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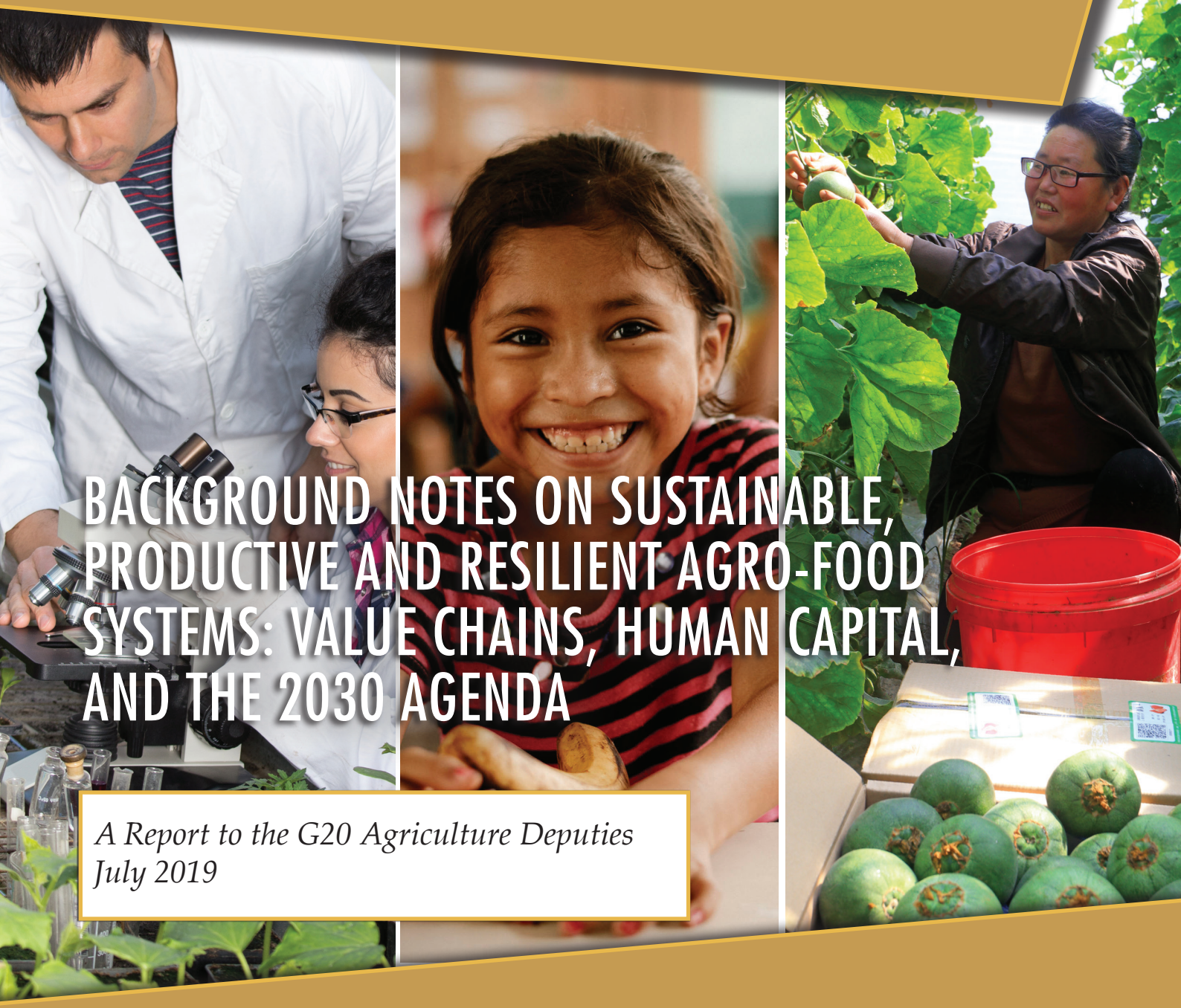

BACKGROUND NOTES ON SUSTAINABLE, PRODUCTIVE AND RESILIENT AGRO-FOOD SYSTEMS: VALUE CHAINS, HUMAN CAPITAL, AND THE 2030 AGENDA

A Report to the G20 Agriculture Deputies
July 2019

Inputs from
International Fund for Agricultural Development (IFAD)
International Food Policy Research Institute (IFPRI)
Economic Research Institute for ASEAN and East Asia (ERIA)
World Trade Organization (WTO)

Background Notes on Sustainable, Productive and Resilient Agro-Food Systems:

Value chains, human capital, and the 2030 Agenda

A report prepared for the G20 Presidency of Japan and the G20 Agriculture Deputies

Food and Agriculture Organization of the United Nations (FAO) and the
Organisation for Economic Co-operation and Development (OECD) with inputs from the
Economic Research Institute for ASEAN and East Asia (ERIA)
International Food Policy Research Institute (IFPRI)
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Contents

Acronyms

AAAA	Addis Ababa Action Agenda
AMR	Antimicrobial Resistance
AET	Agricultural Education and Training
ATVET	Agricultural Technical-vocational Education and Training
CSA	Climate-smart agriculture
FDI	Foreign Direct Investment
GAP	Global Action Plan on Antimicrobial Resistance
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIAHS	Globally Important Agricultural Heritage Systems
GVCs	Global Value Chains
ICTs	Information and Communication Technologies
IPPC	International Plant Protection Convention
MDGs	Millennium Development Goals
OIE	World Organisation for Animal Health
PoU	Prevalence of Undernourishment
R&D	Research and Development
SDGs	Sustainable Development Goals
SMEs	Small and Medium Size Enterprises
WHO	World Health Organization

Introduction

Agricultural production more than tripled between 1960 and 2015, owing in part to productivity-enhancing technologies and a significant expansion in the use of land, water, and other natural resources for agricultural purposes. The same period witnessed a remarkable process of industrialization and globalization of food and agriculture. Food value chains have lengthened dramatically both in terms of physical distance from farm to plate, the incorporation of value added from different sectors and countries, but also in terms of more links being progressively characterized by stringent food safety and quality requirements. The consumption of processed, packaged and prepared foods has increased in all but the most isolated rural communities.

Today, more than ever, agriculture faces multiple and complex challenges. It has to provide sufficient, safe, and nutritious food to meet boosting demand by a growing and progressively more prosperous population, and ensure food security for all. It will need to do so while managing natural resources sustainably. Despite undeniable progress, after a prolonged decline, new evidence continues to signal a rise in world hunger for a third consecutive year. In 2017 the number of undernourished people was estimated to have increased to 821 million – around one out of every nine people in the world.[1] A range of health-related issues is coming to the fore, including other forms of malnutrition such as obesity and overweight, animal and plant disease risks, and antimicrobial resistance.

The agricultural and food sector has to generate jobs and incomes and contribute to poverty eradication, rural economic growth, and transformation. The sector, today, is a significant employer in a number of countries. Yet rural people make up four-fifths of the global poor. In developing countries, agriculture and food systems are central to promoting inclusive economic growth and reducing poverty. In developed economies, investments in agriculture and food systems can contribute to vibrant rural economies.

At the same time, climate change is jeopardizing crop and livestock production. Higher average temperatures and the likelihood of increased frequency of extreme weather events can affect agriculture in both the long- and the short-term. The evidence suggests that climate change will affect world regions unevenly, increasing inequalities and further widening the gap between developed and developing countries.[2] The sector has to adapt to changing temperatures, precipitation patterns, and more frequent extreme weather events, mitigate its impact on the environment, and address the provision of ecosystem services.

Disruptive technologies have the potential to transform how businesses, people, and governments work and also to revolutionize agriculture and the food sector in the way food is produced, processed, and distributed. At the same time, the digital economy may pose risks in terms of skills mismatches and rising inequality both within and across countries, especially in rural areas.

Broad G20 actions to foster faster economic growth are mutually reinforcing with efforts to promote agricultural development and improve global food security and nutrition.

Addressing tomorrow's challenges in food and agriculture will require coordination and coherence of actions and policies across countries

The G20 represents a large share of global gross agricultural production value typically in the range of 80 percent. What G20 countries produce, how they produce it, what stocks they keep, and what they import and export have a global impact, including on the most vulnerable. The Group has unique strengths as a coordinating forum, involving emerging and advanced countries at the highest level to focus on the most pressing issues in the world economy.

This draft includes three notes responding to the request by the G20 Presidency of Japan to provide background material and information to support discussions in the G20 Agriculture Ministers meeting in May 2019. Each note focuses on one of three interlinked issues: (i) the policy challenges for strengthening the participation of farmers into modern value chains and promoting value addition, inclusion, sustainability and rural economic growth; (ii) the need for a transformation in the skillset of agricultural workers and a renewed focus on human capital development in agriculture in order to be able to implement technological and economic change, consumers' preferences and concerns, better natural resources management, as well as addressing global trends such as climate change and globalization; and (iii) the contribution of agriculture to the realization of the 2030 Agenda for Sustainable Development – ending poverty, hunger and malnutrition, and responding to climate change while achieving inclusive growth, building resilient communities and sustainably managing our natural resources.

FAO and OECD undertook the preparation of these three notes with inputs from ERIA, IFAD, IFPRI, and the WTO. The international organisations are honoured to provide the G20 Presidency of Japan with the results of this joint effort and look forward to continuing to collaborate within the G20 framework.

1. Integrating farming into modern value chains

Modern food and agriculture systems face many challenges. First, the production of safe and nutritious food needs to increase substantially in the coming decades to meet growing demand. Second, to generate jobs and incomes and contribute to poverty eradication and rural economic growth. Finally, to contribute to the sustainable management of natural resources and the adaptation to, and mitigation of climate change.

Farming is one of the main contributor to overcome these challenges and is already working together with other sectors of the economy to achieve these goals through value chains.[3] The food and agriculture sector is increasingly interlinked – within and across borders – and technology and services intensive. Responding to demand, agri-food products purchased by consumers combine value added from different sectors and countries. The value added from the agriculture sector ends up consumed – domestically or internationally – in a bundle together with products and services from other sectors and countries.

There is a diversity of drivers and pathways for the integration in these global agro-food value chains: focusing on primary agriculture or on processing; increasing efficiency, reducing costs and improving access to inputs; creating market niches for differentiated products and responding to consumers' demands for higher value added goods; and, improving inclusion and access to market opportunities.[4] Each of these pathways or any combination of them can contribute to creating more value from the sector and other rural activities. The optimal pathway for a specific region or business depends on their factor endowments and advantages; their performance is crucially determined by the competitiveness of interlinked network of industries that constitute a value chain, in particular increasingly on services and digital technologies.

A key policy challenge to agricultural value chains is to enhance the positive impacts of the development of these connections not only on value-added, innovation and the rural economy but also on inclusion and sustainability. Policies should target the constraints that bind the achievement of these outcomes. A coherent policy environment to enhance the competitiveness, sustainability and resilience of value chains will cover several policy areas such as agricultural and environmental policies, competition policy, codes of conduct, investment on physical and human capital and standards.

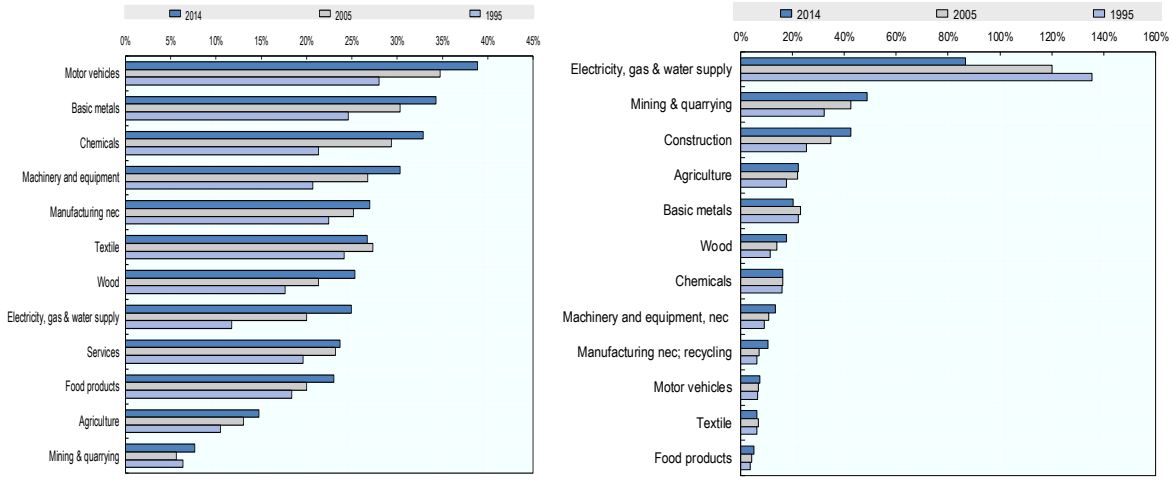
1.1 The increasing interactions of the food economy

The evolution of global value chains has changed the nature of production and specialization around the world. The fragmentation of production challenges the way we look at the global economy and the linkages between economic sectors.[5] Value chains represent all activities involved in producing and transforming raw materials into the final consumer product, including production, marketing ,and delivery to the final consumer. The fact that these activities are increasingly spread over several countries and combine products and services from different firms and sectors is what makes these value chains more global and interconnected with other industries, domestically and internationally. This trend is not only relevant in industrial products, but also agriculture and food, opening new challenges and opportunities for the agro-food sector.[6]

The level of engagement in Global Value Chains (GVCs) is assessed by looking at flows of intermediates measured with comparable country indicators of participation as a user of foreign importer intermediates (backward) and as a supplier to other countries' exports (forward indicator).[7] Despite initial lower levels than other sectors, both indicators have significantly grown in the last two decades in agriculture and food (Figure 1). Agriculture is linked to GVCs generally as an upstream provider of materials used in other production processes, with the food sector more of a downstream user of materials. The primary agricultural sector has higher forward participation in export markets than most industrial sectors. However, these average numbers hide considerable variation in the levels of GVC participation by agro-food sectors and across countries. For instance, in many developing countries, food production and consumption remain mostly local[8].

Figure 1: Agro-food sectors' participation in GVCs[1] has increased

Backward participation *Forward participation*



Notes: 1. Food includes food products, beverages and tobacco. 2. Services include construction. 3. Agriculture includes agriculture, hunting, forestry and fisheries. 4. Average across the countries in the TiVA database (64 countries including all G20 members, http://www.oecd.org/industry/ind/tiva-2018-countries-regions.pdf).
Source: OECD. 2015. *TiVA database*, (https://stats.oecd.org/index.aspx?queryid=66237).

Involvement in GVCs can also be a key driver of economic transformation and sector growth.[9] This occurs because participation in GVCs offer additional opportunities to access new markets, more efficient and higher quality inputs and services, and potential productivity gains resulting from technology spillovers. Increased access to better inputs and services also benefit producers in shorter, local value chains. While local value chains are underpinned by domestic connections both for sourcing inputs and selling to final consumers, their competitiveness is also linked to the performance of upstream and downstream agro-food industries. Ensuring that these opportunities materialize requires appropriate policies, innovation, and skills to reap the benefits of combining value added from different sectors and countries.

Innovation in agriculture is increasingly taking place in interactive and dynamic processes involving a diversity of public and private actors across sectors.[2] This is partly because innovation in agriculture is dependent on the technologies developed outside agriculture such as genetics and digital technologies. Innovation in the sector is increasingly driven by economy-wide processes and organisational innovations, developments in ICT, and the bio-economy. A higher degree of interconnection between the sectors through value chains supports the innovation process in agriculture by making knowledge and experiences in other fields and sectors available for their development and adoption in the agro-food sector. These links can enhance and complement innovation that is taking place at the farm level, where local innovations in

[1] The indicator of backward participation in GVCs is the foreign value added embodied in exports, as a percentage of total gross exports of the exporting country. The indicator of forward participation in GVCs is the domestic value added embodied in foreign exports (other countries 'exports) as a percentage of total gross exports of the source country. http://www.oecd.org/trade/measuring-trade-in-value-added.htm#access .
[2] 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.

areas such as natural resource management and climate change adaptation have high potential.

