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Agriculture, Employment and Climate Change—With Specific Reference to Developing Countries

Chapter 10

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Abstract and Introduction[1]

This chapter is intended to: i) describe the evolution of global agriculture over time, and up to the present, ii) explain the reasons for variations in agricultural performance between regions and within regions, iii) assess the potential for the agriculture sector to expand employment opportunities in developing countries, iv) assess the impact of climate change on agriculture and v) undertake a preliminary analysis of the impact of the COVID-19 pandemic on global agriculture.

The chapter finds agriculture production to have expanded globally prior to the COVID-19 pandemic. The year 2019 saw the total value of global agricultural production achieve a record. However, there are significant differences in performance between regions. Generally, East Asia, South Asia and North America have agricultural sectors that have been flourishing. Africa and West Asia continue to lag, with Latin America in between. Within each region, there are vast differences in performance between countries. COVID-19, however, has had an important negative impact on agriculture, at the farm level and in terms of domestic and international trade.

A major proximate explanation for a country's agricultural performance is the amount of private and public expenditure on agricultural research and development, rural infrastructure, fertilizers, and farm mechanization. Government agricultural policy is important in determining agricultural performance, including by influencing the amount of investment in R&D, infrastructure, and farm inputs. Policy that effectively taxes agriculture and over-regulates, inhibits performance.

The chapter finds that the potential for agriculture to expand employment opportunities is limited. However, at the margins, governments can slow the exit of labour from agriculture by switching subsidies away from direct payments to farmers into the support of public goods, such as agricultural R&D, education, infrastructure and territorial development.

The chapter summarizes the literature on the impact of climate change on agriculture, predicting significant impacts, mostly negative in the tropics, though sometimes positive in northern climes (such as Russia, Canada and Scandinavia). However, the latest data suggests that up to the present, the negative impact of climate change on agriculture in the tropics has been offset to date in many countries by successful farmer adaptation. The question is whether further increases in temperature, reduction in rainfall and other climate changes can continue to be adapted to by farmers as these events become more severe. The latest publications on this subject almost

1. Harinder Kohli, Amnon Golan, Martin Raine, Adolfo Brizzi and Iqbal Sobhan, all made valuable suggestions, including editing suggestions, for this report. An agriculture database was created, held by the Centennial Group, consisting of agricultural data from the World Bank, Food and Agriculture Organization (FAO), United States Department of Agriculture (USDA), International Food Policy Research Institute (IFPRI) and the Organization for Economic Co-operation and Development (OECD).

all predict very negative impacts on agriculture, which will be difficult to adapt to. Increased funding for agricultural adaptation will, therefore, be important. Switching agricultural subsidies from farmer and crop support to the support of measures to assist farmers to adapt to climate change, and to measures to mitigate the impact of farming on CO_2 and methane emissions is essential, though politically difficult.

Based on the analysis, recommendations are provided for consideration by governments on how to reform agricultural policy to stimulate better agricultural sector performance, including in employment creation and adaptation to climate change. It is found that there is considerable room for additional financing of developing country agriculture. This is more difficult than it may first appear, as many long-standing donors continue having difficulty funding effective agricultural projects and policies, and there will be resistance to shifting funding and subsidies towards climate change adaptation and mitigation in agriculture.

The impact of the novel coronavirus pandemic on agriculture was beginning to be felt as this report was being prepared. By October 2021, reports had emerged in the international press and among institutions, which monitor agriculture performance, that the pandemic had negatively affected the supply and demand for agriculture products. Supply has been curtailed worldwide resulting from labour shortages on farms (reduced numbers of migrant workers in North America and Europe), disruption of agricultural and farm input supply chains due to increased transport bottlenecks, and the closing of food processing plants and plants producing farm inputs. This, in turn, was negatively impacting farm production. The World Food Programme (WFP) recently reported a negative impact on food aid provided to food deficit countries, particularly in Africa. A rigorous analysis of the impact of the pandemic on global agriculture remains to be done since the pandemic is still rageing as this is being written.

The State of Global Agriculture and Regional Differences

What Is Included in 'Agriculture'?

Nearly every government defines agriculture to include primary agricultural production. Most often, agriculture also includes livestock, forestry, and fisheries. It sometimes includes agro-industry, farm input supplies, and agricultural marketing. For the purpose of this report, agriculture will refer to primary production, livestock production, fisheries, and forestry. Agro-industry, farm input supply, and agricultural marketing will be treated separately and lightly.

The Long-term Trends in Agricultural GDP, and World Agricultural Prices, Broken Down by Region

Table 10.1 shows considerable variation in agricultural growth rates between both countries and time periods. This huge variability reflects the vagaries of weather, changing government policies, changing agricultural trade patterns, and changing directions of agricultural aid. Differences in growth rates are also affected by agricultural endowments (available land and labour, and available capital). Growth rates of 4 per cent per annum or better are exceptional for agriculture, while growth rates lower than 2 per cent per annum reflect poor performance. In the most recent period, agricultural value added has grown best in the Middle East and North

Table 10.1: Agriculture, forestry and fishing, value added (annual growth, %)

	1982–1986	1987–1991	1992–1996	1997–2001	2002–2006	2007–2011	2012–16	2017–21
Africa - Eastern and Southern	1.0	2.9	3.6	2.6	2.8	3.2	3.3	2.5
Africa - Western and Central	4.2	3.4	2.8	3.6	11.7	4.8	4.2	3.3
Central Europe and the Baltics	-1.1	-1.4	1.7	0.5	0.7	0.5		
Caribbean small states	0.0	3.3	3.7	-0.8	-1.1	2.2	1.7	-0.2
East Asia and Pacific	5.9	3.5	3.2	2.4	3.4	3.7	3.0	2.8
Europe & Central Asia	-3.1	-1.6	1.3	1.4	2.2	1.1	1.3	
European Union		3.4	0.6	0.3	1.5	0.3	0.6	
Fragile and conflict affected situations	2.7	2.6	4.2	2.9	7.6	3.5	2.2	2.7
Latin America and Caribbean	1.1	2.2	3.7	2.5	3.6	2.4	2.0	2.4
The Middle East and N. Africa	6.3	4.4	3.4	1.9	4.7	1.8	1.3	3.4
North America			5.9	2.9	-2.1	5.4	2.7	
Sub-Saharan Africa	2.2	3.1	3.3	3.0	6.7	4.0	3.8	3.0
World	4.0	3.0	2.4	2.5	3.1	2.8	2.7	2.8

Source: World Bank 2021b

Africa, Sub-Saharan Africa and East Asia, in that order. The poorest performances have come from the Caribbean, the European Union, and Central Europe and the Baltics.

Per capita food production indexes prepared by the FAO are another useful indicator of agricultural performance. This data differs from agricultural GDP (which includes more than food, relative prices affect GDP figures but not food production indexes, and per capita food production indexes are adjusted for population growth). Per capita food production indexes show the most rapid increases occurring in South Asia and South America, followed by West Asia. Africa and North America show declines. The problem in Africa is that population growth has outstripped food production. Population growth in East Asia and South Asia has been much less rapid than the growth in food and non-food agricultural production (World Bank 2021b).

Another way to look at agriculture performance is through trade balances (net agricultural export value minus agricultural imports). Table 10.3 shows Africa and Asia to be major net agricultural importers, while the Americas are major net agricultural exporters. Europe has transitioned from a major importer to an exporter.

The implication of these three ways of looking at agricultural performance (agricultural GDP growth, growth in per capita food production, and net agricultural trade balance) are that Africa and Asia have started with a major agricultural production deficit, reflected in the negative trade balance and poor agricultural performance historically. However, in much of Asia (particularly East Asia), growth of food production and agricultural GDP have been higher than population growth. In Africa, since 2004–06, food production growth is slower than population growth. Per capita food production is improving in South America (with, of course, variation between countries).

