSOCmap) was launched by the GSP in 2017 in support of the Sustainable Development Goal Indicator 15.3.1 to assess carbon stocks above and below ground.1 GSOCmap aims at providing a precise and reliable global view on soil organic carbon (SOC) that is needed under different UN conventions, such as the UN Convention on Climate Change and Desertification (UNCCD), but especially as part of the Sustainable Development Goals (SDG).

At national level, such data can be used as reference soil carbon stocks, with the aim to refine national greenhouse gas inventories, and to assess the sensitivity of soils to degradation and climate change. The GSOCmap provides users with useful information to monitor the soil condition, identify degraded areas, set restoration targets, explore SOC sequestration potentials, support the greenhouse gas emissions reporting under the UNFCCC, and make evidence based decisions to mitigate and adapt to a changing climate.

International agreements on soil and land resources are helpful but they are all to no avail unless there are complementary policies and coordinated activities at regional, national, district and local levels. Appropriate and effective policies need to reflect the local context in terms of the natural resource issues, culturally acceptability and economic feasibility.

Sources: Progresses on the Global Soil Information System (http://www.fao.org/global-soil-partnership/resources/highlights/detail/en/c/1026182/); The GSOCmap, a stepping stone in our knowledge of soils (http://www.fao.org/global-soil-partnership/pillars-action/4-information-and-data/global-soil-organic-carbon-gsoc-map/en/)

[65] https://www.4p1000.org/

3.6.Way forward

96. Soils constitute a resource that if sustainably managed – by promoting carbon sequestration, enhancing soil biodiversity and thus soil health and increased soil fertility - could contribute to sustainable productivity growth, climate change adaptation and mitigation, food security and nutrition, poverty alleviation, and sustainable development.

97. Maintaining and increasing SOC stocks is not only crucial for reducing GHG emissions and removing CO2 from the atmosphere but also for harnessing the benefits of increased SOC for soil health and fertility, through improving water storage and thereby increasing the access of plants to water, and resilience to drought. Maintaining and increasing SOC stocks should be promoted, therefore, under the wider umbrella of sustainable soil management (SSM).

98. Noting that soils are currently considered in the development agenda, it is fundamental to develop and strengthen synergies between the ongoing initiatives in order to foster positive impact and make proper use of the limited resources available. While this document highlights many of the efforts currently being made, it also focuses on many issues that require further support in order to achieve healthy soils for a healthy life.

3.7.Recommendations

1. In relation to international initiatives, G20 members:

   1.1 Continue to support the Global Soil Partnership and the Intergovernmental Technical Panel on Soils, and undertake actions to promote the Principles and Guidelines of the revised World Soil Charter and the Voluntary Guidelines for Sustainable Soil Management.

   1.2 Support the efforts to establish global information systems, such as the Global Soil Information System, the International Network of Soil Information Institutions, and the Global Soil Organic Carbon Map.

   1.3 Support the implementation of the Koronivia joint work on agriculture, decided at the 23rd Conference of the Parties (COP 23) to the United Nations Framework Convention on Climate Change (UNFCCC), and its special focus on soil organic carbon, soil health and soil fertility.[66]

   1.4 Take note of the 2017 United Nations Environment Assembly Ministerial Declaration[67] on mitigating and managing soil pollution, and the organization of the Global Symposium on Soil Pollution.

2. At the national level, G20 members:

   2.1 Promote sustainable farm and soil management practices that are tailored to specific soil types and to country needs, and address soil degradation by prevention and restoration/rehabilitation of degraded soils, through policies and measures that are in line with the WTO Agreements.

[66] https://unfccc.int/files/meetings/bonn_nov_2017/application/pdf/cp23_auv_agri.pdf
[67] http://web.unep.org/environmentassembly/documents/political-declaration-pollution

2.2 Promote sustainable soil management by facilitating the development of synergies with the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Forests and Fisheries in the Context of National Food Security (VGGT) adopted by the Committee on World Food Security in May 2012.

2.3 Integrate knowledge of soil resources into formal education, promote multilevel and interdisciplinary training, and strengthen research, development and extension programs.

2.4 Develop national soil information systems and institutions, including for monitoring soil health, in consistency with global information systems.

2.5 Embrace ICT and digital data innovations to improve the sustainable soil management, and promote their use to monitor the state of soils and improve the quality of research; to design better agri-environmental policies and regulations; and, to provide targeted technical advice on farm practices by extension services.

2.6 Consider the role of soil management practices in the adaptation to and mitigation of climate change and in maintaining biodiversity, as recommended by the Global Symposium on Soil Organic Carbon and its Outcome Document 'Unlocking the Potential of Soil Organic Carbon'.[68]

2.7 Consider ways to structure financial vehicles and arrangements that would support the investments needed to restore soils and ensure their health and sustainability, through improving project preparation, addressing data gaps on financial performance, improving instruments designed to fund infrastructure projects, and improving coherence.[69]

[68] http://www.fao.org/3/b-i7268e.pdf

[69] IFPRI Blog (Diaz-Bonilla, E.). Financing a sustainable food future. How Argentina's G-20 Presidency can target a key priority. February 16, 2018. IFPRI. https://www.ifpri.org/blog/financing-sustainable-food-future