Intermediate goods and services are embedded in agriculture production

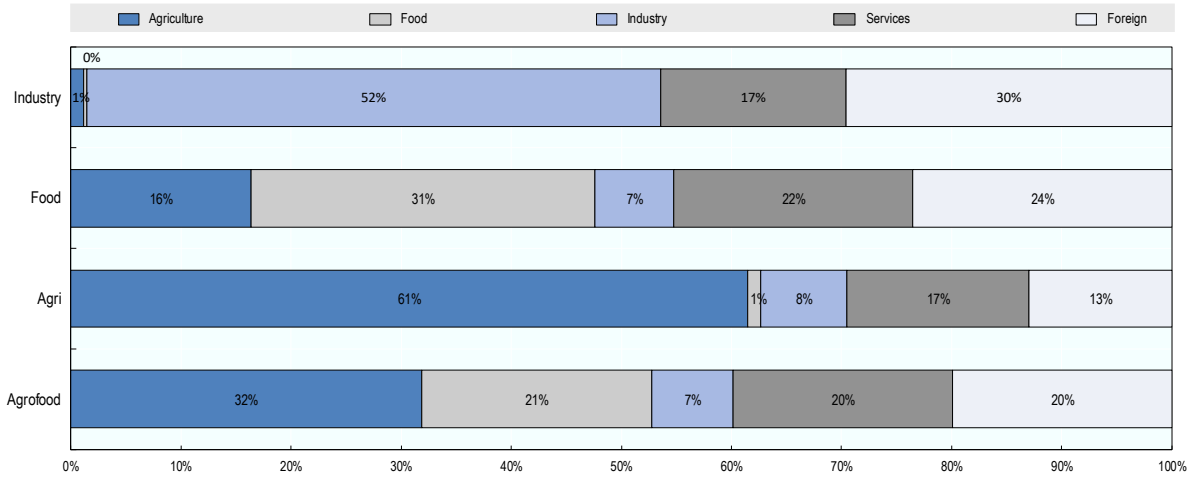
Value chains do not only link agro-food sectors across the world, but they also create linkages with other sectors in domestic markets. These linkages are an important determinant of competitiveness. The role of the service sector in value chains has been increasing, and its competitiveness is thus an important determinant of agro-food production and performance. Not only because these services can contribute to reducing costs, but they can also differentiate the final product as a response to the changing nature of competition and demand in agro-food markets. Agro-food sectors are often using service content as a form of product differentiation. In the presence of stronger competition, services help differentiate, customise, and improve product quality, bundling them with products and services, and helping develop closer, more longstanding relationships with customers.

The service content of agro-food demand (domestic demand and exports) is significant and rising – particularly in exports from the food sector.[3] The share of the value of domestic services in the production of agro-food reached 20 percent in 2014, a higher share than the 17 percent in industrial production (Figure 2). The share of services in agri-food is also higher in high-income countries. Agro-food sectors make use of a range of service inputs, including logistics and transport. In aggregate, services delivered by the wholesale and retail sector account for the largest share of service content in the final value of agriculture and food products, but business services, including digital services, also account for a large share.

[3] These trends are not reflected in the world average share of services in agro-food demand that has not experienced a significant increase in the last decade because of changes and composition and prices: the growing importance of developing countries that have lower shares and the increase in the prices of agro-food products compared to other sectors. OECD. 2018. Dynamic changes and effects of agro-food GVCs, by Greenville, J., K. Kawasaki and M.A. Jouanjean, *OECD Food, Agriculture and Fisheries Papers* No. 119 OECD Publishing, Paris.

Figure 2: Where the value of agro-food and industry is coming from?

Sources of value added used for the production of agro-food, agricultural, food, and industrial goods, by country of origin (domestic or foreign) and by domestic source sector. Average sector shares of value added in 2014.



Note: Average shares across the 140 countries and regions included in the GTAP database (https://www.gtap.agecon.purdue.edu/databases/regions.aspx?version=9.211)
Adapted from: OECD. 2019. Value adding Pathways in Agriculture and food global value chains: the role of services.

Using services along the value chain is an important driver of domestic value-added growth. Increasing service use across the value chain (represented by an increase in the service share of production, both for exports and within the domestic production chain) is beneficial for domestic value-added growth. This highlights that the development of agriculture and food value chains is not just about low-cost production of standardised products. The 'de-commodification' of output means that it is not only about what is produced, but also *how* it is produced and *how* it gets delivered to export markets or final consumers wherever they may be. This *how* is the service element of the value chain.[10]

Most agriculture value added enters into longer value chains

The value added created by the agriculture sector enters into complex domestic and global value chains, and only a small share is sold directly to domestic consumers – 36 percent on average in 2014 (Figure 3). The largest share of value added – 54 percent on average – reflects intermediates and is consumed indirectly embodied in products processed for the domestic or foreign demand of other sectors. The remaining 10 percent of the agro-food value added is exported directly as raw products from the sector. These numbers reflect the reality of increasingly integrated value chains that, upstream, increase the opportunities of farmers to connect with input suppliers and with services providers; and downstream, link their production with processing, retailing and other transformations and services. However, not all farmers are equally poised to access these opportunities, and inclusive policies should facilitate this access.

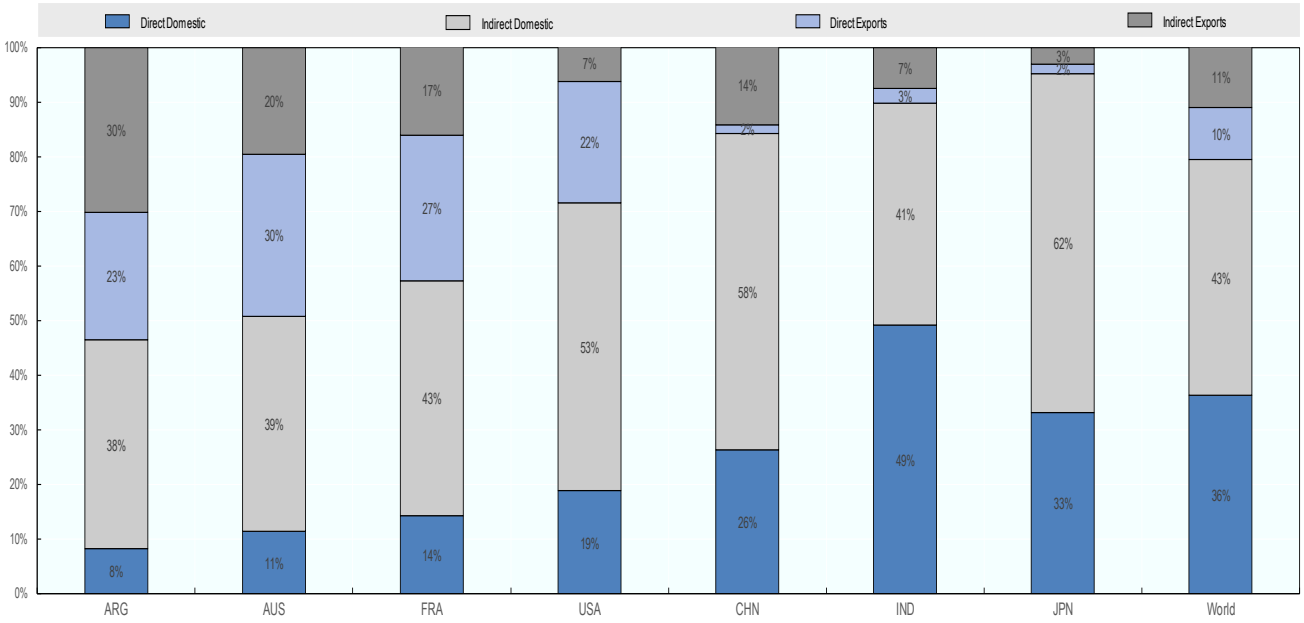
Value chains generate opportunities for the agro-food sector that depend not only on its competitiveness but also on the competitiveness of other sectors and the efficient integration with other economic activities. Domestic and global inter-connections with other industries are the essence of modern agri-food value chains. These connections go

beyond the production of food and fibre with growing shares of value added from agriculture entering into other sectors of the economy such as energy.

The significant differences across countries (Figure 3) reflect not only their performance but also the mix of products in their agricultural sector and the different way in which their agricultural sectors participate in value chains. Developing countries tend to have a larger share of agricultural value added directly sold without further processing to domestic consumers (e.g. 49 percent in India). In land abundant net exporting countries, such as Argentina and Australia, over half of agricultural value added ends, directly or indirectly, in final demand in foreign countries. Other countries have a very substantial share of agricultural value added indirectly reaching domestic consumers through other sectors in the domestic economy (e.g. Japan 62 percent).

Figure 3: Destination of agricultural value added by domestic and foreign demand

Average shares of domestic and foreign demand, direct and indirect (through other sectors), in total value added of agro-food 2014.



Adapted from: OECD. 2019. Value Adding Pathways in Agriculture and Food Trade: The Role of GVCs and Services, *OECD Food, Agriculture and Fisheries Papers* No. 123, OECD Publishing, Paris.

The quantitative importance of domestic and global value chains is reflected in global numbers. Looking upstream in the chain, 26 percent of the value of agricultural products is coming from other domestic sectors and 13 percent from foreign countries (Figure 2). Looking downstream in the chain, 43 percent of agricultural value added ends indirectly (through other sectors or countries) in domestic demand, and 21 percent ends indirectly in foreign demand or direct exports (Figure 3). These linkages – inside and across borders – are part of the same global value chains that are subject to similar economic and policy challenges. The implications for national and local economic activity are of particular interest for policymakers.

1.2 A diversity of agro-food value chain strategies

Both primary and processed pathways into the chain can equally create domestic value

Increasing trade and exchange in agro-food sectors within global value chains have the potential to offer new opportunities and enhance existing ones to add value to agricultural production. However, there is no single model of integration into value chains, and different pathways coexist. Modern value chains allow for the various stages of the production of food and clothing to be distributed across different sectors and countries. Changes in the way products are commercialized – as differentiated products with specific attributes rather than just raw commodities – also have contributed to creating a range of value-adding opportunities for the agriculture sector.

There are at least two possible stylized value adding pathways to engage in global value chains. The first is the primary pathway – where domestic value addition occurs to the primary or raw product. The second is the processing pathway – where domestic value addition to agriculture occurs through downstream processing sectors. In GVCs, while all countries export agricultural value added both in primary and processed forms, both pathways co-exist in different value chains in the same country. However, some countries specialize more in one versus the other.[11] Underlying these differences, there is a mix of production activities and other factors that may provide a country with an advantage in primary or processed exports.

The two pathways appear to offer similar overall economic benefits from trade. Arguments in favour of downstream value adding often are based on notions of higher total returns of domestic processing compared to adding value to primary products. But this is not necessarily the case and there is evidence that specialisation in one over the other does not alter the total returns created. Countries that participated in trade and GVCs primarily via the primary pathway generated equivalent overall trade-related domestic value-added returns to those which participated primarily through the processing pathway.

This suggests that alternative pathways for increasing domestic value added – beyond moving into downstream processing or increasing the length of the chain – exist (Box 1). Understanding the differences between the pathways can shed light on how countries can gain from adding value to primary or processed products and what the impacts of doing this are over time. This may be particularly important for developing countries to better understand policies that could aid in sector transformation and development.

Box 1: The development of direct marketing of primary agricultural products in Japan

Although conventional food marketing through wholesale markets has been a dominant channel, Japan has developed alternative channels of food marketing in the last few decades, connecting producers and retailers, restaurants, and food processors. While conventional wholesale market deals with standardized products, direct marketing usually markets specialty products in terms of quality and variety. They sometimes set up contracts where variety, quantity, and price are predetermined between the two parties. The alternative food marketing channels cut the marketing margin, but also allow producers to have more control on prices, reduce income risk and capture more value in the food chain.

For example, rice has been marketed through agricultural cooperatives, but the share of rice that the Japanese consumer purchased through internet increased to 9.6 percent in 2016. Excluding own consumption and gift, producers marketed one-third of rice through direct sales to consumers or retailers. The diversification of marketing channels is supported by the development of service industries, including delivery service and e-commerce.

New services providers have emerged to provide ICT infrastructure and consulting to producers. For example, Nousouken Corporation, established in 2007, manages marketing facilities where producers can decide based on price which retail outlet to market and package. Producers receive 60 to 65 percent of sales price and the company provides market information. On the other hand, Planet Table Corporation established a marketing system to connect producers and restaurants, which have particular needs in terms of freshness and quality rather than volume and packaging. By reducing the food loss in the marketing process, producers receive 80 percent of the sales price. In 2018, 4000 restaurants in Tokyo registered in this system.

Source: Annual Report on Food, Agriculture and Rural Areas in Japan, FY 2017.

Well-known strategies such as standards and contracts could be part of the pathway

Product and process standards have proliferated in the last decades, coinciding with the development of more interconnected value chains. These standards are voluntary schemes or embedded in regulations on the characteristics of the product and on the methods for primary production, processing, and marketing.[12] They cover areas such as food safety and health (e.g. pesticide residues), environmental effects (e.g. organic products, low carbon dioxide emissions),[4] nutrition requirements (e.g. low fat) and social concerns (e.g. no child labour). These standards are set both by governments (public standards, e.g. Sanitary and Phytosanitary or other technical measures) and by commercial organizations (private standards that can be more stringent than public standards). The implementation of these standards often implies bundling food with services that guarantee the conformity with the specific requirements. They increase requirements but at the same time facilitate transactions that would not occur otherwise;[13] they increase production costs, but at the same time, increase the value of the products. Standards can be part of a strategy to increase value, often associated with changes in market structure and vertical and horizontal integration. Meeting standards may require upgrading skills and capacity building.[14]

[4] The largest number of environmental labeling and information schemes introduced between 1970-2012 focuses on food and agriculture product characteristics. See Gruère, G. 2013. A Characterisation of Environmental Labelling and Information Schemes. *OECD Environment Working Papers*, No. 62, OECD Publishing, Paris. Available at https://doi.org/10.1787/5k3z11hpdgq2-en.

Many agriculture transactions are made through contracts rather than spot markets. These contracts could include marketing and production specifications and lead to a deeper vertical integration of the value chain. These arrangements respond to needs to align incentives, share risks, enforce quality standards, and improve efficiency. They also may raise questions about their implications for competition and market power.[15] Cooperatives play an important role in many agro-food value chains, coordinating producers, providing services that add value to the final product, and increasing the negotiating power of their members. Governments have a key role in proving the enabling regulatory environment that enhances contract enforcement and facilitates cooperative arrangements while ensuring fair competition and inclusiveness.[16]

Agriculture performance depends on access to competitive services and ICT

One of the key differences observed in agricultural exports between the pathways is the share of services value-added. Overall, services value added is higher in countries that participate more in the primary pathway, and higher shares of services in value added are found to be an important determinant of growth in primary export value added for middle-income countries. Services sector input into agriculture is a key driver, and differentiating factor of growth in primary agricultural value added. To gain the most from primary agriculture, access to competitive service inputs are critical.