World prices are a good indicator of global supply and demand balances, as the market for agricultural products has become globalized. World prices fluctuate constantly, as world

Table 10.2: Gross per capita production index

	1990	2000	2010	2015	2019
World	94.3	99.85	101.97	44.64	69.8
Africa Total	97.52	100.55	99.26	57.7	80.63
North America	88.53	94.81	95.42	97.04	98.98
South America	62.26	72.88	93.2	101.93	107.28
Asia Total	62.61	78.32	93.27	99.98	103.75
Central Asia	N/A	65.46	86.3	100.51	101.47
Eastern Asia	50.37	73.54	91.81	100.71	102.29
Southern Asia	75.4	80.82	92.75	98.44	107.31
South-Eastern Asia	62.91	73.29	94.48	100.15	104.16
Western Asia	119.58	110.83	101.74	100.82	104.29
Europe	106.53	91.23	91.35	99.77	101.79
Oceania	98.27	107.58	93.01	100.13	88.11

Source: FAO 2022

Table 10.3: Net food (excluding fish) trade (USD million)

Region	2000	2010	2018
Africa	-7398	-26789	-30672
Americas	23546	101828	105194
Asia	-46161	-102888	-191420
Europe	-192	-14724	31821
Oceania	13332	25866	42722

Source: FAO 2020

demand and supply conditions vary constantly. Cereal prices have, over the long term, tended to be relatively depressed compared to meat and dairy prices, in particular, but also compared to prices of fruits and vegetables as well. This reflects the rapidly rising demand for meat and dairy, fruits and vegetables, with slower increase in demand for cereals (FAO 2020).

Crop Yields (Production Per Hectare)

Because agricultural GDP involves both production and relative prices, it is dependent in part on the crop mix in a country's agriculture. A country that is a major coffee producer, for example, can suffer an agricultural GDP decline as a result of a decline in the real export price of coffee, even when its production increases dramatically. For that reason, it is useful to look at performance in terms of physical production per hectare of major agricultural products.

Table 10.4 shows that with few exceptions, crop yields in Africa have been below those in Asia and South America, and far below crop yields in Europe and North America. They also show slow growth in crop yields in Africa (except for wheat and to a lesser extent, cotton), suggesting that this region is not catching up with the rest of the world. Increases in agriculture

Table 10.4: Crop yields (tons/hectare); and per cent increase 2000–18

	Maize		Wheat		Seed Cotton		Rice Paddy		Green Coffee	
	2000	2018	2000	2018	2000	2018	2000	2018	2000	2018
Africa	1.8	2.0	1.8	2.9	0 .9	2.1	2.3	2.3	0.4	0.4
Per cent increase	11		61		24		0		0	
Asia	3.6	5.4	2.6	3.4	1.7	2.1	3.9	4.8	0.8	1.1
Per cent increase	50		31		24		23		38	
Europe	4.7	7.5	3.3	4.0	3.2	3.0	5.2	6.4		
Per cent increase	60		21		-7		23			
South America	3.2	5.3	2.4	3.0	1.9	3.7	3.6	6.1	.8	1.4
Per cent increase	66		25		95		69		75	
North America	3.5	11.7	2.7	3.2	1.8	2.7	7.0	8.6		
Per cent increase	234		18		50		23			

Source: FAO 2020

productivity, as measured by crop yields, are occurring in South America, North America, Asia and to a lesser extent, Europe.

Agro-industry, Agricultural Marketing, and Farm Input Supply

Most agricultural products are marketed and processed, and the processed products are marketed again. Think of cocoa, for example, which is processed into a myriad of chocolate products. All farm production of raw cocoa is in the tropics: tropical Africa, Asia and Latin America. Cocoa goes through an elaborate collection by private, public or cooperative companies, depending on the country. These companies do the initial processing, consisting of weighing, sorting, drying, bagging, aggregating and shipping. Most is sold to European and American buyers who combine the cocoa with other products (notably sugar, milk and preservatives) into chocolate products. These chocolate-producing countries import the cocoa from tropical countries. The tropical countries that produce most of the high-quality cocoa for export only produce chocolate for domestic consumption. It is difficult for companies from developing countries to break into the European and American markets with processed chocolate products, while it is easy for them to export raw cocoa. This is because of high transportation costs, quality issues, marketing costs and, in most cases, trade barriers erected by importing American and European countries. Most of the sales prices of final chocolate products goes to the big European and American chocolate-makers, not to the farmers and marketing enterprises in developing countries.

Many agricultural products have some variant of the above situation (tea and coffee, for example). Cotton is more widely grown than cocoa (India, several Sahelian African countries, China and Uzbekistan are major cotton producers, for example), while its eventual processing into cotton clothing is done all over the world. Maize and rice are widely produced, processed and consumed in many countries.

Despite the obvious advantages of domestic agro-industry, the data suggest that most developing countries have not seen large increases in agro-industrial growth, and are still largely

dependent on primary agricultural production. The exceptions are some countries in Asia, particularly China, and for some commodities. Cotton is an exception with much of the industry producing cotton products having moved to developing countries.

The World Bank's most recent World Development Report found evidence that participation in global supply chains (including agro-industry) results in a boost to agricultural productivity, income, and employment (World Bank 2020b). A major policy objective in developing countries with important primary production should, therefore, be the encouragement of agro-industry investment.

Policies that boost value chain development include, most importantly, those which attract foreign investment as well as domestic investment. These include trade liberalization, contract enforcement, investment in human capital investment, and policies that improve business climate (World Bank 2020b). Foreign direct investment in the agricultural and food sectors of Africa, Asia and Latin America has grown from US$790 million in 1993 (in constant 2005 dollars) to US$8.3 billion in 2010 (2005 dollars). Most of this has been for agro-industry.

Box 10.1: Côte d'Ivoire's cashew value chain

Cashews are Côte d'Ivoire's third-ranking export after cacao and refined petroleum products, and they are an important source of cash for smallholders and processors. Although Côte d'Ivoire produces 23 per cent of the world's cashew supply, fewer than 7 per cent of raw cashew nuts are processed domestically. In 2017, a government programme provided training, access to inputs, and market information, along with processing demonstration units. The programme was supported with access to new sources of finance for smallholders, notably through the introduction of a warehouse receipts system that enables processors to use unprocessed nuts as collateral for working capital loans. About 225,000 cashew farmers are expected to benefit from the upgrading and improved value chain integration.

Source: Adapted from World Bank 2020a

Box 10.2: Rwanda's coffee value chain

The coffee sector was historically Rwanda's main export crop and a major source of earnings for up to half a million rural Rwandans. But at the end of the 1990s, fallout from the civil war helped put the sector on the verge of collapse because of the low quantity and quality of its product. To address this challenge, the country put in place a strategy, completed in 2002, to upgrade technology, increase production, and boost skills and improve quality. The result has been more skilled farming techniques, better use of technologies, and higher productivity. Private investment in coffee washing stations grew by an average of 120 per cent a year in locations with the highest cherry (the fruit that contains the coffee bean) availability, water supplies, and road linkages. The total number of coffee washing stations rose from just two in the entire country in 1998 to 299 in 2015. Meanwhile, the higher-quality coffee began to merit higher prices, with Rwandan coffee now fetching a premium in international markets.

Explanation for Regional Differences in Agricultural Performance

Factors Contributing to Differences in Agricultural Growth and Performance between Regions and Countries

Why are agricultural yields and productivity in Europe and North America so much better than that of Africa, the Middle East and Latin America, and why is Asia catching up while most of the rest of the developing world is not?