Among these services, the role of ICT and the adoption of digital technologies is prominent and promising as a significant contributor to growth and socio-economic development in all countries and sectors. Nearly 40 percent of the global population has access to the internet, and even among the bottom poor households and in rural areas, mobile phone use is increasing. These trends are already leading to important changes in the agricultural sector.[17] Digital technologies are already changing the way we grow and distribute food, fibre, and fuel. On-farm opportunities include: using satellite data to monitor crop growth, land quality, water resources, or other environmental outcomes; combining sensors, automated farm machinery and advanced analytics software to fine-tune and automate agricultural production; and, machine learning to automate agronomic advisory services. For example, Precision Agriculture is a modern farming management concept using digital techniques to monitor and optimize agricultural production processes. Already today, farmers use precision agriculture to guide their tractors in tilling their fields, applying water, fertilizer, and pesticides. In so doing, they ensure that all applications are fine-tuned to the nutrient content of their soils and the water needs of their plants. Not only do these applications increase yields and boost the overall efficiency of the way they use their inputs.

Further, digital technologies show promise for agri-food value chains as a whole, for example, to connect farmers with consumers and other industries in new ways; and experimenting with blockchain technology and other innovative data management systems to improve efficiency and transparency of agri-food value chains. Together, all of these developments, with the appropriate enabling environment and set of incentives, hold the promise of achieving more resilient, productive and sustainable agriculture and food systems, and enabling comprehensive farm-to-fork traceability.

At the core of these innovations lies the “datafication” or the increasing capacity to capture, analyse, and exchange agriculture and food data.[18] However, the spectrum of digital applications in agriculture and food sectors is broad – from low-tech solutions that use mobile devices and platforms, to high-tech “digital farms” that make use of integrated systems involving satellites, drones, robotics, sensors, and big data analytics.

On the demand side, e-commerce platforms can directly link the farmer to the food processing and retail stages of the value chain. Digital technologies enhance the opportunities for traceability and innovation, and for building niche markets that respond to specific consumer demands on environmental outcomes, production and processing methods, and food characteristics. The digital transformation and increased capacity to create and share data provide an opportunity to reduce transaction costs and constraints to trade and address the related market failures. It also provides opportunities for the entry of new actors into the value chain. Producers, even small ones, increasingly have access to a range of digital tools allowing them to access information (for example, product prices, standards) and various services (such as payment services) more easily and at a much lower cost, reducing the cost of negotiating and undertaking transactions.

Small firms can now be "born global," and consumers can directly purchase and participate in trade, substituting traditional wholesalers or retailers with new types of digital intermediaries. These intermediaries often provide an additional range of services. Smallholders can also access services and new markets with increasing opportunities for entrepreneurial activities in non-farm agro-food and rural small and medium size enterprises (SMEs). Production processes can be registered and evaluated, with full traceability through to consumers, enabling producers to receive a price premium for consumer preferences related to quality or positive externalities from production practices, or from "fair trade" systems for producers. They can also facilitate timely payments to farmers and SMEs.[19] For SMEs, being part of a value chain may have major advantages in terms of access to markets, information, finance, and technology. But it can also create overdependence on a few suppliers and disproportionate costs to meet standards' requirements.

1.3 Promoting a coherent multi-sectoral policy

The diversity of interactions in agriculture and food value chains and their links to the process of innovation and structural adjustment requires a coherent set of policies across many areas and an appropriate enabling environment.[20] Policies should focus on identified constraints, including the removal of potential policy barriers to entry the sector (e.g., policy entitlements or lack of access to land) and innovate using digital technologies (e.g., lack of access to broadband internet).[21]

Market structure, transparency and market power

There is evidence that, over time, farmers have been receiving a declining share of the food dollar.[22] Final consumption products increasingly embody value added from other sectors, in particular services. These changes in the share of the agro-food sector in the final value of the product is related to adding services value, and is compatible with increases in the total value added from the sector. Policies that create conditions for value chains to incorporate service value added can increase producer returns and total value added of agro-food, although in relative terms the share of the final dollar captured by producers may actually be smaller.[23]

There are high concentration ratios in the input, processing, and retailing sectors in the agro-food value chains. Increasing concentration and the possibility of market power in agro-food has raised concerns on development and inclusiveness.[24] However, strong

concentration by itself does not necessarily imply market power or non-competitive behaviour. For instance, a recent study found evidence of increased concentration on seed markets due to mergers between seed companies and with complementary services such as digital technologies. The statistical analysis did not find evidence that the increase in concentration raised seed prices or hampered innovation.[25] Often in many countries concentration in input industry can be explained by the potential economies of scale and the high up-front investments required. Nevertheless, there are complex interactions between concentration in food and agricultural value chains, efficiency, and the distribution of welfare gains. For example, a 10 percent increase in competition globally, could increase fertilizer use by 13–19 percent and rural incomes by 1–2 percent in regions like sub-Saharan Africa.[26] Competition policy should reduce the potential for market power and rent-seeking by processors and retailers, while policies should also improve information gathering on price formation along the food chain and facilitate voluntary initiatives to improve price transparency and dialogue among stakeholders (Box 2).

Box 2: Dialogue mechanism through value chain in Canada

Canada's twelve Value Chain Round Tables (VCRTs) are mechanisms for cooperation across the supply chains at the national level. Launched in 2003, the VCRTs bring together key industry leaders from across the value chain – input suppliers, producers, processors, food service industries, retailers, traders and associations (geographical regions and sector diversity are also considered) – with federal and provincial government policymakers. VCRTs have become central vehicles for: identifying sector strengths and weakness; capitalising on domestic and international market opportunities; sharing information and building trust across commodity sectors; identifying research, policy, regulatory and technical requirements; creating shared visions and cooperative long-term strategies; and responding to crises.

Source: Moreddu, C. (2016), "Public-Private Partnerships for Agricultural Innovation: Lessons From Recent Experiences", *OECD Food, Agriculture and Fisheries Papers*, No. 92, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jm55j9p9rmx-en

Investment and risk management in the value chain

Investment in the agro-food sector is essential to materialize the benefits from more integrated value chains, and increases of value added. International initiatives like the Principles for Responsible Investment in Agriculture and Food Systems (CFS-RAI)[27], the Policy Framework for Investment in Agriculture PFIA,[28] the OECD-FAO Guidance for Responsible Agricultural Supply Chains,[29] and the OECD Guidelines for Multinational Enterprises define how responsible investment in agriculture and food systems can contribute to food security, nutrition and sustainability, and how to create an attractive investment environment for all investors, private or public, domestic or foreign, small or large.

Upgrading investment in agro-food value chains also requires the development of proper strategies to manage risks, particularly in the context of natural disasters and climate change that can cause disruptions in the chain. All opportunities for investment and innovation are associated with risks and uncertainties that need to be managed, particularly in the context of increasing intensity and frequency of extreme weather events due to climate change. Managing agricultural risks is the main responsibility of

farmers and the agro-food value chains, but there is a role for governments to provide public goods and an encouraging regulatory and business environment for the development and accessibility of private and market solutions, and to assist in the case of devastating natural disasters (Box 3).

Box 3: Managing future water risks in the agrofood chain

Farmers, agro-food companies and governments share the burden and responsibility of confronting future water risks, particularly, in hotspot areas, and will respond differently according to their incentives and capacity to respond. Farmers respond to future water risks if sufficiently well informed about the impacts and possible solutions by adopting better practices or shifting activities. However, they may not be as responsive to water risks to which they contribute. For instance, a farmer is more likely to change practices in response to a drought, than to reduce the use of fertilisers or pesticides in response to a pollution problem.

Agro-food companies in water risk hotspot regions face different constraints and are more likely to respond when they heavily rely on products vulnerable to water risks. Companies may resort to purchasing products from farms outside hotspot regions; they may change their agricultural inputs or ingredients or may collaborate with farmers to address risks under stewardship programmes. Large companies, in particular, may have more incentive to respond to agriculture water risks when they face reputational damage.

Governments should complement efforts by private stakeholders to mitigate water risks and coordinate responses in hotspot regions. Governments should provide incentives to farmers to engage in risk-reducing behaviours. This can be done by increasing the benefits of acting or the cost of inaction and encouraging supply chain actors also to play their part.

Source: OECD. 2017. Water Risk Hotspots for Agriculture, OECD Studies on Water, OECD Publishing, Paris. Available at https://doi.org/10.1787/9789264279551-en; OECD. 2016. Managing water risks for agriculture: A discussion with the private sector. Summary of the workshop. OECD, Paris. Available at http://www.oecd.org/tad/events/WorkshopSummaryJan2017.pdf .

Changing production conditions increasingly call for farmers to adapt their production systems and for innovative coping mechanisms in the light of new risks. Risk management and resilience in integrated value chains cannot be dealt with fragmented strategies and require a holistic approach to different sources of risks, allowing for risk diversification and an array of risk management tools. Value chains can provide opportunities to manage some of these risks that can be shared with other players in the chain through contracts and more strategic whole value chain risk assessment and management. For instance, price risk can be shared along the chain, and sanitary risks can be more efficiently managed through pest and diseases strategies that are coordinated within the value chain.

Contribution to farm and rural employment

The integration in global value chains and technological progress affect the demand for labour across industries and countries. They are potent drivers of value creation and employment, with a complex picture emerging whereby technology and globalisation can be both positively and negatively related to employment growth and skill formation, depending on the type of GVC participation and technology development and adoption. Allowing the benefits to materialise to a greater extent and to be distributed more equitably thus requires countries to activate or step up actions in multiple policy-making areas, in a coordinated fashion.[30] A good policy environment can contribute to more inclusive business models that address the specific difficulties of some actors – such as small family farmers, youth, and women – to integrate and participate in agro-food value chains[31].

Having access to competitive foreign inputs and the innovation and production spillovers from using those inputs has a positive impact on the value added captured by

the producing industry itself, with a larger share of a larger amount. This means higher returns to farmers and domestic food processors. The strongest effects are seen for capital, land, and unskilled labour, but skilled labour also benefits.[32]

In agriculture, education and extension represent fundamental areas of policy action, as they empower youth and workers with the ability to integrate with the changing labour demand of agro-food value chains, bringing new skills that facilitate benefiting from innovation and new market opportunities. Both technical and entrepreneurial skills and their combination in "bundles" of skills emerge as being key for performance.

Innovation and productivity growth in agro-food value chains

The production of food increasingly requires a wide range of technologies with close links with other fields of research such as resource management, health, machinery, construction, ICT, and genetics. Agricultural innovation covers many different activities from basic research to development and transfer of technology and adoption, all along the value chain. As a result, the need to cooperate across sectors and institutions is particularly acute. Some issues may require an extensive range of partners with different financial size, capacity, and culture, from multinationals to small farmers, from government research agencies in developed countries to local authorities in developing countries, from local NGOs to international entities, from different levels of government and different ministries. For global challenges, cooperation between countries is required.[33]

The creation and diffusion of knowledge is supported by Agricultural Innovation Systems (AIS). Despite the diversity of situations between countries, they face common opportunities and challenges for improving agricultural productivity sustainably. The private sector, organized through value chains, has a key role to play to identify and implement applied research and innovation strategies, aligning the incentives of different actors in the chain (Box 4). AIS need strategic focus and be inserted in regional or international initiatives.

Box 4: Private innovation initiatives in Argentinian agriculture

Argentina has a long experience of associative movements led by the private sector specifically, focused on promoting innovation and entrepreneurship. Organizations like AACREA and AAPRESID have been important drivers of the remarkable innovation and transformation performance of its agro-food sector in recent decades.

The Argentinian Association of Regional Consortia for Agricultural Experimentation (AACREA) is a farmers' organization initiated in the 1960s following the model of the French Consortia for Agricultural Technology Experimentation (CETA). It is a private organization of agricultural entrepreneurs aiming at sharing experience and knowledge to increase their profitability and sustainability. Their small groups of 10 to 12 members meet monthly and hire a shared technical advisor to lead applied experimentation to solve specific problems, facilitating knowledge flows and innovation. AACREA provides technical and business training, transfer knowledge through the value chain, and integrates results into local communities beyond its membership.

The Argentinian Association of Non-Till Agriculture (AAPRESID) is a non-governmental organization (NGO) that brings together agricultural producers, technical advisors and service providers pursuing sustainable agricultural principles and practices. It initially focused on the diffusion of non-till agriculture in the 1990s actively contributing to the rapid adoption of this practice in 90 percent of the cultivated land during the last two decades. These organizations benefit from research and extension services from public institutions like the National Agriculture Technology Institute (INTA), and they work together with public researchers and extension experts on a daily basis.

Source: OECD (2019): Review of Agricultural Policies in Argentina.

Imports and Foreign Direct Investment (FDI) are among the central conduits of international technology diffusion, either through supply chains or due to interactions among competitors. Absorptive capacity in a broader sense depends not only on basic technological literacy and R&D capacity but also on political and macroeconomic stability, quality of regulation, and other government actions targeting market failures.

Trusting digital technologies

It is widely acknowledged that an important factor in ensuring that the benefits of digitalization for farmers, businesses, and consumers materialise is the degree of trust in the activities of different players operating in the digital space. But with the growing collection of personal data, the risks to individual privacy increase and consumers and farmers are increasingly asking for assurances that their data is being handled appropriately. The approach to privacy and personal data protection varies across cultures, which is why regulation also differs. Countries may also restrict the flow of data, or mandate that data be stored locally, in order to meet other regulatory objectives such as access to information for audit purposes, protection of information deemed to be sensitive from a national security perspective, and helping develop domestic capacity in digitally intensive sectors, as a form of digital industrial policy.[34]

The UN Global Pulse, an innovation initiative of the United Nations Secretary-General to harness safely and responsibly the potential of Big Data for sustainable development and humanitarian action, has developed a set of Privacy and Data Protection Principles in consultation with its Data Privacy Advisory Group.[35] In 2013, the OECD published its Guidelines on the Protection of Privacy and Transborder Flows of Personal Data, revising work originally carried out in the 1980s to enhance privacy protection in a

data-driven economy.[36] More recently, new work on trade and cross-border data flows provides a taxonomy of the range of different approaches that are currently in place[37].

Digital technologies can also improve policies by helping to overcome information gaps and asymmetries, lowering policy-related transaction costs, and enabling people with different preferences and incentives to work better together. Furthermore, technologies can enable new types of measures that are more results-based or less compliance-driven, in areas such as the management of natural resources. By embracing digital technologies for policy design and implementation and ensuring access in underserved rural communities, governments can promote the inclusive adoption and diffusion of technology in the value chain.

The sustainable use of natural resources has long-term externalities that are not always fully internalized in the value chain. Digital technologies can be used to improve policy design to internalize these externalities and open an opportunity to better management of environmental and natural resources along the value chain, with better traceability for agri-environmental policies.

1.4 Key points for action

Policies should provide the enabling environment and appropriate incentives for innovation and transformation to take place along the value chain. The objective is to increase productivity and the competitiveness of the agro-food sector, ensuring all actors in the chain have good access to services and industrial activities that can be bundled with domestic agro-food and create additional value, in particular in the rural economy. There are different equally valid pathways for the integration in value chains that are likely to coexist across countries and within each country.

Several policy areas are key to enhance the capacity of agro-food value chains to amplify their positive impacts on productivity and value creation, rural employment, sustainability, and market transparency:

- Facilitate access to services and the adoption of digital technologies in agro-food value chains and rural areas, with the appropriate enabling infrastructure and the use of digital technologies for policy design and implementation.
- Develop appropriate curricula for formal agricultural education and training, and facilitate the development of a diversity of extension services, making the farming and the agro-food sector permeable to demands from value chains in particular on ICT and entrepreneurial skills.
- Invest on Agricultural Innovation Systems, in particular on the provision of knowledge infrastructure and basic research on the long term and as public good aspects such as natural resource management, ensuring partnership and collaboration with the private actors in the value chain.
- Strengthen market transparency and competition, facilitate access to information and initiatives for information sharing in the value chain, and reduce undesired impacts of policy and regulations on barriers to entry.
- Promote dialogue amongst value chain actors, such as farmers' organizations, input suppliers, wholesalers, food processors and retailers to facilitate the exchange of information, the identification of research, and policy requirements, and resilience.

- Implement open trade policies that have the potential to enhance access to good quality competitive inputs and services, high value output markets, and transfers of knowledge and technology.

2. Innovation and human capital development in agriculture

2.1 Development of Agricultural Innovation Systems

Innovation is the central driving force which will transform agri-food systems, lift the rural poor out of poverty, and help the world to achieve food security. Continuous innovation in technologies, practices, and organisation along the value chain is key to the development of a more productive, competitive, and sustainable food and agriculture sector. The sector needs to both widen the adoption of modern technologies and practices, and adopt break-through innovation to overcome three intertwined challenges: sustainably increase agricultural productivity to meet global demand; contribute towards economic growth and employment; and, adapt to and mitigate the impacts of climate change.

The predominant model for innovation has been mostly supply-driven: scientists in the public sector create new technologies which are then disseminated by extension officers to the farmers who are asked to adopt them. Many countries have reviewed their Agricultural Innovation Systems (AIS) in response to concerns about the lack of adoption of innovation, and the need to address emerging and pressing challenges. As a result, innovation policy is moving beyond supply-driven approaches focused on R&D and specific technologies towards a systematic approach that takes into account the many factors and actors that influence innovation performance.

Today, innovation is increasingly taking place in a network-based setting, which fosters interaction and learning. For agriculture, farmers and their organizations, extension workers, research institutions and universities, vocational education centres, agri-business, food processors, and the government, all interact and participate in the innovation process, jointly generating, learning and using knowledge. Working with farmers to generate, validate, and adapt technologies in an integrated way lies at the heart of AIS.

Non-technological innovation, such as marketing or organisational innovations, also receive more attention today. Economy-wide processes and organisational innovation and developments in ICT, increasingly drive innovation in agriculture. Today, innovation in agriculture is more dependent on technology and skills in other sectors, requiring farmers to collaborate with a diversity of public and private stakeholders across the sectors.

2.2. Promoting farmers' skills and strengthening their role in agricultural innovation

Innovations and innovative processes require progressively more professional skills and call for new capacities for individuals or organizations to work effectively. These include the ability to collaborate effectively, adapt, and respond efficiently, reflect, and

learn jointly, and engage in dialogue and strategic processes. Addressing tomorrow's challenges will require a transformation in the skillset of agricultural workers and, therefore, a renewed focus on human resource development in agriculture. Education, training, and extension lie at the heart of AIS and play a critical role in strengthening capacities of producers, as well as facilitating linkages and coordinating innovation processes among other actors. Skill uptake programs and activities must reflect the technological and economic change, consumers' preferences and concerns, better natural resources management, as well as addressing global trends such as climate change and globalization. For example, climate-smart agriculture uses knowledge-intensive approaches, such as conservation agriculture, integrated plant nutrient management, integrated pest management, and water management and pollination (see Box 5). It also requires knowledge of the type and extent of expected changes in the climatic variables that affect crop production.

Modern agricultural value chains require entrepreneurial skills to develop and carry out integrated businesses. Sales through more sophisticated channels, such as supermarkets, require from farmers greater managerial and logistics skills, an ability to provide continuity of supply, and capacity to meet demanding food safety and quality requirements. The food and agriculture sector's capacity to innovate also depends on its ability to attract skilled labour, giving rise to improved remuneration and working conditions in agro-food jobs, relative to competing sectors.

The information needs of farmers in both developing and developed countries will only increase as they have to make more and more complex decisions on how to use their land, what crops to produce and how in which markets to buy inputs and sell their products. Their decisions, which also include choices on how to finance their business, and reduce the risk they face, affect the livelihoods of their families and society. Information and Communication Technologies (ICTs) are crucial in lowering information and coordination costs, and farmers will have to acquire the necessary knowledge. ICTs can have a profound impact on both efficiency, resilience, and inclusion.

Enabling farmers to unlock their potential to innovate and harness the opportunities generated by technological advances and market developments is crucial to ensure farms are productive, profitable, and sustainable. In agriculture, human capital – farmers' knowledge, skills, health, or values – directly influences agricultural productivity, efficiency, and incomes.

Agricultural extension and development of skills

Agricultural extension and advisory services are central to achieving sustainable productivity growth. Agricultural extension operates within a broader knowledge and innovation system that includes research and agricultural education and provides non-formal – agriculture-related continuing adult education. By facilitating farmers' access to information, extension can help reduce the gap between potential and actual yields and improve farmers' management skills.

Extension also forms a broker of technology and practices that facilitates the innovation process and knowledge sharing at the farm level. The relationship among farmers,

agricultural extension and agricultural R&D is even closer, because of the knowledge that agricultural extension transfers are usually generated by agricultural research through an interaction of many actors, including farmers, on applied and adaptive agricultural research. In many G20 countries, diverse public and private extension and advisory services play a critical role in facilitating farmers' access to modern technology and management practices and have an increasing role as brokers of innovation at farm level.

Although it is difficult to estimate their impact, the evidence suggests that extension services worldwide have had significant and positive effects on knowledge, adoption, and productivity. Studies have shown that investments in extension – in common with investments in agricultural research and development – have delivered high rates of return.[38] A review of extension programmes found that although rates of return to extension varied widely, they exceeded 20 percent in three-quarters of the 81 extension programmes considered.[39] A survey of quantitative studies of rates of return to research, development, and extension, also found high, but variable returns to agricultural extension.[40] Another study on the impact of extension on the agricultural sector of a developed economy suggests that extension accounted for 7.3 percent of annual productivity growth for the period 1947-2002.[41] Apart from significant financial gains, extension and advisory services have also yielded positive social returns, particularly for women, people with low literacy levels, and farmers with medium landholdings.[42] Some participatory extension programs, such as Farmer Field Schools, have also shown positive impacts on the environment and health.[43]

Currently, moving beyond the transfer of technology, agricultural extension plays a broader role by investing in human capital, enhancing skills and knowledge for agricultural production and processing, improving access to markets, facilitating farmer and producer groups to innovate, and promoting sustainable natural resource management. Today's agricultural extension systems have transformed from government-driven technology transfer mechanisms to broader and more pluralistic systems of advisory services taking into account the diversity of farmers' needs, offering broader ranges of advice and involving different actors in providing it.

Private companies, non-governmental organizations (NGOs) and producer organizations play more active roles alongside traditional public sector extension providers. It is notably relevant, as farmers are highly diverse, differing in resources, gender, market access, crops, and livestock systems, and therefore require different types of information and services to achieve sustainable productivity growth and better livelihoods.

Advisory services provided by the **private sector**, such as agricultural input suppliers, or buyers of farmers' produce, is often not a stand-alone activity but is provided to complement commercial services. For example, extension can take place through embedded services, where advice is given when a farmer buys a product (pesticides, fertilizers, etc.).[44] Out-grower schemes (contract farming) are also a potentially effective way of delivering expertise to farmers, especially in value chains with a high degree of vertical integration requiring compliance with standards that need the appropriate

application of inputs, and entrepreneurial capacities.[5] Private sector extension services form the basis of extension systems in many developed economies and are on the rise in many developing countries, especially in Asia in the form of seed and input companies, distributors and dealers, service providers, food processors, and mobile phone companies.[45]

Privatization of services supported by the appropriate enabling environment (policies, finance, regulation, etc.) can strengthen the efficiency and effectiveness of extension and advisory services. In the Netherlands, the privatisation process of extension services transformed smaller advisory firms with limited innovative capacity of their own into firms larger in scale, more knowledge-intensive and with stronger innovative power that have become better at articulating their demand for knowledge. Farmers hiring advisors are more critical on getting value for money and request concrete advice, (e.g. on legal issues or farm expansion), thus allowing for new specialised entrants in the advisory business and leading to increased competition. Increasingly specialist advisors participate in network projects and apply research projects allowing them to stay up-to-date and keep contact with the farmers.[46]

In many parts of the world, **non-profit organizations** or **non-governmental organizations** are active providers of extension and advisory services, often when there is not enough commercial appeal to attract the private sector.[47] NGOs extension services delivery tend to be participatory, demand-driven, and client-centred in their approach. They have limited bureaucracy, and services are often well managed, efficient and cost-effective. On the other hand, especially in developing countries, NGO extension services tend to depend on donors for funding, which can make longer-term sustainability a problem; programmes are often of short duration, and geographical coverage is limited.[48]

Box 5 Innovation and Climate-Smart Agriculture

Climate-smart farming techniques can increase agricultural productivity and incomes, make rural communities more resilient to climate change and where possible, mitigate climate change. Climate-smart interventions are highly location-specific, knowledge-intensive and often interdependent. Considerable efforts are required to disseminate the knowledge and build capacities to make CSA a reality.

Different elements of CSA include:

- Holistic, integrated farming practices to ensure greater efficiency in the use of resources and more sustainable management of natural and human-created processes in the landscape. Integration can significantly reduce the pressure on natural resources and minimize the need for external inputs (e.g., energy, chemical fertilizers, and pesticides). Such practices include conservation agriculture, integrated plant nutrient management, and integrated pest management,
- Ecosystem and landscape management to conserve ecosystem services that are important for food security, agricultural development, adaptation, and mitigation. More productive and more resilient agriculture requires a major shift in the way land and water are managed to ensure that these resources are used more efficiently. Sustainable Land and Water Management (SLM) includes a broad range of practices and methods, including the restoration of peatlands and degraded lands.

[5] In contract farming, buyers generally enter into contracts with groups or individual farmers. The contracts specify the amount, quality, delivery schedule and price to be paid for produce.

- Livestock can make a large contribution to climate-smart food supply systems. Options to reduce greenhouse gasses are available along the entire supply chain and are related to feeding management, enteric fermentation, and manure management. Livestock's role in climate-smart practices relates primarily to the management of organic matter and nutrients. These practices include pasture management, zero-grazing, grassland restoration and management, manure management, and crop-livestock integration.

The Global Alliance for Climate Smart Agriculture (GACSA) is an inclusive, voluntary and action-oriented multi-stakeholder platform on Climate-Smart Agriculture (CSA). Its Knowledge Action Group (KAG) has identified extension services for CSA as a priority work area and work is being undertaken to promote CSA through extension (see http://www.fao.org/gacsa/action-groups/kag/en/).

Sources:
FAO. 2016. The State of Food and Agriculture: Climate Change, Agriculture and Food Security. Rome.
Global Alliance for Climate Smart Agriculture. 2016. Promoting Climate-Smart Agriculture through Extension - An Overview of Existing Tools and Services.

Farmers' organizations play a significant role in rural advisory services. Typical groups and organizations include local farmers' groups, primary cooperatives; producers' associations and their federations at the regional and national levels; processing and export organizations; and national industry bodies. Studies have shown that advisory services provided by such organizations are often more relevant and tailored to farmer demands than services from other providers.[49] Accountability also increases, as the organizations are, in principle, directly accountable to their members. Strengthened producer organizations are critical in not only providing services to their members but also engaging in the generation of R&D and the policy and decision making processes along the value chains.

It is increasingly difficult to measure the full extent of modern extension and its coordination mechanisms as it has become more decentralized, and covers a broader range of areas of advice with the private sector and NGOs delivering it. The Worldwide Extension Study provides some information on the human and financial resources of agricultural extension and advisory systems worldwide and presents data on the primary extension service providers in each country, including the primary farmers' groups they target.[50]

Linking farmers to different information services, to diverse service providers and input and output markets, is critical for inclusive advisory approaches. This bridging function should emphasize the importance of different knowledge sources for farmers and leverage the potential of pluralistic services by drawing on the advantages of different service approaches while recognizing their individual limitations.

Experiences with various service providers to date suggest that the emergence of pluralistic extension services exploits complementarities between different types of service providers who individually would be too limited to ensure inclusive service systems. Multiple providers of services, with varying approaches of extension and numerous sources of funding, tend to respond better to farmers' needs and priorities.[51] Indeed, there is significant diversity across countries in the way extension, and advisory services are organized, coordinated, delivered, and funded, as well as to the extent to which the public sector is involved.

New forms of arrangements can promote collaboration among the public and private sectors and civil society. Public-private partnerships (PPP) can leverage the strengths of both sectors to develop extension programs that provide services to farmers. In addition, they can function interactively between R&D suppliers and farmers, by delivering demand feedback to technology suppliers and technical information to farmers to enable them to contribute to, and evaluate potentially useful new technology better and ultimately to adopt it in their production systems.[52]

The main role for the government is in the governance of the system to ensure provision is adequate, and all farmers have access to a competitive supply of advisory services, covering both productivity and sustainability aspects, and different types of advice on technology, management, policy or marketing. In a pluralistic setting, effective coordination assures an adequate mix of services to meet the diverse demands and needs of farmers. It also allows advice to be linked to complementary services such as access to markets, financial services, and inputs. Good coordination helps avoid conflicting messages and duplication of efforts in areas with a higher concentration of providers.

An important role of the public sector in extension is that of coordinating pluralistic advisory systems so that their activities, scope, and scale of the different service providers are aligned and inclusive; the quality of services is assured; providers are accountable; farmers are able to influence R&D and advisory services; and lessons learned are shared among service providers.[53]

Nevertheless, coordination is context-specific, and in many cases, farmers' organizations and associations play a central role in coordinating extension systems and in matching the variety of services demanded with service providers. For example in several countries, farmers' organizations provide coordination of agricultural extension, supported by an enabling environment shaped by regulations and accreditation mechanisms that ensure the quality of service provision. For example, in Denmark, the Danish Agricultural Advisory Service (DAAS) is farmer-based, -owned and -controlled advisory system. Since 2004, DAAS extension services are entirely funded by farmers' payments for professional services.[54]

Innovations in financing mechanisms match the diversity of agricultural extension and advisory. When farmers pay for the services they receive, either directly or indirectly through membership fees or levies to their organization or cooperative, they can influence and frame the services according to their needs and preferences. On the other side of the spectrum, the public provision of services is rarely demand-driven. Public funding can finance services provided by non-public agents, such as farmer organizations, cooperatives or private service providers through competitive grants, vouchers to farmers or subsidies, allowing farmers to decide and choose the services they require and have a choice of service providers.[55]

In general, public funding will continue to play a crucial role as many tasks of extension and advisory services have a public goods nature, including functions related to regulation, quality control in the value chain, the coordination of service provision, and natural resource management, as well as the provision of services to marginal farmer groups, which are unlikely to access or afford private advisory services.[56]

Box 6: ICT and extension

ICTs can increase access to timely extension by reducing the cost of extension visits, enabling more frequent two-way communication between farmers and extension agents, and improving agents' accountability (Cole and Fernando, 2014). ICTs also enhance access to private information from social networks, thus facilitating learning from one's peers, which is crucial for technology adoption. By increasing communication linkages between farmers, extension agents, and research centers, ICTs can improve the flow of relevant information among all these agents.

Knowledge sharing and training methods based on ICTs are essential vehicles to improve access to information and enhance knowledge on sustainable production intensification technologies. ICTs can facilitate dialogue between stakeholders, and trigger learning with knowledge networks and platforms that provide a venue where the diverse actors can connect (FAO, 2013).

By integrating local and hyper-local knowledge, ICT innovations can have a significant impact on improving the content for extension and training, and promote technology adoption that can enhance adaptation in both developed and developing countries. For example, in India, the International Food Policy Research Institute (IFPRI), in partnership with the e-Extension Centre of Tamil Nadu Agricultural University, developed the Advanced Agricultural Practice Knowledge Portal for the Centre for Advancement in Agricultural Practice (ICAAP) in 2012. This portal serves as a gateway for knowledge and best practices from CGIAR and other international and national agricultural research centres. Designed to respond to the information needs of local knowledge intermediaries such as research scientists, extension professionals, farmers associations, NGO staff, and agricultural entrepreneurs, the portal provides information that benefits farmers directly through improved extension services, and indirectly through the improved use of information by intermediary organizations (see IFPRI & ICAAP, 2012).