The proximate causes for the difference in agricultural productivity and growth between regions, and indeed between countries within regions, is well-known and involves differences in fertilizer use, water use (and irrigation), mechanization, farm-level investment, rural energy, rural infrastructure, changes in rural land use, changes in rural labour availability, labour skills and, most importantly, R&D.

Expansion of agricultural land would be a relatively easy way to increase agricultural output, though not of productivity. However, agricultural land declined globally since 1990, with continuous decline in Europe and North America. There has been a modest expansion in Africa until 2010, with a slight decline thereafter. A similar pattern has been followed in South Asia. East and West Asia have a relatively stable amount of land under agriculture. The causes for decline in agricultural land include urbanization and suburbanization, conservation efforts (putting land into parks and public land into forestry) and pollution (salinization of irrigation areas, saltwater intrusion) (FAO 2022).

Agricultural growth is nowhere propelled by an expansion in agricultural land. On the contrary, the modest decline in agricultural land has probably contributed negatively to agricultural production.

Chemical fertilizer use is expanding across the entire globe, but has started at a much lower level in developing countries. Fertilizer use has caught up in East Asia. South Asia is rapidly expanding the use of chemical fertilizers. Sub-Saharan Africa barely uses chemical fertilizer, and the Middle East, North Africa and South America are way behind Asia. However, the figures look starker than the reality because farmers in many developing countries use on-farm fertilization techniques, including the use of animal manure and crop residues as fertilizers. Nevertheless, the lack of use of chemical fertilizers is an important proximate cause of lower crop yields in much of the developing world outside of Asia.

Table 10.5: Fertilizer use (kg per hectare of arable land)

Region	2002	2015	2018
East Asia and Pacific	253.2	326.5	293.5
Latin America and the Caribbean	101.4	139.6	171.2
South Asia	102.5	164.4	170.1
The Middle East and North Africa	93.4	74.0	76.5
Sub-Saharan Africa	13.8	15.5	20.0
World Average	108.2	135.8	136.8

Source: World Bank 2021b

The use of farm machinery follows a slightly different pattern than that of fertilizers. The proxy used to measure the use of farm machinery is tractors per 1,000 farm workers. The use of tractors in Sub-Saharan Africa is miniscule and not growing significantly. It remains low in East Asia and South Asia, but is growing rapidly. It is higher in the Middle East and North Africa, and growing. It is higher still in South America and growing (FAOSTAT 2022).

Water is critically important for agriculture. Where rainfall is deficient in quantity, or comes at the wrong time, supplementing it with irrigation is important. The percentage of cropland under irrigation is the typical measure of its degree of development. This is not a very good indicator because the need for irrigation varies considerably. Where rainfall is adequate and spaced adequately, irrigation is not needed at all. In very dry areas, agriculture is impossible without it. The data suggests, however, that Africa is most poorly served by irrigation. The per centage of Sub-Saharan African cropland under irrigation is tiny, and not growing. In Latin America, it is small and growing very slowly, but outside of a few areas, less necessary. Asia has more than 14 per cent of cropland under irrigation, while Africa has less than 2 per cent. The significant use of irrigation in Asia has contributed to good agricultural performance in terms of growth and crop yields.

Table 10.6: Share of area equipped for irrigation in land area (per cent)

Region	2000	2015	2018
World	5.9	7	7.1
Africa	1.2	1.4	1.4
Americas	4.1	4.7	4.7
Asia	11.8	14.2	14.3
Europe	5.5	5.6	5.7
Oceania	0.6	0.9	0.9

Source: FAO 2020

The use of modern varieties of crops is important in agricultural growth, as these varieties confer great advantage in terms of yield, resistance to pests and diseases, and adaptation to climatic conditions. There has been a remarkable spread of modern varieties of cereals in East and South Asia. The use of modern varieties of cereals in Sub-Saharan Africa, though starting late, is beginning to catch up albeit with a long way to go. Sub-Saharan Africa in the 2010–2014 period reached the level of use of modern varieties in Latin America in the year 2000. The Middle East and North Africa had 69 per cent of their area sown to wheat using modern varieties by the year 2000, which has resulted in expanded crop yields (FAO 2019).

This brings us to labour, which is of special interest to this report. Available data suggests that agriculture is shedding labour throughout the world, except for Sub-Saharan Africa, North Africa, and West Asia (which includes the Middle East). Available data shows the growth of cropland per worker; namely, each worker is increasingly operating on more land (US Department of Agriculture Economic Research Service 2018).[2] This is because, globally, labour use is declining, while land under cultivation is changing very little. Expanding labour use is, therefore, not a factor behind agricultural growth anywhere. Most remarkable is the movement of

2. Measures the number of adults economically active in agriculture.

labour out of agriculture in China. The rapid growth of agricultural production in China, and indeed throughout Asia, has occurred despite a reduction in the use of labour, largely due to the introduction of improved crop varieties, mechanization, irrigation and the use of chemical fertilizers, as well as productivity improvements not represented by these inputs, but reflected in the total factor productivity figures presented in Table 10.7. The much slower introduction of modern agricultural improvements in Africa and the Middle East has resulted in lower productivity gains and continued dependency on the use of labour.

This takes us to the remaining source of growth, namely total factor productivity, which represents the portion of growth in output over and above that obtained by expanding inputs of the types described above. Productivity is measured as value added, divided by indexes measuring the various inputs. This data show that total factor productivity growth is remarkably high throughout Asia. Contrary to the data on inputs, growth of agricultural total factor productivity is also relatively high in West Asia and North Africa. Latin America is doing less well, and Sub-Saharan Africa is far behind in total factor productivity growth.

Table 10.7: Growth in total factor productivity (annual per cent growth, 2001–15)

China	2.8
South Asia	2.7
Southeast Asia	2.5
West Asia/North Africa	2.3
Sub-Saharan Africa except Nigeria	0.6
World	2.5

Source: FAOSTAT 2018 (Database)

Since 2015, data shows total factor productivity declining in Sub-Saharan Africa and Oceania, and increasing only very slowly in North America. Asia continues to be the champion, with Europe and Latin America improving (USDA 2021).

The most important input into total factor productivity is research and development. It is the intangibles, such as the use of digital technologies, improved farmer skills, better intellectual property rights, removal of government policy barriers to agricultural innovation, introduction of risk management tools, improved land tenure systems, better rural infrastructure, and freer international trade, that matter here. Behind these factors lie government policy and investment. Pro-agriculture policy measures include, among other things, greater investments in agricultural research, agricultural schools, farmer education, land tenure security, farm risk management tools, rural infrastructure, and rural finance. The return on agricultural R&D was estimated in 2008 by the World Bank at an astounding 43 per cent (World Bank 2008). Good policy will not only affect total factor productivity but will also affect the quantity of agricultural inputs and machinery, fertilizer use, labour use, and land use. It is to these policies that we now turn; the more fundamental causes of agricultural growth versus stagnation.

Agriculture Policy and Investment of OECD countries

Beyond the proximate causes for differences in agricultural performance described above are a set of less obvious causes. Among these are agricultural policy and investment of OECD

countries, including foreign aid to developing countries. Early foreign assistance programmes aiding developing country agriculture were modelled on the internal agricultural policies and programmes of OECD countries. After all, OECD countries, for the most part, had highly productive agricultural sectors and had developed sophisticated agricultural production and trading systems. Movement of agricultural products to agro-industry, and to market, worked well in all OECD countries.