Notwithstanding the vast opportunities that ICTs can bring to agricultural extension and advisory services and their clients, the digital dividends are not automatic, and not everyone can benefit equally, and several concerns still exist over the quality of the content and the mechanisms to use ICT for effective extension (Torero and Nakasone 2016). A necessary enabling environment, newly required skills that include both digital literacy and capacity to take appropriate decisions based on ICT, and accountable institutions, are not equally present everywhere and accessible for everyone. Usually, these types of challenges are described as a "triple divide" consisting of the digital, rural, and gender divides (FAO, 2018). The digital divide between developing and developed countries 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.

Over the last twenty years, farmers in developed countries have already been using ICTs in large scale farming for Precision Agriculture - a whole-farm management approach using information technology, satellite positioning (GNSS) data, remote sensing and proximal data gathering - including in soil analysis, irrigation, farming equipment, weather forecasting, and more. The fast pace of technological development, which allows for increased data storage and analytics and progressively lower costs have helped reach these farming advances. The approach is currently used mainly by large arable farms in Central and Northern Europe, the United States,and Australia.

In addition to the various on-farm benefits of the approach, Precision Agriculture operations often feed into and generate key elements of Big Data and its applications. Big Data, a collection, and analysis of large and complex data sets, can be used to provide tailored advisory services to farmers and assist on crop, livestock and soil management (Wolfert *et al*., 2017).

Box 6: ICT and extension (continued)

Examples of such data exchange platforms that utilise Internet of Things and Big data include FieldScripts, a commercial service provided by Monsanto that analyses data and provides the farmer with seeding prescriptions and real-time advice that will potentially increase yield and reduce risk; and, and *Farmsight*, provided by John Deere to optimize logistics and machinery use.

Serious games are digital gaming environments that are designed for training the player in solving problems. They gain popularity in many areas, such as public policy, defence, corporate management, education, and training. They are simulation platforms that allow learners to experience a number of scenarios and situations and provide solutions, having a positive impact on analytical skills, learning and recollection abilities, problem recognition and problem solving. AgriManager, a serious game developed by Credit Agricole, helps agronomy students to acquire farm management skills through problem-solving, including in entrepreneurship, banking, and insurance.

Sources:

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Torero, M., E. Nakasone, & B. Minten. 2014, The Power of Information: the ICT Revolution in Agricultural Developmen. Annual Review of Resource Economics, Vol. 6 pages 533-550, October

Strengthening the role of farmers in the innovation process

Establishing a more demand-driven agricultural innovation system requires the participation of more diverse actors, including in the definition of strategies and objectives of innovation policy. In some countries, formal institutions have been created to facilitate discussion and co-operation throughout the innovation process. In some cases, farmers contribute to the funding of agricultural R&D via statutory or voluntary levies. All these, help ensure that research adapts to their needs and will be widely adopted, and to channel public R&D expenditure into more competitive R&D agendas.

To ensure innovation occurs, it needs to provide adequate support services to all actors by fostering interactions and constructing knowledge. An innovation support service is a broader term that covers various tasks that support innovation. Aside from providing innovation brokering before, and facilitation during the project, innovation support services may also help to promote innovation and innovation-funding formats, organise brainstorming events and animation of thematic or cross-sectoral groups.[57]

In Australia, for example, the Australian Research and Development Corporation model, based on 50-50 co-funding by farmers and the government, channels a large part of agricultural R&D funding. In Canada, mandatory levies are used to financially support both marketing and research activities for a variety of farm products.[58] In Colombia, research activities conducted by producer associations are funded through commodity taxes levied on private sector production or exports. Thirteen producer associations are involved in agricultural research. Some producer associations have their own research facilities, called "supply chain research centres", and conduct their own research.[59]

In Denmark, the Knowledge Centre for Agriculture acts as a knowledge facilitator and bridges university research and education with extension and farmers' organizations. Innovation support services by the Knowledge Centre for Agriculture are financed partly through users' direct payment of services and partly through funds from taxes (there are three tax reimbursement funds) and production levies.[60]

In the European Union, the agricultural European Innovation Partnership (EIP-AGRI) brings together innovation actors (farmers, advisers, researchers, businesses, NGOs and others) at EU level and within the rural development programmes. The EIP-AGRI focuses on forming partnerships and linking people from different professional backgrounds in the EIP-AGRI network through different types of activities, such as Operational Groups and EIP-AGRI Focus Groups. Different actors within innovation and agriculture work together, share their ideas, and turn existing knowledge into innovative solutions and research results that can more easily be put into practice.[61]

In the United States, USDA's Agricultural Research Service engages in R&D partnerships to address major challenges in agriculture. An agriculture-specific institution, the Foundation for Food and Agricultural Research, was created in 2014 as an independent, board-driven, non-profit organisation, to foster collaboration between government, university, industry, and non-profit researchers.[62]

2.3 Vocational and tertiary education

Human capital shapes productivity and wages in emerging economies, and improving skills of farmers, efforts should focus on improving and upgrading skills along the value chain through life-long training, and on responding to future skills needs through agricultural education and training (AET).[63] AET remains the leading supplier of human resources to the agriculture sector. Typically, the labour force for the food and agriculture sector is trained through a combination of universities, faculties, vocational and technical colleges, and training centres.

Vocational training on agriculture is usually provided by polytechnics, institutes, or colleges that prepare technicians at the diploma level (the post-secondary, sub-degree level). This category is commonly referred to as agricultural technical-vocational education and training (ATVET).[64] Tertiary education takes place in universities, and some countries in specialised, high-level schools. Tertiary education is another opportunity for individuals to acquire the higher-order general cognitive skills—such as complex problem-solving, critical thinking, and advanced communication, which are so important to the changing nature of work but cannot be acquired through schooling alone.)[65]The fast pace of change and innovation in modern commercial agriculture

requires agricultural education and training to evolve at a similar pace if it is to provide workers in food and agricultural activities with the skillsets they need. Indeed, the skills required by those working on food and agriculture have expanded to encompass processing and value addition, but also skills that include fiscal, contractual arrangements, logistics, and marketing competencies. The core objective of improving the education system in agriculture is fostering the skills of all actors to undertake innovative strategies to adopt new technologies and processes and to adapt to new environments, to solve new problems and to collaborate with a diverse network of stakeholders. It requires education programmes that reflect the technological, economic, and environmental change, as well as the demand from the industry and consumers.

In many G20 countries, agriculture is a sector where labour is ageing more rapidly than elsewhere, and retaining workers, in particular, youth, in agriculture, becomes challenging. Rural youth is increasingly turning away from agriculture as it is mainly viewed as a hazardous, underpaid sector with little opportunity for advancement, and located in areas with lower access to services. Agri-food industries close to farming (e.g. slaughterhouses) also suffer from similar lack of attraction. Retaining young workers is vital to facilitate an inter-generational transition of tacit knowledge and experience.

It is common for the skills of young graduates to fall short of meeting the needs and expectations of the job market. Considering the knowledge intensity of the sector and the increasing pace of change and innovation taking place in agriculture, institutions for higher education need to evolve and adapt to current needs.[66] A mismatch between supply and demand of skills is often observed in agriculture. For example, in Australia, only 75 percent of vacancies were filled in agriculture and horticulture occupations and for a total of ten applications per vacancy, only two were suitable for the vacancy in 2013/14. Making ATVET more attractive and relevant can play a critical role in attracting talent, resolving potential mismatches of skills in the labour market, and addressing global challenges such as climate change. As a response, the sector in Australia implemented a series of initiatives to improve the quality of ATVET to meet the demands of the labour market, while the agro-food industry also announced their vision of skill priorities and strategies for action (Box 7).

To maximize the potential of vocational education and training, public and private institutions programmes need to ensure that these meet the demand and content needs of modern agriculture. Important characteristics of an effective vocational system include: (i) meeting the needs of the labour market; (ii) adequate core academic skills; and, (iii) systematic integration of work-based learning.[67]

Reforming the tertiary education system is a challenging task. It requires a long-term commitment, coordination across multiple stakeholders, and often increased funding. Some elements of a successful agricultural higher education reform include coordination between educational institutions on the specific reforms to take place, bringing them closer to the needs of the sector and up to contemporary challenges such as climate change; ensuring that reforms are implemented across the educational system, and guidelines and policies are available to all stakeholder groups; and close coordination between ministries of education and agriculture. [68]

Box 7: Australia's initiative to identify skill priorities and strategies in Agri-food sector

Agrifood Skills Australia, one of the 11 Australia's Industry Skills Councils mandated to link the industry and educators, released the agro-food industry's vision of skill priorities and strategies for action. This is a broad framework spanning from business capacity to plan jobs and promote skills, through attracting new skilled generation, to enhancing and better utilising knowledge and skills of the existing workforce. Beyond issues common to many sectors, this framework emphasizes the need to tackle the specific challenge of boosting student preference for agro-food careers. It also stresses the importance of exploiting the potential of on-the-job training through informal education, given the important role of tacit knowledge in agriculture.

Source: OECD. 2015. Innovation, Agricultural Productivity and Sustainability in Australia, OECD Food and Agricultural Reviews, OECD Publishing, Paris.

Dialogue and coordination between ministries of education and agriculture, employers of ATVET graduates, and staff and administrators of entities that train them for the public and private sectors are essential to establish an effective ATVET. In particular, proactive engagement of industry is a key to reflect the needs of the labour market in ATVET. For example, in the Netherlands, the Human Capital Agenda was developed as an integral part of the R&D strategy aiming to get more involvement and responsibility of agribusiness in education and skills development, and to attract sufficient students at various levels to ensure an adequate future supply of qualified employees in agriculture and horticulture (see Box 8).

Providing continuous education opportunities is also salient for farmers to acquire new industry knowledge and technology, as returns to education are especially high when technology is changing because people with higher human capital adapt faster to technological change.[69] Ensuring that human resources are ready to meet the needs of the sector, will require evolving beyond traditional classroom settings and integrate ICTs into their programmes. The use of ICTs is particularly instrumental in the areas of distance education and e-learning. While reforming the higher education system may be necessary in some cases, evidence from several countries indicates that much can be achieved through the reform of agriculture curricula only.[70] Curricula reform should be based on wide consultation with the key stakeholders in the sector to ensure that the resulting degree, diploma, or programmes are relevant and match evolving market needs and demands. Curricula reform also needs to be paired with pedagogical reform, to ensure that the methods at hand are geared toward maximum learning. Examples of

successful curricula changes include changes across degree programs, to split traditional agricultural degrees into various better-focused programs, or to enhance existing curricula by adding new coursework to fill identified knowledge gaps.

Box 8: Development of green education in the Netherlands

In the Netherlands, agricultural education is embedded in the so-called green education (agriculture, nature and food) and organised through close co-operation with the agro-food private sector. Secondary education includes pre-vocational secondary education programmes (four years), which combine general and vocational education and prepare students for senior secondary vocational education and training (four years). The higher education is provided by two types of institutions: Research universities and Universities of applied sciences. Research universities are primarily focused on research-oriented programmes, while the other offer programmes of higher professional education to prepare students for specific professions.

The Human Capital Agenda was developed as a part of the R&D strategy. It aims to get more involvement and responsibility of agribusiness in education and skills development and in attracting sufficient students at various levels and ensure the adequate supply of qualified employees in agriculture and horticulture. The Human Capital Agenda identified three important themes: 1) improving the sector's image and being a good employer, 2) developing a job-oriented curriculum, and 3) promoting life-long-learning. To stimulate the involvement of agribusiness, the stakeholders co-finance vocational education. In return , tools, trainings and internships will be provided, and students and teachers perform projects (e.g. research) for the agribusiness partners

The government supports farmers' access to training, extension, innovation brokerage, and advisory services. Methods to deliver education are also changing: life-long learning and distance learning programmes are developing rapidly, allowing for a larger potential student base. The need to focus vocational education on entrepreneurship and managerial training is also being increasingly recognised.

Wageningen University & Research is at the centre of the Dutch Agricultural Knowledge System. Its consolidation as a global centre of excellence on plant sciences fostered the creation of a food and agricultural innovation hub. The University acts as a magnet for agricultural technology start-ups and experimental farms. Its solution-oriented approach entails a close relationship with the farmers, to understand their problems and needs and search for answers to contemporary challenges.

Many elements secured the success of the model in place in the country. In particular, the research and innovation agendas were pursued in close coordination with farmers and their needs, with the aim to develop solution-oriented and commercially viable innovation. These reforms resulted in a highly innovative and export-oriented food, agriculture and horticulture sector in the Netherlands, and consolidated the country as a leading global food exporter. In 2016 the Netherlands was the world's largest exporter of agricultural products (by USD value).

Sources:

Kupper, H., R. Laurentzen & M. Mulder. 2012. Analysis of recent policy developments in green education in The Netherlands. The Journal of Agricultural Education and Extension, 18, 2, pp. 121-139.

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2.5. Policy challenges and key points for action

Agricultural Innovation Systems are in transition worldwide to better reflect user demand and generate innovative solutions more effectively. Empowering people to innovate is one of the priorities for government to address the productivity and sustainability challenges in food and agriculture.

Innovation requires a wide variety of skills, both technical and functional, such as the capacity to learn, adapt or retrain, to bring existing or new products, processes and forms of organization into social, and economic use.[71] Empowering people to innovate relies not only on broad and relevant education but also on the development of wide-ranging skills that complement formal education. Fostering the skills of farmers to innovate, to solve new problems, and to engage with other stakeholders is at the heart of AIS and improvements in education and training enable AIS to function effectively.

Adding to human capital in agriculture and sharing knowledge about technologies and innovative practices among farmers is important for addressing the challenges of the future and closing existing gaps in agricultural productivity and sustainability between developing and developed countries. While there is no standard model for delivery of extension services and vocational and tertiary education governments, private businesses, universities, NGOs, and producer organizations can all play a role.

In spite of the growth of private extension, there is still a role for governments in ensuring access to extension and advisory services, and in updating the education system to respond to new demands. Education and advisory services can generate important public goods facilitating innovation and technology adoption and improving productivity and sustainability, having an impact on the economic transformation of rural areas and poverty reduction in developing countries. However, policies to foster human capital in agriculture need to be integrated in the broader innovation system and be responsive to changing skills and knowledge requirements.

In order to address the challenges of the future, governments should:

- Promote human capital improvements in agriculture and rural areas within the efforts to establish an effective Agricultural Innovation System with capacity to innovate at: (i) the individual level, through investments in education and training; (ii) the organizational level, through capacity development of farmers' and community based organizations; and, (iii) the policy level through policies and rules that govern the mandates and operations of research and extension organizations and their engagement with other actors in the system.
- Facilitate the development of a demand-driven, market-oriented, pluralistic extension system in which public and private service providers complement each other to meet existing demands. Enhance the coordination role of the government and farmers' organizations to align the activities, scope and scale of the different service providers; assure the quality of services; make providers accountable; ensure farmers are able to influence extension services; connect farmers and extension service with other AIS actors including R&D institutions

through innovation support services and other mechanisms to facilitate co-operation throughout the innovation process and share lessons.

- Ensure all farmers have access to a competitive supply of advisory services, covering both productivity and sustainability aspects, and type of advice (technology, management, policy or marketing). Focus the public role on services that the private sector typically under-provides, such as geographically disadvantaged areas, small, family farmers, and the promotion of sustainable technologies and practices. Farmers unable to pay for services need to be empowered to have a say in who is contracted to provide what services, channeling funds through producer organizations or stimulating co-funding of services.
- Develop and support fora and mechanisms – both national and international – for the exchange of experiences and evidence on agricultural extension services and their impact to help policy-makers and stakeholders make better decisions such as the Global Forum on Rural Advisory Services (GFRAS), African Forum for Agricultural Advisory Services, and the Consortium on Extension Education and Training.[6]
- As part of an integrated AIS, develop a more demand oriented agriculture-related education and training system, connected with technological and organizational innovations, through proactive engagement of industries. Reforms in the curriculum of tertiary and vocational education should reflect the needs in the labour market and integrate work-based learning. In consultation with a wide range of stakeholders, identify current, and future skills needs in the agro-food industry, to avoid mismatch of skills demand and set-up targets for the education and training system.
- Invest in training in entrepreneurship and management, and the development of new practices and climate-smart agriculture techniques that allow farmers to adapt to climate change while increasing agricultural productivity sustainably. In this context, governments should invest in sustainable technologies, reinforce research and extension services to identify relevant field practices and promote capacity development and help develop strong linkages between research and development institutions and farmers in research priority setting and process.[72]
- Address skills mismatches and rising inequality, especially in rural areas, arising due to the digital revolution by promoting digital technologies in agriculture and food systems and the dissemination of digital skills in rural areas, especially to youth to shape a competitive and digitally literate rural workforce in the future. Digital inclusion is key to create opportunities for quality and decent job provision, rural income growth, and welfare improvements.[73]
- Develop policy and market environments that are conducive to innovation and improve working conditions in food and agriculture and promote a reliable knowledge infrastructure to attract young talent.

[6] At the international level, the Global Forum on Rural Advisory Services (GFRAS) represents an important effort in this direction. Its main objectives are to provide a voice for advisory services in global policy dialogues and promote improved investment in rural advisory services; to support the development and synthesis of evidence-based approaches and policies for improving the effectiveness of rural advisory services; and to strengthen actors and fora in rural advisory services through facilitating interaction and networking. See http://www.g-fras.org/en/about-us/vision-mission.html

3. The role of food and agriculture in the realization of the 2030 Agenda

The 2030 Agenda for Sustainable Development was adopted in 2015 to guide and encourage global action towards peace, prosperity, and sustainable development in the coming years.[74] The 2030 Agenda and its 17 Sustainable Development Goals (SDGs) are the outcomes of a long collective process and a build-up of international commitment, ambition, and capability. They reflect a paradigm shift in development, raising the ambition (from halving to eradicating poverty and hunger), and therefore calling for transformational change to leave no one behind, with a bold commitment to address the most vulnerable first.

The same year two other historical agreements were adopted, namely, the Addis Ababa Action Agenda (AAAA),[75] that provided a global framework for financing development post-2015, and the Paris Agreement on Climate Change,[76] that targets the impact of greenhouse-gas-emissions on the planet, its mitigation, adaptation, and the related finance. These three initiatives are mutually supportive, require a multi-stakeholder, multi-actor response, and demonstrate a shared commitment to global objectives.

The agriculture sector is responsible for the production of sufficient, safe and nutritious food, and agriculture practices directly affect natural resources and ecosystem services. Agriculture is the main source of income and forms the base of livelihood for rural populations across many regions of the world. Food security is a necessary condition for the achievement of the 2030 Agenda.[77] The present section expands on how agriculture is connected to the SDGs and how it contributes to their achievement. The role agriculture plays in the achievement of the SDGs is discussed under three broad categories, namely agriculture's contribution to eradicate poverty and hunger and to promote health, to protect the environment and, lastly, to foster sustainable and inclusive economic growth. A discussion on the role of the private sector follows, and a policy summary concludes.

3.1 Food, agriculture and the Sustainable Development Goals

As the primary connection between people and the planet, agriculture is of cross-cutting importance to all of the SDG, and its role is reflected across the 2030 Agenda with dedicated SDG targets (Box 9). Inadequate food and nutrient intake conditions every aspect of life, and has persistent impacts on health, learning, productivity, and overall development. After a prolonged decline, new evidence confirms a rise in global hunger for a third consecutive year. An estimated 821 million people – approximately one out of every nine people in the world – were undernourished in 2017. The reverse of the declining trend in the number of undernourished is caused, in part, by conflict and climate variability and weather extremes, but also due to slower economic growth.[78] Social and economic inequalities that result in unequal access to food can also contribute to instability and unrest, further driving food insecurity.[79]

Agriculture faces a triple challenge. First, it has to increase the production of safe and nutritious food to meet a rising demand driven by population growth and changing dietary patterns associated with an increasingly urban population. Second, agriculture has to generate jobs and incomes and contribute to poverty eradication and economic growth. Finally, agriculture has a major role to play in the sustainable management of natural resources and the adaptation to, and mitigation of climate change which is already affecting the livelihoods of many people, especially the most vulnerable.

Box 9: The role of agriculture to the Sustainable Development Goals

It is possible to draw a direct connection between agriculture and many SDGs, and an indirect one to several others. Investing in agriculture is one of the most effective ways to reduce poverty and hunger (SDGs 1 and 2). Adequate access to safe and nutritious food is a necessary condition for health and well-being (SDG3), and only healthy children and adults can learn and develop to their full potential (SDG4). Growth in agriculture is also significantly more inclusive than economic growth in other sectors (SDGs 8 and 10). Agriculture is directly connected to natural resources and the climate and can make a significant contribution to conserve and protect freshwater resources, the oceans, seas, and marine resources, terrestrial ecosystems and combat climate change (SDGs 6, 13, 14 and 15). Due to the many interlinkages between agriculture and the SDGs, FAO is the custodian UN agency for a total of 21 indicators that monitor progress towards SDGs 2, 5, 6, 12, 14 and 15, and a contributing agency for four more. As custodian agency, FAO will help ensure that national data are comparable and aggregated at subregional, regional and global levels. This data will contribute to annual progress reports, follow-up and review processes.

The Sustainable Development Goals

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Sources: United Nations. 2015. Transforming our world: the 2030 Agenda for Sustainable Development. Resolution A/RES/70/1 adopted by the General Assembly on 25 September 2015. UN, New York; FAO. 2017. FAO and the SDGs Indicators: Measuring up to the 2030 Agenda for Sustainable Development. Available at http://www.fao.org/3/a-i6919e.pdf. See also: http://www.fao.org/sustainable-development-goals/indicators/en/.

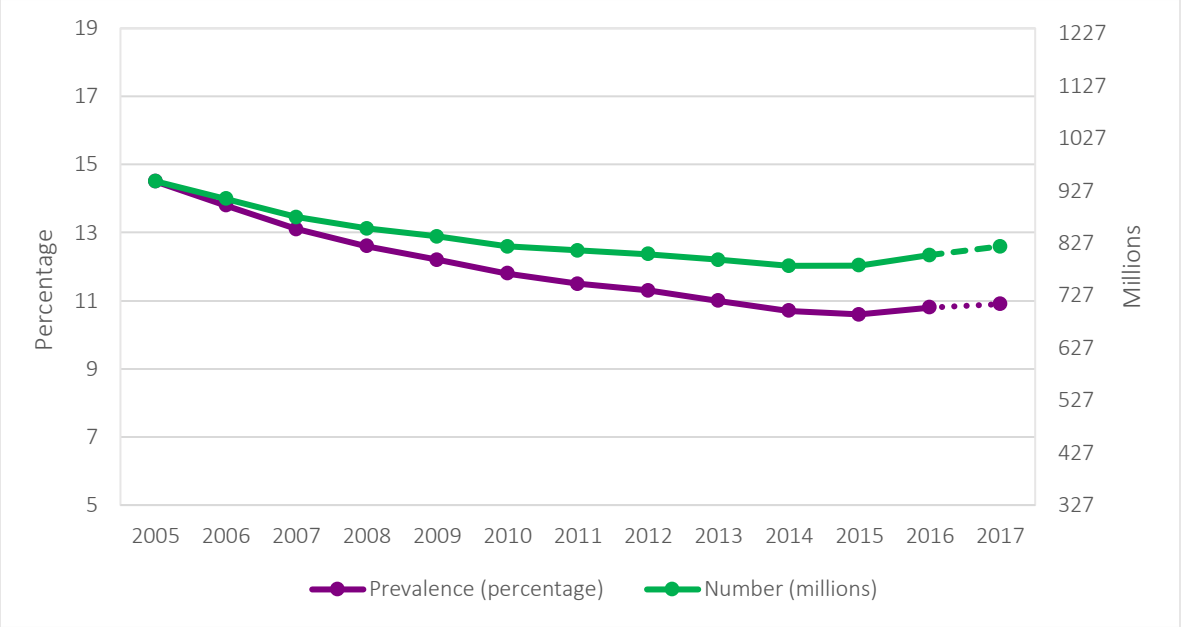
3.2 Agriculture, food security and health

Many countries have a high prevalence of more than one form of malnutrition - undernutrition, micronutrient deficiencies, and overweight and obesity. The immediate causes of malnutrition are complex and multidimensional. They include inadequate availability of and access to safe, diverse, nutritious food; lack of access to clean water, sanitation, and health care; and inappropriate child feeding practices and adult dietary choices. Poor access to food (especially healthy food) contributes to undernutrition, insufficient micronutrients intake, overweight, and obesity. It increases the risk of low birthweight, childhood stunting, and anaemia in women of reproductive age. It is linked to overweight in school-age girls and obesity among women, particularly in upper-middle- and high-income countries.

After over a decade of progress, hunger is on the rise. The number of undernourished people in the world reached 821 million in 2017 (Figure 4). This increase is due to conflict and climate variability and weather extremes, but weak economic growth is also an essential driver in some peaceful settings, particularly where economic slowdowns have drained foreign exchange and fiscal revenues.

This is the case in some parts of Latin America. Although still in a context of a relatively low level of undernourishment, the situation is deteriorating in South America, where the Prevalence of Undernourishment (PoU) has increased from 4.7 percent in 2014 to a projected 5.0 percent in 2017. Such trends may be the result of persisting low prices in key export commodities – particularly crude oil – which has drained financial resources for food imports, reduced the capacity of governments to invest in the economy and significantly reduced the fiscal incomes needed to protect the most vulnerable against rising domestic prices and loss of income.[80]

Figure 4: Number of undernourished people in the world (2005-2017)



Source: FAO, IFAD, UNICEF, WFP and WHO. 2018. The State of Food Security and Nutrition in the World: Building climate resilience for food security and nutrition. FAO, Rome, 2018.

The role of nutrition

Proper nutrition is the foundation for human health and well-being, physical and cognitive development, and economic productivity and growth. A good nutritional status is an essential social benefit in its own right and is key to breaking intergenerational cycles of poverty, as proper maternal nutrition produces healthier children, who grow into healthier adults.

The coexistence of multiple forms of malnutrition - undernutrition, micronutrient deficiency, and overweight and obesity – occurs not only within countries and communities, but also within households, and can affect the same person over their lifetime. For instance, a poor diet can lead an expectant mother to become at the same time, overweight and aneamic, imposing a toll on both mother and infant.

Globally, child stunting levels remain high. Nearly 151 million children under five years of age were affected by stunting, and over 50 million by wasting in 2017.[81] In addition, one in three women of reproductive age is anaemic. Poor access to nutritious food increases the risk of low birthweight, which in turn increases the risk of stunting in children. Poor maternal and infant nutrition can have multiple adverse long-term health effects and are also associated with a higher risk of overweight and obesity later in life.[82]

On the opposite side of the spectrum, over 38 million children under five were overweight in 2017, with Africa and Asia representing 25 percent and 46 percent of the global total, respectively. More than one in eight adults is presently obese. The problem of obesity is most significant in North America, but it is worrying that even Africa and Asia are also experiencing an upward trend. In addition to reduced access to healthy foods, poor dietary

habits also contribute to overweight and obesity. Overweight and obesity are increasing the risk of non-communicable diseases such as type 2 diabetes, high blood pressure, heart attacks and some forms of cancer.[83]

The multiple burdens of malnutrition are more prevalent in low-, lower-middle, and middle-income countries and concentrated among the poor. Historically, obesity has been concentrated among the poor in high-income countries and, alarmingly, is increasing in poor and emerging economies as well. Demand for processed energy-dense foods of high sugar, fat and salt contents tends to increase with income growth and urbanization, as more meals are consumed outside of the home, and changes in lifestyle shift consumer preferences to more convenient alternatives. A diet composed of varied fresh foods is often costlier than one based on processed foods, particularly in urban settings.

The cost of malnutrition to the global economy, as a result of lost productivity and direct health care costs, could account for as much as 5 percent of global gross domestic product (GDP). In 2013, the costs of undernutrition and micronutrient deficiencies were estimated at 2–3 percent of global GDP. The cumulative cost of all non-communicable diseases, for which overweight and obesity are leading risk factors, was estimated to be about US$1.4 trillion in 2010.[84] Poor diets remain the second highest leading risk factor of ill health, only after smoking.[85]

The most direct contribution of agriculture to food security is by making food more available and affordable through productivity growth. Sustainable productivity increases boost farm income and promote affordable food prices, poverty reduction, and rural development. Agricultural growth can also have a significant effect in reducing stunting and underweight among children.[86]

Agriculture also contributes to nutritional outcomes by enabling a more diverse diet. Agricultural policy priorities must include a stronger focus on facilitating the production and access to nutrient-dense foods such as legumes, fruits, vegetables, and animal-source foods. Policies that support smallholder family farming models, which are associated with greater food diversity, can also promote diet diversification and nutrition.[87]

The inclusion of animal-source foods in the diet is vital to improve and safeguard nutrition and should be pursued under dietary guidelines to prevent health risks associated with under and over consumption. Strengthening the focus on the horticulture sector is crucial, given the importance of fresh fruits and vegetables for achieving healthy diets.[88]

Agricultural practices can also enhance the nutritional content of food. Improving the fertility of soils can improve crop yields and improve the micronutrient concentrations in crops. Adding specific micronutrients to fertilizers or irrigation water can also improve yields and micronutrient concentrations.[89]

Biofortification can enhance the micronutrient content of foods through the use of agronomic practices and plant breeding. For example, the Consultative Group on International Agricultural Research's (CGIAR) programme HarvestPlus carries out

extensive R&D on biofortification, relying on conventional plant breeding, but technologies based on molecular biology and genetic engineering can also be involved.[7]

Improving post-harvest handling, processing and storage practices can contribute to maintaining a secure supply of food (and thus of nutrients) throughout the year, preserving quality, reducing losses and making fresh produce available in markets. Adequate infrastructure is critical to maintaining the quality of food as it moves from producer to consumers and processing operations.[90]

Promoting consumer awareness towards healthier food choices is essential to addressing undernutrition, overweight, and obesity. Nutrition standards and labelling can facilitate access to information on healthy foods and promote healthy dietary behaviour.[91] So too, can creating stronger links between food consumers and local farmers through enhanced physical and institutional connectivity between rural and urban areas. A sustainable shift must be made towards nutrition-sensitive agriculture and food systems that can provide safe and high-quality food for all, promoting healthy diets in line with the recommended action of the ICN2 Framework for Action and the Work Programme of the UN Decade of Action on Nutrition.[92]

Antimicrobial resistance and plant health

Animal and plant health is essential to ensure healthy human lives and a healthy environment. The overuse and misuse of antimicrobials in humans, animals, and plants have accelerated the natural evolutionary processes by which microbes become resistant to antimicrobial treatments. When AMR occurs, the severity of illness worsens, posing a threat to life; the length and cost of treatment rise and diseases spread.[93] There is growing evidence that animal-to-human spread of microbial-resistant bacteria reduces the human body's responsiveness to antibiotics.[94]

The Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE) and the World Health Organisation (WHO) united their complementary mandates under a Tripartite collaboration, which was expanded in 2018 to encompass the United Nations Environment Programme (UNEP) and form the "Tripartite Plus".[95] The Tripartite Plus works jointly to promote collective action to minimize the emergence and spread of AMR and develop a two-year Global Action Plan on AMR (GAP) as a cross-sectoral approach to combatting AMR.[96] The second Tripartite self-assessment survey shows that steady progress has been made since the adoption of the first Global Action Plan was developed in 2015.[97]

The International Standards for Phytosanitary Measures (ISPMs) adopted under the International Plant Protection Convention (IPPC),[8] is an additional instrument to

[7] HarvestPlus is a joint venture between the International Center for Tropical Agriculture (CIAT) and International Food Policy Research Institute (IFPRI) and promotes the development of more nutritious varieties of staple food crops that provide higher amounts of vitamin A, iron, or zinc—the three micronutrients identified by the World Health Organization as most lacking in diets globally. See https://www.harvestplus.org/content/about.