Government policy in OECD countries was highly supportive of agriculture, involving substantial aid to farmers. This support was direct in the form of payments to farmers, and indirect through border protection against competing imports and financial support for public goods related to agriculture. The myriad of schemes introduced over time, and the shifting emphasis is too voluminous to describe here. In a nutshell, direct payments to farmers included price support schemes for various crops, public sector-supported crop insurance and mandates (such as the ethanol mandate in the US requiring gas at the pump to contain a mandated percentage of ethanol, sourced from maize). Indirect subsidies included the implicit subsidy accruing to farmers as a result of tariff and non-tariff barriers to farm products from other countries, and subsidized credit to farms and to agro-industry. In addition, there are a myriad of government expenditures on public goods, such as irrigation infrastructure, rural roads, agricultural research, agricultural schools and universities, food safety measures, veterinary services, forest services, and fish and wildlife services. All OECD countries provide these public goods, though to varying levels. The total value of OECD agricultural subsidies to their own country farmers was at about US$210 billion in 2015, according to the OECD.[3]

Most of the literature on the impact of the above policies and programmes suggests that the public goods expenditures in OECD countries have been remarkably effective in stimulating improvements in the use of farm inputs and generating farm-level productivity gains. R&D is a public good, and good public institutions, such as the agricultural universities in OECD countries, have been successful at educating farmers and others working in the sector. Agricultural extension, irrigation investment, and rural road and rural energy investment are highly effective in the OECD. These public goods are increasingly being provided as part of public–private partnerships in which the private sector is mobilized to provide a service, with public funding.

More controversial has been the direct and indirect payments to farmers, which in Europe and North America, go primarily to large industrial farms. The payments are often captured by the most politically astute farmers groups (such as sugar, cotton, dairy and cereals producers in the US), and bypass the less politically connected (such as vegetable growers and producers of organic produce). Because these direct subsidies are usually captured by large farms, they may inadvertently result in a decline in the number of small family farms throughout the OECD, and the consolidation of farmland into large industrial farms. These payments and protection from imported agricultural products also discriminate against agricultural imports from developing countries, which, in many cases, have a basic competitive advantage in comparison to OECD country production (due to cheaper labour), but can't compete due to the subsidies and the protection.

The above issues have been increasingly recognized in the academic, aid and government communities. Progress has been made in the OECD in reducing the direct and indirect

3. FAOSTAT monitors this data, which is prepared by the OECD (OECD/FAO 2020).

subsidies to farms (World Bank 2020a). Unfortunately, there has also been some reduction in government expenditures for the public goods of agricultural R&D, and agricultural education. It is likely that for most OECD countries, agriculture itself would be better off if direct subsidies to farmers and protection from agricultural imports were reduced, and public expenditure increased for agricultural R&D, agricultural extension, food safety, support to veterinary services, fisheries and forest services, and investment in rural infrastructure.

OECD countries have provided considerable aid to developing country agriculture, in part compensating, though unintentionally, for the negative impact of their domestic protectionism. Official Development Assistance (ODA) fluctuated over time. It was flat in current dollars, and declined in real dollars, during the period 1995–2006, despite warnings from the FAO, IFPRI, and International Fund for Agricultural Development (IFAD) that declining aid was adversely impacting developing countries (IFAD 2016). One example is the Asian Development Bank that began decreasing its aid to agriculture much earlier than other development partners, from nearly US$2.7 billion in the 1982–86 period to about US$1.8 billion in the 1987–91 period. This decline continued in the 1997–2001 period, picking up slightly in the 2002–06 period. Total ODA to agriculture, according to the FAO aid monitor, amounted to US$2.5 billion in the year 2000, growing to about US$11 billion in 2017.

In addition to ODA, multilateral development banks have provided loans at near commercial rates to agriculture. There was a decline in lending in the 2000s, though with ups and downs. The decline was driven by poor performance of projects in the sector and changing donor priorities in terms of sectors and instruments (for example, moving towards policy-based loans) (ADB 2019).

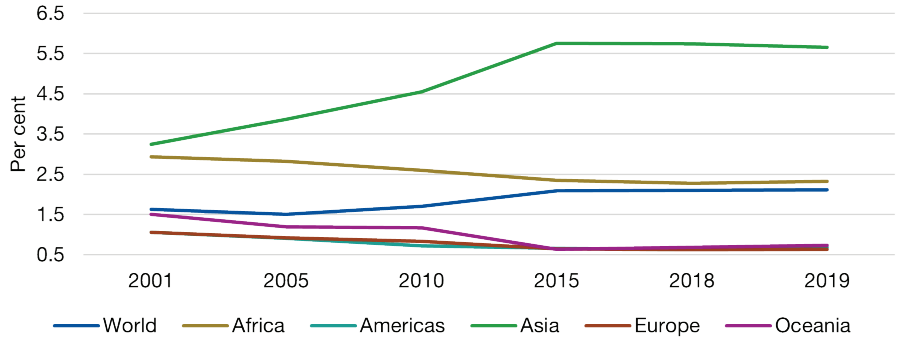
Agriculture Policy and Investment of Developing Countries

The developing world is diverse; there is no one pattern of agricultural policy and investment characterizing all developing countries. However, up until about 2005/2007, contributing factors to many developing countries' poor agricultural performance were found by academic and aid agency researchers to lie largely in macroeconomic and agricultural policies inimical to agriculture growth. Such ineffective policies often included the following (ADB 2007 and World Bank 2008):

1. Many developing countries had a weak enabling policy environment for private investment in agriculture, input supply, agricultural marketing and processing that resulted in limited private investment in the sector. Financial market distortions resulted in limited availability of rural credit.
2. Agricultural policies and a regulatory and institutional framework often permitted or caused harm to the natural environment (pollution of water, land degradation, over-fishing and excessive forest and wildlife loss).
3. There was, in many developing countries, an effective taxation of agriculture through price controls dampening farmgate prices. The purpose was usually to subsidize consumers or to support parastatal marketing and processing enterprises. Controls on the movement of agriculture products, often in the attempt to direct supplies to urban centres, also often served to reduce farmers' income. Border controls preventing or curtailing agricultural imports from neighbouring countries, reduced export possibilities within regions.

4. Low prioritization of agriculture was typical in nearly all developing country government budgets. This demonstrated a lack of interest in agriculture by many developing countries, and was reflected in low public investment in agricultural research, extension, education, infrastructure, livestock and forestry services. Figure 10.1 below shows the declining share of public expenditure going to agriculture in most of Asia up to 2012 (ADB 2019). Africa shows a worse pattern, with the share of public investment going to agriculture hovering in the 2 per cent range (ADB 2019).

Figure 10.1: Agriculture share in government expenditureby region, 2001–19



Source: FAO 2021

The Connection between Nutrition, Health and Agriculture

Agriculture and Nutrition

Discussions of agriculture now go hand-in-hand with discussions of nutrition, and the health consequences of food choice. This is because not all foods provide the same nutrition results. Too much processed food, for example, may satisfy calorie requirements (the traditional way of assessing hunger), but may lead to significantly worse nutritional and health outcomes than, say, the consumption of fresh foods or a mixture of cereals, vegetables, fish and livestock products. Individuals eating too much food, especially of processed food and sugar, become overweight and possibly obese. More food for the individual is, therefore, not necessarily better. In fact, much of the world has seen a shift from a problem of lack of calories (lack of sufficient quantity of food), to excessive consumption of high calorie/low nutritional value food, and a resulting increase in rates of obesity, and the health problems associated with it. Much of the problem lies in phenomena outside of primary production, such as processing technologies and demand (and advertisement), but some of the problem lies in the composition of production.

The numbe of undernourished people in the world declined, from 947 million in 2005, to its low point at 785 million in 2015. The number has increased since 2015, to 822 million at the end of 2018, according to the FAO (FAO et al. 2019). The increase in undernourishment since 2015 is attributed by the FAO to civil wars in some countries, economic slowdown in 2016 and beyond, poverty, and continued problems of access to water and sanitation, health services,

education and food. The COVID-19 pandemic has worsened the problem. Access to food is itself a function of local production, imports, poverty and levels of violence, including war. The regional distribution of undernourishment is shown in Table 10.8.