[8] The ePhyto Solution is an example of an innovative initiative that aims to provide developing countries that lack a national system with a simple generic system for the production, sending and receipt of electronic phytosanitary certificates. The ePhyto Solution contributes to both meeting phytosanitary measures and standards and increasing trade

contribute to the fight against AMR. The Codex Alimentarius[9] established task forces to develop science-based guidance on how to assess and manage the risks to human health associated with the presence of antimicrobial resistant microorganisms in food and feed (including aquaculture). The Codex's texts on veterinary drugs and their residues, food hygiene and animal feed also contribute to tackling AMR by preventing the development and minimizing the transmission of AMR through the food chain. These instruments play a significant role in helping countries to improve their plant health status through plant surveillance and pest eradication and control.

In 2017 the G20 Agriculture Ministers proposed to containing the development and spread of antimicrobial resistance in line with the "one health approach", welcoming the work by the G20 Health Working Group supported by OECD, WHO, FAO and the OIE. The G20 Agriculture Ministers re-emphasized the importance to combat AMR in 2018, as it remains an urgent need, particularly in the animal and food sectors, for more investment action and commitment on combating AMR.[98]

Plant health is fundamental for life on earth. Plants produce oxygen and provide more than 80 percent of the food we eat. In addition, they are the source of clothes, shelter, medicines, and a primary source of income for nearly half of the earth's population. FAO estimates that invasive pests damage up to 40 percent of all food crops globally every year, causing substantial loss to trade of agricultural products. The IPPC provides a framework to protect the world's plant resources from the harm caused by pests. In July 2017, the FAO Conference adopted a resolution with the aim to proclaim 2020 the International Year of Plant Health (IYPH). The proclamation of an IYPH in 2020 is important to increase global awareness on the importance of healthy plants to achieve the SDGs.[99]

3.3 Agriculture and environmental sustainability

Agriculture depends upon the environment and the climate, while simultaneously placing a serious burden on both in the process of providing humanity with food, fibre, and fuel. Agricultural production depends directly on natural resources – including biodiversity, land, vegetation, rainfall, and sunlight – which are, in turn, inextricably linked to climate and weather conditions.

Agriculture as a user of natural resources

Agriculture is at the centre of natural resources management. Agriculture is the largest user of freshwater resources worldwide accounting, on average, for 70 percent of total freshwater withdrawals – but these can be much higher in some developing countries.[100] Cities and industries compete with agriculture for water and an increasing number of countries, or regions within countries, are reaching alarming levels of water stress. Agriculture is also a major source of water pollution from nutrients, pesticides, and other contaminants, which if unmanaged, can lead to significant social, economic, and environmental costs.

flows. See more at: http://www.standardsfacility.org/PG-504. The e-Vet is a similar example in the livestock sector. See http://www.standardsfacility.org/PG-609.

[9]The Codex Alimentarius establishes international food standards, guidelines and codes of practice to ensure the safety, quality and fairness of international food trade.

Currently, approximately 33 percent of the world's land is moderately to highly degraded due to the erosion, salinization, compaction, acidification, and chemical pollution of soils.[101] By 2050, soil erosion may result in 10.25 percent of crop loss, equivalent to the removal of 150 million hectares from crop production.[102] Soil nutrient imbalances contribute 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.

Many of these problems are related to inadequate agricultural practices. The Green Revolution, which was based on high-input and resource intensive farming, led to important productivity increases in many countries but had equally important environmental impacts.

Agriculture is also a major contributor to climate change and together with forestry and other land uses (AFOLU) generate about one-fifth of GHG emissions. Agriculture contributes to climate change directly by emitting methane, nitrous oxide and carbon dioxide through crop and livestock production and the use of fossil-fuel energy; and, indirectly by affecting net carbon emissions through its impact on soil, forests and other land uses, particularly through the deforestation of land for conversion to agriculture.[103]

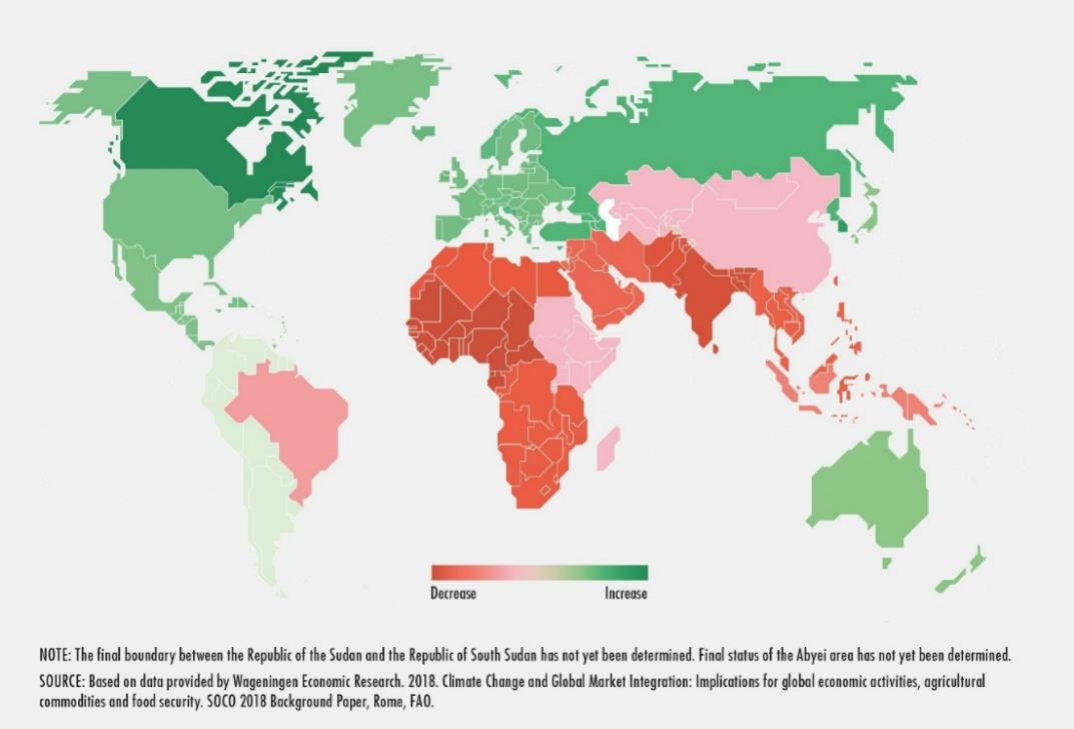
Increasingly, however, it is recognized that sustainable agriculture and forestry can also have positive externalities such as the provision of environmental services and amenities, for example through water storage and purification, carbon sequestration and the maintenance of rural landscapes. Agricultural policies should provide incentives to both reduce pressure on environmental resources and increase positive externalities.[104]

The need to adapt to climate change

The impact of climate change will be uneven across regions and countries (Map 1). In low-latitude regions, where most developing and least developed countries are located, agriculture is already being adversely affected by climate change, specifically by a higher frequency of droughts and floods. For a number of developing countries, climate change could exacerbate the food security challenges they already experience.

Conversely, countries in temperate areas, many of which are developed economies, are expected to benefit, on balance, from warmer weather during their growing season according to projections to 2050. As a result, climate change could exacerbate existing inequalities and further widen the gap between developed and developing countries. The increase in carbon dioxide in the atmosphere is also expected to impact the nutritional quality of crops, affecting protein and micronutrient contents of food.

Map 1: Projected changes in agricultural production in 2050



Source: FAO. 2018. The State of Agricultural Commodity Markets 2018. Agricultural trade, climate change and food security. Rome.

Food production will need to increase substantially in the coming decades to keep its pace with population and demand growth, while adjusting to the effects of climate change, contributing to reduce its emissions of greenhouse gases (GHG), and reducing its overall pressure on the environment. In 2050, agriculture will need to produce almost 50 percent more food, feed, and biofuel than in 2012.[105] Producing more with less, while preserving natural resources and enhancing the livelihoods of farmers, is a key challenge for the future.

Climate-smart agriculture (CSA) is an approach that guides actions to help agriculture and food systems (including fisheries and aquaculture) to adapt to a changing climate and ensure food security. CSA has three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and, reducing, and, or, removing GHG emissions where possible.[106]

Technological change, extension, and training will play a vital role in promoting CSA approaches and ensuring sustainability in agriculture under climate change. Farming methods will need to embrace technological improvements and production systems that use fewer inputs per unit of output, and move towards approaches and methods that can contribute to sustainable productivity growth. For example, agroecology, agro-forestry, and conservation agriculture hold significant potential for all sizes of farms and agro-ecological systems. Smallholders can play a key role in this regard (Box 10). Improving the efficiency of farming systems would enhance food security and reduce their carbon footprint simultaneously.[107]

Box 10: Smallholders – custodians of natural resources, biodiversity and ecosystem services

In many countries, most farmers cultivate small plots of land. Small family farms produce food for a significant share of the global population. Often, these farmers are custodians of traditional knowledge and the natural environment. Despite having limited access to resources, smallholder farmers have developed Globally Important Agricultural Heritage Systems (GIAHS) throughout the world. GIAHS are agricultural systems in which nature and the landscape dovetailed with human activity and the local culture. These systems were developed over centuries as a response to the constraints and potential of the land, in a pursuit to increase and stabilize crop yields sustainably. Smallholder farmers crafted GIAHS to endure ever-changing environment and climate conditions, ultimately acquiring resilience and robustness. Since a guiding principle was to preserve the surrounding environment to ensure long-term viability, these traditional systems offer many lessons on how to overcome the challenges posed by the harsh weather and terrain conditions.

Climate change is likely to increase the frequency and severity of extreme weather events. Most analyses suggest that the variability for key food staples such as rice, maize, and wheat will increase as the century progresses.[108] Agricultural insurance forms an important component of CSA and will be increasingly necessary to help farmers in managing climate risks and in investing in their farms. Strengthening the capacity of agriculture to manage risks will be essential and will contribute significantly to adaptation efforts.[109]

The need to contribute to mitigating climate change

Opportunities for climate change mitigation in agriculture include reducing emissions from land use change, soil, and livestock management practices. Increasing carbon capture and storage in soils and biomass can also contribute to mitigation. Improving consumer awareness can help individuals make informed decisions about their food choices and consumption habits in developed and rapidly urbanizing emerging economies. Raising consumers' awareness to reduce their food waste and shift dietary preferences to foods of lower carbon content could drive significant progress on mitigation. Food labeling that

makes complex nutritional and environmental information accessible to consumers can help in this respect.[110]

Many land-based agriculture mitigation options overlap with sustainable land management and climate change adaptation measures. There is vast potential for synergies in practices such as adopting improved crop varieties; avoiding bare fallow and changing crop rotations to incorporate food-producing cover crops and legumes; increasing judicious fertilizer use in regions with low nitrogen content (as in much of sub-Saharan Africa) and adopting precision fertilizer management elsewhere; seeding fodder and improving forage quality and quantity on pastures; expansion of low energy-intensive irrigation; and expansion of agro-forestry and soil and water conservation techniques that do not take significant amounts of land out of food production. The Voluntary Guidelines for Sustainable Soil Management (VGSSM), developed within the framework of the Global Soil Partnership (GSP) and endorsed by the 155th session of the FAO Council, provide general technical and policy recommendations on sustainable soil management (SSM) and can help stakeholders to adopt sustainable soil management practices.[111]

Where trade-offs between food security objectives and adaptation and mitigation targets exist, a mix of policies will be needed. For instance, organic soil management yields very high carbon benefits, and could also increase labour demand contributing to rural employment and growth, but it can lower productivity. Trade-offs can also occur when mitigation options take land out of production, either temporarily or permanently. For instance, restoration of degraded lands often requires that land not be used for production at least in the short-term, whereas avoiding draining or restoring wetlands would directly take land out of production permanently. Some trade-offs can be managed through measures to increase efficiency or through payment of compensation, but most solutions will need to be tailored to specific local challenges and needs.[112]

At the 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2017, parties adopted the Koronivia Joint Work on Agriculture (KJWA). The KJWA requests the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation to jointly address issues related to agriculture, working with constituted bodies under the Convention and taking into consideration the vulnerabilities of agriculture to climate change and approaches to address food security.[113] This constitutes an important step since, for the first time, agriculture is acknowledged as a significant sector in adapting to and mitigating climate change. Going forward, it will be important to explicitly discuss methods and approaches that can help address potential trade-offs between food security and mitigation objectives.

Trade can help increase food systems' resilience

Trade is one of the key means of implementation of the 2030 Agenda, with trade-related targets specified under several of the SDGs. Open, transparent, predictable, and fair global commodity markets can provide a reliable source of food, reduce food price volatility, and contribute to eradicating global hunger. The World Trade Organization (WTO) remains an

important venue for negotiations that aim to strengthen the multilateral trading system and minimizes distortions in world agricultural markets.

Trade can help stabilize short-term food shortages and local prices when extreme weather events undermine food production, contributing to increasing food availability and access. Trade can also promote long-term food stability and access by moving food from surplus to deficit areas. Improving market access for smallholder farmers and developing countries, in general, could significantly contribute to poverty reduction.

In well-functioning global markets, trade patterns will respond to changes in the comparative advantage of agricultural production across regions and countries. The impact of climate change on the comparative advantage of agricultural production of some countries means that countries should assess and employ all suitable measures to enhance productivity and maintain or increase their comparative advantage to ensure the continued viability of agriculture, vibrant rural areas, and food security.

Examples of measures that can increase resilience and promote adaptation and food security with minimally trade-distorting effects include research and development, extension, training, technical assistance, and investments.

Emergency humanitarian food reserves can also complement the role of trade. Public food reserves designed to meet emergency food needs can help mitigate the impact of production shortfalls, particularly in countries where transportation costs may delay imports in times of supply shortages. Such food emergency reserves are less likely to disrupt private sector storage activity, and if linked to social protection mechanisms can effectively target the poor and the vulnerable. Regional emergency food stockholding schemes, such as the ASEAN Plus Three Emergency Rice Reserve (APTERR) and the Economic Community of West African States (ECOWAS) Regional Food Security Reserve, can allow countries to pool risks and reduce stockholding costs.[114]

3.4. Agriculture as a vector for sustainable and inclusive economic growth

With the 2030 Agenda, world leaders vowed to leave no one out of economic, social and technological progress. Agriculture remains the world's biggest employer and largest economic sector in many countries. Yet rural people – who produce 80 percent of our food – make up four-fifths of the global poor.[115]

Agriculture productivity, economic growth and poverty reduction

Economic growth, employment and rising incomes are key elements in alleviating poverty and reducing hunger and malnutrition. The relationship between economic growth, poverty, and hunger is complex and calls for effective policies. Economic growth brings increases in the income of households, through higher wages or stronger demand for labour. In a growing economy, more members of the household can find work and be paid well for their working time. This is essential for improving food security and reducing poverty. But the relationship runs in two ways. Improved food security and nutrition strengthens the human resource base and increases productivity, promoting economic performance, and reducing poverty rates.