The prevalence of undernourishment increased everywhere in 2019, except Asia and Europe. Undernourishment is high in Sub-Saharan Africa and is not decreasing there, although

Table 10.8: Prevalence of undernourishment (per cent of population)

Region	2005	2010	2017	2018	2019
World	12.3	9.4	8.2	8.3	8.9
South Asia	20.6	15.9	13.4	13.5	14.5
East Asia & Pacific	9.6	5.6	4.4	4.3	4.3
The Middle East & North Africa	8.8	9.1	10.4	10.4	10.7
Europe & Central Asia	3.1	2.7	4.4	4.3	4.3
Sub-Saharan Africa	23.3	20.0	18.5	18.8	20.3
Latin America & Caribbean	9.4	7.2	6.9	7.1	7.7

Source: World Bank 2021b

there is considerable variation between African countries. The overall situation in Latin America is worsening slightly (again with huge variation between countries). Asia has seen the most dramatic declines in undernourishment, especially between 2005 and 2010 and at much slower decline thereafter.

According to the WFP, the current pandemic has exacerbated the undernourishment problem. *The Washington Post* reported on 15 May 2020, that 1.6 billion of the world's 2 billion informal workers had lost their jobs (citing the International Labor Organization). The resulting loss of income was propelling about 50 million additional people into poverty (World Bank data was cited). The United Nations (UN) estimated at the time that 580 million people could become impoverished. The WFP projected that 265 million people would be at risk of starvation. The most recent data from the World Bank (December 2021) stated that 2.37 billion people lacked adequate access to food in 2020 (World Bank 2021a).

Obesity

Obesity is increasingly emerging as a worldwide phenomenon, with no region being exempt. According to the FAO, obesity contributes 4 million deaths per annum (FAO et al. 2019). Around 207 million adolescents and 2 billion adults were overweight in 2016. Obesity is estimated by the FAO to cost US$2 billion per annum in loss of productivity and increases in healthcare. Causes for the dramatic rise in obesity cited by the FAO include the expansion of the quantity and reach of low-cost, high-processed and often sweetened foods, advertisement and lack of nutrition education, stimulating an increased demand for low nutritional quality foods. Much of the developing world has considerably lower rates of obesity than do North America and Europe, but rates of obesity are increasing everywhere (FAOSTAT 2022).

Food Waste

Ironically, with widespread nutritional and food security problems, up to 30 per cent of food is lost to waste, from the farm to the fork. In most developing countries, the problem of food waste is concentrated on the farm and in primary marketing. Farms and marketing agents typically have poor storage facilities (including an absence of cold storage), poor transport facilities, and poor retail marketing outlets. In more developed countries, which have fewer of the above problems, the main source of wastage is at the supermarket, restaurant, and consumer levels. A reduction of waste in developing countries would require significant investment in the deficient items listed above. In developed countries, the problem is at least conceptually more difficult to resolve, as it would require significant behavioural changes. This could be accelerated by education.

Agricultural Employment and Migration

In practically every country, labour is leaving the agricultural sector. At the same time, agriculture is a huge employer of labour throughout the world. The FAO published a document in 2018, entitled 'The State of Food and Agriculture in 2018: Migration, Agriculture and Rural Development', which provided data on this issue (FAO 2018). There are 608 million farms in the world, according to FAO, of which 90 per cent (550 million) are family farms, occupying 70–80 per cent of farmland, and producing 80 per cent of the world's food in value terms (Lowder et al. 2019, 13). The remainder of the farms are industrial farms owned by companies. However, not all family farms are small (FAO's definition of small farms includes farms less than two hectares). Small farms account for 84 per cent of all farms worldwide, operate on 12 per cent of agricultural land and produce 36 per cent of the world's food (Lowder et al. 2019, 13). This means that some family farms are big.

In geographical terms, 43 per cent of the world's farms are located in East Asia and the Pacific, 30 per cent in South Asia, 12 per cent in Sub-Saharan Africa, 6 per cent in low-income Europe and Central Asia, 4 per cent in Latin America and 2 per cent in high-income countries. The largest 1 per cent of farms operate on 70 per cent of the world's farmland (Lowder et al. 2019, 8–13). Hence, the political and economic clout of the large farms.

This brings us to farm labour. Family labour exceeds hired labour on most farms worldwide. The ratio of household members to hired permanent workers in agriculture averages five (Lowder et al. 2019, 67–70).[4] The data in the FAO study, which is the source of this information, suggests that worldwide there are on average 0.54 permanent workers per farm (not including family members). Large industrial farms will have many hired workers, while small family farms often have none. With 608 million farms of all types worldwide, this suggests that some 330 million people are permanent farm workers, not including household members. Agricultural household members are estimated at 2.3 billion people (Lowder et al. 2019, 67–70).[5]

Modern history in both industrial and developing countries is one of movement of rural peoples to towns and cities, and to more developed countries. The literature suggests that in many, if not most, cases, rural-urban migration has been beneficial to the migrants themselves

4. This is based on a review of agricultural census material from fifty-one countries, and then extrapolated to the world. The margin of error is huge. These numbers are approximations only.

5. Calculated from the data available from fifty-one country agricultural censuses and extrapolated to the world. These are very crude approximations.

(who improve their own standard of living and that of their families), beneficial to the towns and cities to which they move (by bringing needed labour) and to the rural areas from which they came (through remittances back to family members remaining in the rural areas, which improve the well-being of those left behind). The positive effects are most characteristic of demand-pull migration in which higher productivity and higher-wage jobs in cities attracts lower productivity and lower-income farm labour. This migration has helped reduce poverty, particularly in parts of Asia (China, Taiwan, South Korea and Vietnam) as well as in North America and Europe. The positive impacts on rural areas occur not only through remittances but also by enabling land consolidation and by stimulating farm modernization. Farm modernization occurs through greater investment in labour-saving technology and productivity improvements in the rural areas left behind by the migrants.

Rural-urban migration can, however, also have negative consequences, most frequently when the reasons involved are push factors, such as social breakdown in rural areas, forcing rural people to seek refuge in other countries or in the big cities (examples abound from Somalia, Sudan, Congo, Syria, parts of the Sahel, Afghanistan and parts of the Middle East and Central America). Push migration often overwhelms the receiving cities and countries, with migrants encountering joblessness and social ostracism. The rural areas from which they come may receive little in the way of remittances (this varies; in Central America, for example, the remittances are substantial), and conditions on the farms they have left behind are often too disrupted to benefit in terms of land consolidation and investment. In these cases, the decline in the rural labour force is much faster than it would have been without such disruption. The answer lies outside of agricultural policy in these cases; it is rather one of conflict-resolution.

There are situations in between the above extremes, where demand pull from urban areas combined with poor agricultural policy and investment results in an excessive rate of rural-urban migration, which cities and foreign countries cannot absorb. Parts of Asia, Latin America and parts of Africa are in this situation.

The outcomes of these forces on labour use can be seen in the rate of change in the ratio of land to labour in agriculture. This ratio is growing very fast in China as labour departs agriculture and agriculture modernizes. Chinese agricultural growth has not been compromised, and its agricultural sector has supplied much-needed labour to urban areas. The ratio of land to labour is also increasing in Southeast Asia, though at a lesser rate than in China. Urban areas are absorbing this labour, and agriculture is growing quickly. The same phenomena, though much less rapid, is occurring in South Asia. However, in the Middle East and in Sub-Saharan Africa, the size of farms is shrinking, and the land-labour ratio is declining. Labour is migrating off the farms in Africa and the Middle East/North Africa. But the growth of rural populations and the lack of employment opportunities in most African and Middle Eastern cities means that there are an increasing number of agricultural labourers per hectare despite the migration. Because agricultural productivity growth is low in most African and Middle Eastern countries, this expansion in agricultural labour is occurring along with a decline in average farm incomes. Labour would migrate off these farms even faster if there were adequate employment opportunities in the cities, or easier access to foreign countries.

The literature suggests that the dream of developing countries' agricultural sectors absorbing the large rural populations is unlikely anywhere near to being accomplished. A thriving agro-industry can help, but even where agriculture is thriving, for example, in North America,

parts of Europe, Australia and New Zealand, there continues to be rural-urban migration. Rapidly growing agricultural sectors in China and South Asia are shedding labour the fastest. Slow-growing agricultural sectors in Africa and the Middle East are absorbing labour, but into low productivity farms and only because the opportunities elsewhere are so limited.

The objective of absorbing more labour in agriculture can be at least partly achieved in countries characterized by push factors (pushing labour out of agriculture and out of rural areas) due to civil war, civil strife, extreme rural poverty, drought, etc., by attacking the cause of the push (end to civil strife, drought mitigation, etc.). On the opposite extreme are countries such as China and those in Southeast Asia, where there is no need to take explicit measures, as the movement out of agriculture is positive—for the people who move, the industries to which they move, and for the farmers left in rural areas who receive remittances, have bigger farms and are modernizing more rapidly than would otherwise be the case.

In the intermediate cases, where rural-urban migration is too fast for cities to absorb, more aggressive rural development measures are appropriate. In these situations, improved agricultural and rural policy and investment to make rural areas more attractive is the answer. These policies include territorial investment, rural infrastructure, rural health and education, improved agricultural R&D and often improved land tenure regimes. Greater focus on rural development, including greater public investment, should generate rural jobs (particularly in agro-industry and service industries, including public services), in turn slowing migration. Such investments are, of course, desirable everywhere, even in advanced industrial country agriculture because the continued growth in agriculture and agro-industry helps stimulate overall economic growth. But in the countries which are shedding agricultural labour too quickly for cities to absorb, these proactive rural and agricultural development policies and investments take on added importance.

On the margins, there are policies that can slow the rate of out migration from the farm, if desired. For example, in the United States, the bulk of agricultural subsidies go to large grain farms, sugar estates and cotton farmers. Organic farming and vegetable growing receives much less. But organic farming and vegetable production uses more labour per hectare than the highly mechanized grain, cotton and sugar producers. Switching the subsidies to the former would tend to be labour-using, though likely to have only a small effect on agricultural employment.

Climate Change and Agriculture

The Intergovernmental Panel on climate change's (IPCC) Sixth Assessment report, 'Climate Change 2021' (2021) says that 'Global surface temperature in the 2001–20 period was .99 degree centigrade higher than the average temperature during 1850–1900.' The report finds that this, along with other human influences, has already resulted in melting of the Greenland ice sheet, a shift in mid-latitude storm tracks poleward, a global sea level increase by 0.2 metres between 1901 and 2018, hot extremes more frequent and more intense, a greater frequency of more intense precipitation and storm events, and more severe drought. Climate change is already here.[6] IPCC's Sixth Assessment Report has modelled various scenarios, with

6. IPCC AR5; 'Climate Change 2014: Impacts, Adaptation and Vulnerability', Part A; 'Global and Sectoral Aspects', IFPR; 'Climate Change, Impact on Agriculture and Costs of Adaptation'; Food Policy Report 2009, Washington DC, October 2009. Union of Concerned Scientists; 'Climate Change and Agriculture', 20 March 2018. FAO, 'The State of Food and Agriculture; climate change', Agriculture and Food Security, Rome, 2016.

an intermediate scenario suggesting a 2.1 to 3.5°C average temperature increase by the year 2100. This would bring even more extreme changes of the type listed above.

Although the most recent IPCC report on the impact of climate change on agriculture is not yet out (expected in February–March of 2022), there is now a significant literature on this subject.[7] The literature overwhelmingly finds that the impacts of agriculture on climate change, and the impact of climate change on agriculture, are significant, and will continue to grow as climate change evolves.

Generally, agriculture in the tropics is found to have already suffered from climate change and is projected to suffer more. The 2007 synthesis report of the IPCC stated: 'By 2020 in some African countries, yields from rain-fed agriculture could be reduced by up to 50 per cent. This would further adversely affect food security and exacerbate malnutrition' (IPCC 2007). The literature since then shows vast ranges of possible effects of climate change on agriculture (Muller et al. 2011; Aydinalp and Cresser 2008). Most show severe negative effects, but some show positive effects for some countries. A 2011 US National Academy of Sciences study on climate risks for Africa projected a range of from 100 per cent to 168 per cent decline in agriculture production from climate change in the long run, based on econometric studies (Muller 2011). A recent study found that 'flood shocks, defined as annual rainfall higher than one standard deviation from the 50-year average, is associated with a 35 per cent decrease in food per capita consumption and a 17 per cent point increase in extreme poverty in Sub-Saharan Africa' (Azzarni and Signorelli 2020). On the other hand, in northern climates, such as those found in Russia, Canada and Scandinavia, rising temperatures combined with CO_2 fertilization can increase crop yields and permit cultivation in areas previously uncultivated.

The difference in impact is due to the variation in the nature of climate change. Where rainfall declines or becomes more variable (more deluge followed by longer periods of drought), and where temperatures are already high but get warmer, agriculture of all kinds suffers. Changes in temperature and rainfall also bring new pests and diseases, cause rising sea levels and hence sea water intrusion in coastal agricultural areas. These changes also cause stress on forests and on fisheries.[8]

Rainfall has been declining, and temperature has been increasing in Sub-Saharan Africa since the 1950s, hence the dire IPCC prediction. As predicted by the IPCC, rainfall has shown a long-term decline, and temperatures a long-term increase in Sub-Saharan Africa.

In 2016, the FAO predicted net crop yield decreases in the tropics by 16 per cent for wheat and 6 per cent for maize due to a two-degree temperature increase (FAO 2016). This was before taking into account changes in rainfall, impact of new pests and diseases, etc., and not accounting for the impact on livestock. A recent World Bank study found that 'for every degree centigrade increase in temperature, average global cereal yields are expected to decline 3 per cent to 10 per cent' (Fugli 2020). An IPCC study in 2014 projected negative impacts on agricultural yields double the positive effects in the period 2020–49. For the period 2016–29, IPCC 2014 projected that the negative and positive effects globally would be equal and offsetting (IPCC 2014).

7. Ibid.

8. For further information see the Union of Concerned Scientists, 'Climate Change and Agriculture', The World Bank: Climate Smart Agriculture (2020), 20 March 2019; and IFPRI, 'Climate Change: Impact on Agriculture and Costs of Adaptation', Food Policy Report 2009, Washington DC, October 2009.

It is now 2022, and we can see to what extent the initial projections have materialized. The answer is that globally, they have not. Global agriculture has continued to grow, as has agriculture in most of the developing world, including the tropics; in fact, 2019 was a record year for global agriculture production. How has this happened, since the agricultural science is clear that the physical impact of less rainfall, higher temperature, new pests and saltwater intrusion must be negative? The answer is that agricultural adaptation to climate change has worked so far, and on aggregate. The IPCC, the World Bank, and the FAO all explained that the negative impacts could be mitigated, and in those circumstances where the impacts were positive, they can be further promoted, through adaptation of agriculture to the new circumstances.