Not all types of growth are effective in reducing hunger and malnutrition. The extreme poor cannot participate in growth processes that require capital or generate employment for the educated and skilled. And the greater the inequality in the distribution of assets such as land, water, capital, education and health, the more difficult it is for the poor, and the slower the progress in reducing poverty and undernourishment. Since the main asset of the poorest is labour, sustainable productivity growth can play a significant role in poverty reduction. To secure their ability to engage in productive activities, a twin-track approach is needed so that short-term, immediate, hunger relief interventions are accompanied by long-term support for agriculture.[116]

Investing in agriculture is one of the most effective strategies for reducing extreme poverty and hunger. Evidence shows that growth in agriculture is significantly more effective to reduce extreme poverty than growth in other sectors of the economy.[117] This occurs in part because most of the poor base their livelihoods upon agriculture in poor developing countries. In sub-Saharan Africa, for instance, as much as 57 percent of the population was employed in the agriculture sector in 2015, and 41 percent of the population was extremely poor.[118]

In developing countries, agriculture also has a strong multiplier effect on other sectors. The regions where agricultural capital per worker and public agricultural spending per worker have stagnated or fallen during the past three decades are also the epicentres of poverty and hunger in the world today.[119] Evidence also demonstrates that public expenditure on research and development for agricultural innovation has a very high return to the investment in terms of poverty reduction.[120] The multiplier effect of investments in the agriculture sector on poverty reduction is highest when these are accompanied by investment in other sectors such as rural infrastructure, education, manufacturing, and the services sectors.

Economic and rural transformation

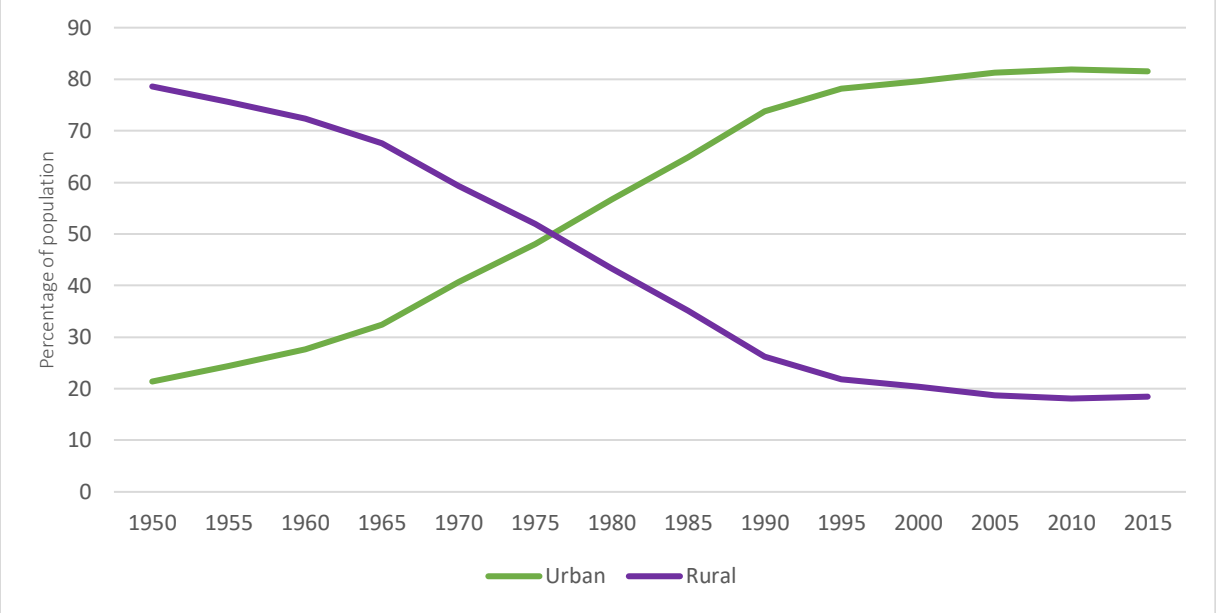
Investments and policies that promote increases in the productivity of labour in agriculture lead to increases in rural income. Farmers grow more food, become more competitive and their income increases. Productivity increases in agriculture contribute towards broader economic growth not only by reducing the price of staple food. With well-functioning labour markets, this productivity growth can help people shift to fast-growing sectors, such as manufacturing and services. Rural household members diversify their income sources by obtaining better-paid off-farm work. Poverty and hunger decline, while the share of agriculture in GDP and employment falls, as people exit the agricultural sector.

The process of structural transformation of the economy involves a shift from mainly subsistence farming to commercial, highly diversified production systems. At the individual farm level, the process favours specialization, which allows economies of scale through the application of advanced technologies and modern delivery systems for both inputs and outputs. This, in turn, promotes tighter integration of a more diversified farming sector with the rest of the economy and with international markets.[121] It also entails large scale rural-urban migration.

In East and Southeast Asia, the transformation from an agriculture-based economy to an industry - and the service-based economy went hand in hand with large-scale, rural–urban migration. Since the 1960s, in line with considerable improvements in agricultural productivity, rural out-migration has caused a fall in the share of rural population from 70 percent to about 50 percent, or even more for some countries. For example, in the Republic of Korea, the share of the rural population dropped from more than 75 percent in 1950 to about 15 percent in 2015 (Figure 5). The main drivers of this out-migration have been faster growth and increasing incomes in manufacturing and associated services. Productivity increases across all sectors have generated a positive dynamic for rural and structural transformation and led to major reductions in overall poverty.[122]

The Green Revolution's impact in East and Southeast Asia is particularly notable for the degree to which they combined rapid industrialization with a profound agricultural transformation that committed to smallholder family farming. Experiences in countries as diverse as Korea, Japan, Malaysia, and China demonstrated that substantial agricultural productivity improvements could be achieved even with a predominance of small production units. It also showed that a policy commitment to inclusive development through smallholder family farmers was compatible with structural transformation. The result in these instances was a process that combined very rapid and widely shared economic growth, and accelerated poverty reduction, with social peace.[123]

Figure 5: Trend of the share of rural and urban population in the Republic of Korea (1950-2015)



Source: FAO IFAD IOM WFP. 2018. Based on data from UN DESA, Population Division.

Such a process is sustainable if accompanied by overall economic growth that generates jobs for the poor and raises the unskilled labour wage rate. But increasing agricultural

labour productivity in countries with large small-scale agricultural sectors and growing populations is crucial in this transformation process.

Nevertheless, structural transformation is far from a uniform process over time and across countries. The nature of economic growth and its ability to integrate existing agricultural workers into the non-agricultural sector has been changing in identifiable ways, posing challenges for policymakers.[124] For example, in the case of East and Southeast Asia, transformations in rural and urban areas produced synergies that contributed to significant poverty reduction. Productivity improvements in agriculture and non-agriculture sectors, especially in the manufacturing sector, have reduced the total number of poor, both urban and rural, by more than 800 million since the 1990s.[125]

Rapid urbanization in sub-Saharan Africa has not been matched by a comparable growth in manufacturing and modern service sectors. People exiting low-productivity agriculture are moving mostly into low-productivity informal services, usually in urban areas. The benefits of this transformation have been very modest.[126]

In situations characterized by lagging growth, agro-industry may be an important source of employment for those exiting agriculture. As labour exits agriculture, and pressure for rural out-migration increases, transforming countries will need to create jobs in off-farm agriculture-related activities, such as food processing and trading. The growing demand for food, and the dietary transition away from staple foods can present an important opportunity for industrialization.

Food industries have proliferated in the developing world in the past three decades. Agro-industry accounts for more than 50 percent of total manufacturing value added in low-income countries, and 30 percent in middle- income countries. Because food processing tends to be more labour-intensive, and labour productivity is above the average in manufacturing, the food and beverages subsector has a high potential for creating decent employment.[127]

A territorial development approach that focuses on the linkages between rural and urban areas can help offer solutions to some of the challenges associated with economic growth and rapid population increases. Improved territorial planning of metropolitan areas, small cities, and towns, together with improved connective infrastructure, can dampen rates of out-migration to overburdened large cities or other countries by generating opportunities in closer proximity to rural areas. Where local jobs are lacking, investments in connective infrastructure specific to the food system – such as warehousing, cold storage, and wholesale markets – can generate employment in both agriculture and the non- farm economy. In this way, the needs of potential migrants can be met before they decide to leave. Where rural people are attracted by more prosperous conditions in urban centres, investments in “agglomeration” services – such as education, health, communication and leisure facilities – in small cities and towns distributed over a territory and in proximity to rural areas, can also reduce rates of out-migration to overburdened larger cities.[128]

In developed countries, where agriculture makes up a small part of GDP and employment, the rural non-farm sector provides the link between commercial agriculture and livelihoods earned in the modern industrial and service sectors in urban centres. But the ageing of the agricultural workforce is increasingly common. Farmers in the higher age classes predominate in the European Union (EU), where around 30 percent of all farm managers are over 65,[129] and Japan, where 56 percent of all farm managers are over 65.[130] Older farmers in these countries tend to manage smaller farms, while larger farms tend to be managed by relatively young farmers. In Japan, the largest 3 percent of farms cultivate nearly half of the land and account for more than half of production (in value terms).[131] This trend comes with challenges – the absence of young men and women from rural areas can affect agricultural productivity, as older farmers can be less likely to invest and innovate, for instance.

Building inclusive societies

The potential of agriculture to contribute to more inclusive societies is immense. Inclusiveness requires targeted public policies that empower local communities – especially the most vulnerable groups, such as women, youth, and indigenous peoples – to participate in the structural transformation process. If women in rural areas had the same access to land, technology, financial services, education, and markets as men, agricultural production could be increased and the number of hungry people reduced by 100-150 million.[132] This reinforces the message that growth in agriculture must be one of many policies pursued to trigger and subsequently consolidate structural transformation in poor developing countries, and should be matched by policies that promote inclusiveness. In the developing world, investments and policies will need to focus on women, who are the backbone of the rural economy. Yet they receive only a fraction of the land, credit, inputs (such as improved seeds and fertilizers), agricultural training and information compared to men. Empowering and investing in rural women has been shown to significantly increase productivity, reduce hunger and malnutrition, and improve rural livelihoods.

While the tendency is for small plots of land to be consolidated, forming larger farms when agricultural transformation occurs, this is not always the case. In some countries, farm sizes are getting smaller, owing to population growth and population density trends. In these countries, declining farm sizes pose additional challenges to smallholder farmers. These relate to sustainable productivity growth, technology adoption, and economies of scale required to participate in modern value chains.[10]

3.5 Partnering with the private sector

Farmers themselves are the largest investors on their farms. Their own investment surpasses foreign direct investment, official development assistance, and investments by governments. This occurs in spite of weak enabling environments (in terms of policy,

[10] Typically, small farms have a high land productivity, combine with low labor productivity. Small farms constitute a pillar of national food security.

institutions and infrastructure) faced by many farmers. On-farm investment in agricultural capital stock was more than three times as large as all other sources of investment combined for the period 2005-2007.[133]

Public investment remains important to provide the infrastructure and services needed by farmers as well as to deliver public goods, overcoming market failures. But partnering with the private sector will be essential to mobilize the levels of investment and action required to eradicate poverty and hunger. Many multilateral initiatives can help frame and promote private investment in agriculture.

The Addis Ababa Action Agenda on Financing for Development (AAAA)[134] provides a global framework for financing development post-2015. It recognizes the importance of a multi-stakeholder partnership to deliver on the 2030 Agenda and calls on the private sector to help overcome sustainable development challenges. It commits governments to design the necessary policies and strengthen regulatory frameworks to make this possible.

There is immense potential for the private sector to contribute to sustainable growth through investments in the green economy, agro-food value chains, trade, and more. Private investment can be one of the main drivers of innovation and technology adoption. Responsible agro-food investment and policies that further advance technology and entrepreneurship within related activities – linked to tailored learning and education opportunities, including quality and relevant education in rural areas – can contribute to inclusive economic growth and creating employment opportunities. This will be especially important to retain and engage youth in rural and agro-food sectors and to address economy-wide patterns of inequality, which have emerged as challenges in G20 countries. Ensuring the adequacy of working conditions and remuneration in agro-food sectors remains a challenge, with cases of exploitative and unsafe conditions being documented in multiple countries, many involving the use of migrant and refugee workers.

A number of guidelines can help put private investment onto a responsible track. The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT), and the Principles for Responsible Investment in Agriculture and Food Systems (CFS-RAI)[135] promote responsible investment in agriculture and food systems and are important to achieve higher productivity, inclusive growth, poverty reduction and improved food security and nutrition. Sustained global support for the implementation of CFS-RAI and the VGGT is important to secure progress in these areas. Discussing, at a global level, the necessary steps to promote the wide adoption of standards, principles, and commitments (CFS-RAI, VGGT, the OECD Guidelines for Multinational Enterprises,[136] and the OECD-FAO Guidance for Responsible Agricultural Supply Chains[137]) can also add significant value and facilitate responsible investment in agriculture and food systems.

3.6 Policy areas for consideration

- *Increase both food availability and access.* In many countries, it is possible to achieve substantial, sustainable productivity growth through the adoption of already available technologies and improved farming practices. Immediate hunger relief needs to be provided where extreme poverty undermines access to food to ensure that the poorest can engage in productive activities.
- *Promote improved nutrition*. Achieving and maintaining adequate nutrition requires a comprehensive, multisectoral and multi-stakeholder approach, integrated action and complementary interventions in i) the food and agriculture production systems, to ensure that the food produced is nutritious, varied, safe and efficient in providing the basis for healthy diets; ii) the infrastructure sector, to ensure that food distribution systems are efficient and resilient to adequately transport and deliver food, preserving quality and nutritional properties until it reaches processors and consumers; iii) the public health sector, to ensure appropriate access to safe water, sanitation and address broader health issues essential to the adequate absorption of nutrients; and iv) the education sector, to raise awareness on healthy child feeding practices and adult dietary choices, and to raise consumer awareness and facilitate access to information on the importance of a healthy diet.
- *Support the G20 Nutrition for Growth (N4G) Summits.* The Summits have emerged as a key fora for promoting multisectoral collaboration and dialogue among governments, experts, food producers, private sector market participants, and consumers.
- *Continue to promote animal and plant health.* To this end, it is indispensable to continue support and commitment to the established international fora and agreed plans and standards that aim to contain the spread of Antimicrobial Resistance.
- *Protect biodiversity, and preserve our soils, water and ocean resources.* Farmers need to be encouraged and guided, through appropriate incentives and governance practices, to adopt farming practices that conserve natural ecosystems and their biodiversity and minimize the negative impact agriculture can have on health and the environment.
- *Adapt to climate change, and make a contribution to mitigation efforts.* Where trade-offs between food security objectives and climate adaptation and mitigation targets exist, a mix of policies will be needed. This mix should go beyond productivity and encompass provisions to address catastrophic events and food emergencies, including through international trade.
- *Contribute to the process of structural transformation.* Growth in the agriculture sector can contribute to broader economic growth. It is important to improve the interconnectivity between rural and urban areas and to promote growth in the modern industrial and service sectors so that these can absorb exiting agricultural workers. By strengthening the linkages between rural areas and urban centers and supporting the rural non-farm sector, policymakers can make the food and agriculture sector more attractive to younger farmers.

- *Guide and encourage private investment.* Private investment will be indispensable to achieve sustainable development. Governments should provide an enabling policy environment to foster investments in the green economy, agro-food value chains, trade, and innovation and technology. Governments remain responsible for ensuring that private investment is responsible and adheres and respects established guidelines under international fora

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