Adaptation includes actions, such as modifying planting times, changing crops (in the tropics to more drought- and temperature-tolerant crops), new cultivars which are drought- or temperature- or salt-tolerant, improving soil and water management, expanding irrigation, introduction of a myriad of conservation agriculture techniques, and on-farm crop and livestock diversification.[9] This widespread adaptation in developing countries has been assisted by agricultural research and foreign assistance, including new agricultural climate adaptation funds. It is almost certain that agriculture would have grown even more in the absence of climate change. But it appears that so far, with the climate impacts already occurring, farmers in most countries are adapting. This does not mean that all farmers are adapting; many have not been able to adapt, and many of them have dropped out of farming. Given the pressure on the land, it is also likely that in many of these cases, other farmers have taken over this land. The global picture also hides considerable variation by country. Many countries in the Sahel region of Africa, for example, will face difficulties in adapting enough to offset the negative effects of climate change (IPCC 2018).

The next question is: what is the likelihood that agriculture will continue to successfully adapt globally, as temperatures continue to rise, rainfall patterns continue to change and additional pests and diseases continue to appear? Is there a limit to farmers' ability to adapt? In answer, it is likely that many places in the tropics will reach a limit, as parts of the Sahel region in Africa appear to have already reached. Rainfall may become too constrained and erratic, irrigation possibilities exhausted, new pests and diseases so devastating that agriculture and/or raising livestock becomes so difficult that farming collapses.

Indeed, the IPCC report on climate change 2014 undertook a substantial review of the literature on climate change and agriculture, resulting in dire warnings for the future. It predicted particularly severe and negative climate impact on wheat and maize, globally. It stated that 'for major crops in tropical and temperate regions, climate change without adaptation is projected to negatively impact production' (IPCC 2014, 17). This underlines the need to greatly expand on the efforts at adaptation, and that agriculture become a major promoter of climate change mitigation.

Adaptation will continue to require its inclusion in agriculture education, and then agricultural research and extension. Predicting changes in agricultural situations likely to occur due to climate change will be critically important. Developing new tools to help farmers to adapt must be a continuous process (different planting and harvesting dates, tools to combat new pests

9. Adaptation measures include, most importantly, better management of rice paddies, which are major CO_2 emitters, zero or minimum tillage, mulching, direct seeding, better water management, reduction in mineral fertilizer use, more poultry and pigs and less cattle and buffalo, better treatment of animal waste, solar drying of crops and reforestation.

and diseases, improved irrigation and improved livestock handling are examples). Individual farmers and farmer associations generally do not have the tools to undertake this type of research and development. Their job will be to master, and apply, these new tools as climates change. Governments and international aid organizations will have the more important role to play in this type of policy and investment. Countries able to do this well may thrive under current projections of climate change, while those not adapting at all will face important agricultural and hence rural challenges.

Agriculture continues to contribute over 20 per cent of CO_2 emissions (including the impact of livestock and deforestation) (FAO 2016). Conservation agriculture (such as no-till farming) can reduce this. Reduction in deforestation and conversion of cropland to tree crops can lessen this impact, but probably not by much. More radical measures, such as reducing livestock production, massive forest planting and use of algae as food, could do more and are possibilities. Many of these measures are also good from the standpoint of nutrition. But it is unlikely that in the absence of these radical measures, requiring enormous changes in dietary patterns, that agriculture and livestock production will contribute significantly less to climate change.

As indicated above, OECD countries, China, Brazil, India, among others, support their farming sectors, with subsidies totalling several hundred billion dollars per annum. Switching some of these subsidies, particularly those consisting of direct subsidies to farmers, to investment in climate change adaptation and mitigation, could supply the additional funds needed for these latter purposes. The constraints to this obvious solution are many. Current recipients of subsidies tend to be politically powerful farm lobbies, which will resist. Some farming and agro-industrial activities (ethanol production in the US, for example) are totally dependent on subsidies, and will likely collapse in their absence (OECD 2020c). A phase-in of subsidies for adaptation and mitigation measures, and a phase-out of direct and indirect payments to farmers will be needed. This should start now.

Prognosis for the Future of Global Agriculture

Projections by the OECD and the FAO (prior to the pandemic) indicate a future in which rising production matches rising demand, resulting in a 'low real price environment' continuing for the next ten years (OECD/FAO 2019). The OECD/FAO analysis suggests that per capita food demand and global biofuel demand are levelling off, meaning that increased demand is coming largely from areas where populations are growing (Sub-Saharan Africa, India, the Middle East and North Africa). Demand for animal products is continuing to increase rapidly, as is the demand for animal feed (maize and soybeans particularly). Fish production from aquaculture is growing rapidly while that from capture fisheries is declining. Relative world prices of these commodities will adjust accordingly, with prices for meat, dairy, fruits and vegetables increasing relative to those of cereals.

The global prospects hide regional differences. Production constraints in Sub-Saharan Africa and the Middle East and North Africa, combined with higher population growth, mean that these regions are likely to be increasingly dependent on food imports and food aid, as well as subject to higher relative food prices. This is already reflected in high food import growth. Latin America, North America, Europe and Oceania were projected to have expanded agricultural trade balances (exports-imports).

The impact of the COVID-19 pandemic has so far been negative on agricultural supply chains, on agricultural production, and on food aid. The FAO/OECD projections were thus too optimistic, largely because they predate the pandemic. Agricultural prices have increased almost everywhere in early 2020–21. The very latest summary of the impact of COVID-19 on agricultural prices globally (29 October 2021) stated that domestic food price inflation remains highest in Africa, followed by Latin America and the Caribbean and South Asia. In most regions, including Africa, food price inflation has picked up in recent months. Rising energy, fertilizer and transport costs pose further risks to global food markets.

However, moving to a more disaggregated level, there is, and will continue to be, great variation in country performance. Within Africa, we already see dramatic differences in performance between countries, with some now achieving very good agricultural growth and growth of agro-industry (Rwanda, Ghana are the champions), while others are going backwards (Congo, Sudan, Egypt, Zimbabwe, Ethiopia and parts of the Sahel). Within Asia, there is a similar pattern of very mixed performance, with China, Taiwan, South Korea and Vietnam continuing to outpace the rest of Asia, while Central Asia is stagnating. This can change with policy and investment of the types recommended below. This requires, in many cases, political and institutional changes. The ability to deal with the rural-urban migration equation and climate change will become increasingly important as migration continues, and climate change becomes even more daunting. The impact of future climate change on agriculture is very dependent on the world's ability to change policy and investment in response. Agriculture could be disastrously affected or, on aggregate at least, adapt depending on the global policy and investment response.

New Directions Needed in Agricultural Policy and Investment

Desirable and undesirable policies and approaches to agriculture development have been described above. New approaches which need to be added to the mix include the following.

Agriculture, and the enterprises which provide its inputs and market, and process its outputs, are increasingly viewed as a private sector, not a public sector. Even in developing countries with strong public sectors, such as China and Vietnam, the essential private sector nature of agricultural production, processing, and marketing is recognized in policy and investment. Major development partners are expanding their assistance to private agri-business, often through equity investment and non-sovereign lending,[10] while development institutions such as International Fund for Agricultural Development (IFAD), which do not have a non-sovereign lending instrument, are channelling more of their funds through projects involving public-private-producer partnerships. The World Bank and International Finance Corporation (IFC) have been undertaking joint projects in the sector through their plan to maximize financing for development in agricultural value chains by crowding-in private investment and optimizing the use of scarce public resources (World Bank 2020a).

Project investments and policy advice are increasingly viewed within the framework of the 'value chain'. The idea is to view agricultural products as commodities and to develop related investments and policy advice, beginning with the inputs required, and including farming,

10. Such as by ADB, African Development Bank, European Bank for Reconstruction and Development, European Commission, UK's Department for International Development (DFID), the Agence Française, United States Agency for International Development and the World Bank.

marketing, processing and consumption. Value chain support for basic staples, such as maize, rice and wheat, would, therefore, consider inputs such as seed supply, fertilizer needs, land use, water and farm equipment. It would then focus on farming techniques appropriate to the location, storage and marketing of the product, processing into different products, and finally retail and consumption. Included in this analysis would be environmental issues, nutritional concerns, gender aspects and finance. This new approach has led to the realization that the value chains of different commodities (for example, tea or coffee) have different requirements. Further, the value chains for the same commodity will differ across countries. In most value chains, the requirements of private farmers and agri-business (or cooperatives in some cases) are likely to dominate. However, government policy changes and public investment in infrastructure, education, and agricultural research and extension are almost always present. Access to finance is also important. The involvement of both private and public investment often requires private-public linkages and partnerships in value chain development.

In many parts of the developing world, ecological damage is evident in the form of growing biodiversity loss, water scarcity, water and air pollution, ocean acidification, fisheries depletion and wetland degradation. In 2008, Asia and the Pacific recorded the world's highest number of threatened species, with Southeast Asia experiencing the most serious cases (UNDP 2010). In South Asia, water security is already low and these areas may be disproportionately affected by more frequent and intense droughts and other stresses on water management (ADB 2013). In the Asia region, many rivers and lakes are dead or dying, groundwater aquifers are over-pumped and some species of aquatic life have been driven to extinction. Agriculture has contributed to this situation through soil degradation and fertilizer and pesticide run-off. There is a decline in forest cover as a per cent of land area for many Asian countries. The conversion of forest land and protected areas to agricultural purpose is happening in Indonesia, Myanmar, Nepal, and Sri Lanka. Bhutan, China, India, Lao PDR, Vietnam and the Philippines have expanded areas under forests. For China, India and Lao PDR, this is particularly remarkable, given the rapid growth in agriculture. This type of damage is less evident in Africa, though forest destruction is important.

It follows from the above that there is a need for much more environmentally sustainable and climate-friendly farming systems. The world's agriculture currently uses 11 per cent of the world's land, accounts for 70 per cent of its freshwater withdrawals, causes 80 per cent of deforestation, 30 per cent of energy consumption, and emits 10 gigatons of CO_2 per annum. There is growing recognition of the need to use limited water and land resources more efficiently and to reverse the environmental degradation. In addition, climate change and climate variability poses large, but regionally differing, threats to agriculture and food security in Asia and Africa through higher temperatures, more extreme weather events, drier conditions in large parts of the region, sea-level rise and flooding, which can impact on crop patterns and yields, and cause crop damage (ADB 2017). This will compound already observed pressures, such as decreasing soil productivity, groundwater depletion and declining water availability, as well as increased pest incidence and salinity. As indicated above, switching of agricultural subsidies from direct and indirect payments to farmers, to the support of measures to help farmers adapt to climate change, mitigate climate change and protect the rural environment will be necessary.

Food safety is a growing issue throughout the developing world. China, for example, while doing very well in terms of agricultural production, has relatively low sanitary and phytosanitary standards for its agricultural goods, but has incorporated food safety as a priority in its most

recent five-year plan. Excessive pesticide residues, low food hygiene, unsafe additives, contamination with heavy metals and other contaminants and misuse of veterinary drugs have all led to trade restrictions with Japan, the United States and the European Union. Similar issues have been widely publicized in Thailand and Vietnam. Other Asian countries and all African countries face similar problems, though the degree of severity is less well-studied (IFPRI 2017).

A related issue is food waste, which is substantial. Waste occurs along the entire supply chain, from the farm, to marketing and processing, to the household. Solutions include more investment in storage and transport at all levels of the supply chain, and consumer education.

As described above, nearly all African countries need productivity-inspired agricultural growth, which expands output per unit of investment, land and water. This is because these three ingredients are in short supply everywhere in Africa. The only ingredient not in short supply is labour. As a result, labour-using productivity improvements will be particularly beneficial. Private investment in agro-processing, marketing and input supply will be beneficial both to stimulate productivity improvements and to expand agro-industry. Governments will have a major role, not in investing in farming and agro-industry directly but by moving to a policy environment, which encourages private investment in these activities (that is, macroeconomic policy, regulation and institutional development). Expanded public and private investment in rural infrastructure, rural education, rural health, rural energy and rural telecommunications will also be important for a healthy agriculture and agro-industry, as well as helping in the adaptation to climate change and in slowing rural-urban migration (which is too rapid in Africa).

Much of Asia requires the same agricultural productivity focus as Africa does, given land and water constraints. Investment constraints in large parts of Asia (especially China) are much less severe, so the rural investments required should be easier to finance; a great part of these investments could come from domestic resources, as these countries are considerably less aid-dependent than Africa. Likewise, the need to retain labour in Asian agriculture is much less important than in Sub-Saharan Africa and the Middle East, as industry has been able to better absorb rural migrants. Government-sponsored or induced R&D to adapt agriculture to climate change and to discover and adapt productivity-enhancing technology will continue to be important. Introduction of better food safety and quality standards and more environmentally benign agricultural technology (due to high levels of water and soil pollution, and negative impacts on human health) are particularly important for the more advanced agricultural sectors in China, Taiwan, South Korea and Vietnam.

Box 10.3: India's agriculture

Indian agriculture is a good example of both the successes of agricultural development and the issues facing developing country agriculture. India is the world's biggest producer of milk, pulses and jute, and the second largest producer of rice, wheat, sugarcane, groundnuts, vegetables, fruit, and cotton. Agriculture is the largest source of livelihood for 70 per cent of Indian households. 82 per cent of India's farmers are 'small and marginal'. India has achieved food self-sufficiency, but has 25 per cent of the world's hungry people, and 190 million Indians are undernourished (FAO 2022). Despite remarkable production gains, Indian agriculture faces significant hurdles, already constraining production, which may become even more daunting in the future. There is considerable stress on water resources, in part due to huge subsidies for energy use in irrigated agriculture, leading to overuse of groundwater, poor irrigation maintenance and management, and coastal intrusion of salt water. Desertification and land degradation are widespread. Government policy subsidizes the production of cereals and water-intensive crops (rice and sugarcane), while not subsidizing more nutrition-rich foods, such as vegetables and fruit. Subsidizing water-using crops also encourages groundwater mining. Underinvestment in on-farm storage and handling, and in-market infrastructure, has led to enormous food waste. The IPCC predicts a significantly negative impact of future climate change on Indian agriculture. The recommendations made above, all apply to India, particularly the need to de-regulate the sector, reform farm subsidies, invest in rural infrastructure, invest in climate change adaptation, protection of the rural environment, and dealing with food safety and waste. Given the political nature of these reforms, a careful phasing in of reform will be needed.

Box 10.4: Getting policies right: Lessons from the People's Republic of China

As arguably the best recent agricultural performer in the world, the case of the People's Republic of China (PRC) is informative. The PRC has been remarkably innovative in its agricultural policy, and its private sector has invested effectively in agriculture and agro-industry. The PRC invests a greater share of its public expenditure in agriculture than almost any other country in the world. In particular, it invests more in agricultural research and development than any other country, with growth in agricultural research and development at nearly 10 per cent on average in the 2000–09 period. Notable policy changes in the past decade have included the PRC's expansion of farmers' land rights by allowing land transfer through the rental market. The PRC has also invested heavily in rural areas in infrastructure, irrigation, rural education and health and improved environmental management. The Chinese government also provided agricultural tax exemptions, granted subsidies for agricultural production, and higher prices for government procurement of agricultural commodities. There has been some domestic and international trade liberalization, and expansion of social as well as environmental protection, and social security coverage in the PRC. There have been failures, however, particularly in environmental protection. Much of China's water and soil is significantly and dangerously polluted. China will need to deal with its severe rural environmental problems, water conservation, and distortions due to farmer subsidies. Switching subsidies to supporting farmer adaptation to climate change and mitigation of climate change will be important in China.