11 Other products

This chapter provides a market overview and a description of the current market situation for roots and tubers (i.e. cassava, potato, yams, sweet potato, taro), pulses (i.e. field peas, broad beans, chickpeas, lentils), and banana and major tropical fruits (i.e. mango, mangosteen and guava, pineapple, avocado, and papaya) markets. It then highlights the medium term (2021-30) projections for production, consumption and trade for these products and describes the main drivers of these projections.

11.1. Roots and tubers

11.1.1. Market overview

Roots and tubers are plants that yield starch derived from either their roots (e.g. cassava, sweet potato and yams) or stems (e.g. potatoes and taro). They are destined mainly for human consumption (as such or in processed form) and, like most other staple crops, can also be used for animal feed or industrial processing, notably in the manufacturing of starch, alcohol, and fermented beverages. Unless they are processed, they are highly perishable once harvested, which limits the opportunities for trade and storage.

Within the roots and tubers family, potato dominates in worldwide production, with cassava a distant second. With respect to global dietary importance, potato ranks fourth after maize, wheat and rice. This crop provides more calories, grows more quickly, uses less land, and can be cultivated in a broad range of climates. However, potato production, which forms the bulk of the root and tuber sectors in developed countries, has been declining over several decades, with growth in production falling well below that of population.

Output of cassava is growing at well over 3% p.a., almost three times the rate of population growth. Cultivated mainly in the tropical belt and in some of the world's poorest regions, cassava production has doubled in a little over two decades. Once considered a subsistence crop, it is now seen as a commodity and key for value-addition, rural development and poverty alleviation, food security, energy security; and for bringing important macroeconomic benefits. These factors are driving rapid commercialisation of this crop and large-scale investments in upscaling the processing of cassava, both which have contributed significantly to its global expansion.

11.1.2. Current market situation

The largest producing regions of roots and tubers in the base period are Asia (98 Mt) and Africa (92 Mt). In Sub Saharan Africa, roots play a significant role as a staple crop. Globally, about 125 Mt are used as food, 54 Mt as feed, and 61 Mt for other uses, mostly biofuel and starch. As the perishable nature of these crops prohibits significant international trade in fresh produce, countries tend to be self-sufficient. About 14 Mt are currently traded internationally, mostly in processed or dried form. Thailand and Viet Nam are the leading exporters and the People's Republic of China (hereafter "China") is the main destination.

Global production of roots and tubers reached 237 Mt (dry matter) in the base period (2018-20); about 5 Mt has been added annually in the past years and consumed mainly as food. The prices of roots and tubers (measured by the Cassava (flour) wholesale price in Bangkok) decreased in 2020 as yields in many major-producing regions were favourable. Global quantities traded increased by 0.5 Mt.

11.1.3. Main drivers for projections

Producing cassava requires few inputs and affords farmers greater flexibility in terms of timing the harvest as the crop can be left on the ground well after reaching maturation. Cassava's tolerance to erratic weather conditions, including drought, makes it an important part of climate change adaptation strategies. Compared to other staples, cassava competes favourably in terms of price and diversity of uses. In the form of High Quality Cassava Flour (HQCF), cassava is increasingly targeted by governments in Africa as a strategic food crop which does not exhibit the same levels of price volatility as other imported cereals. Mandatory blending with wheat flour helps reduce the volume of wheat imports, thereby lowering import bills and conserving precious foreign exchange. The drive towards energy security in Asia, combined with mandatory blending requirements with gasoline, has led to the establishment of ethanol distilleries that use cassava as a feedstock. With regard to trade, processed cassava manages to compete successfully in the global arena, e.g. with maize-based starch and cereals for animal feeding applications.

Potatoes are generally confined to food use and are a substantial component of diets in developed regions, particularly in Europe and North America. As overall food intake of potato in these regions is very high and may have reached saturation, the scope for consumption increases to outpace population growth remains limited. Developing regions, however, provide some growth momentum to potato production at the world level.

Global sweet potato cultivation has declined in recent years, mostly due to a sharp decline in acreage (which shows no sign of abating) in China, the world's foremost producer. Food demand largely defines the growth potential of sweet potato and other less prominent roots and tuber crops given the limited commercial viability for diversified usage. Consequently, consumer preferences along with prices play important roles in shaping consumption.

11.1.4. Projection highlights

World production and utilisation of roots and tubers is projected to increase by about 18% over the next decade. Production growth in low-income regions could reach 2.3% p.a. while supply in high-income countries should grow at only 0.3% annually. Global land use is projected to increase by 2 Mha to 65 Mha, but there will be some regional shifts. African countries are expected to increase their cultivation area, while reductions are projected for Europe and America. Production growth is mainly attributed to investments in yield improvements in Africa and Asia, as well as an intensification of land use in these regions.

By 2030, an additional 1 kg/capita per year of root crops will enter diets at the global level, driven mostly by consumers in Africa where per capita intake of roots and tubers could surpass 40 kg per year. Biofuel use, albeit from a low basis (3% of use), is expected to grow by more than one-third over the next ten years driven by the Chinese biofuel industry. Feed and other industrial use will remain significant, albeit with slower growth of about 12% and 18% respectively, over the outlook period.

Figure 11.1. Global players in roots and tubers markets in 2030
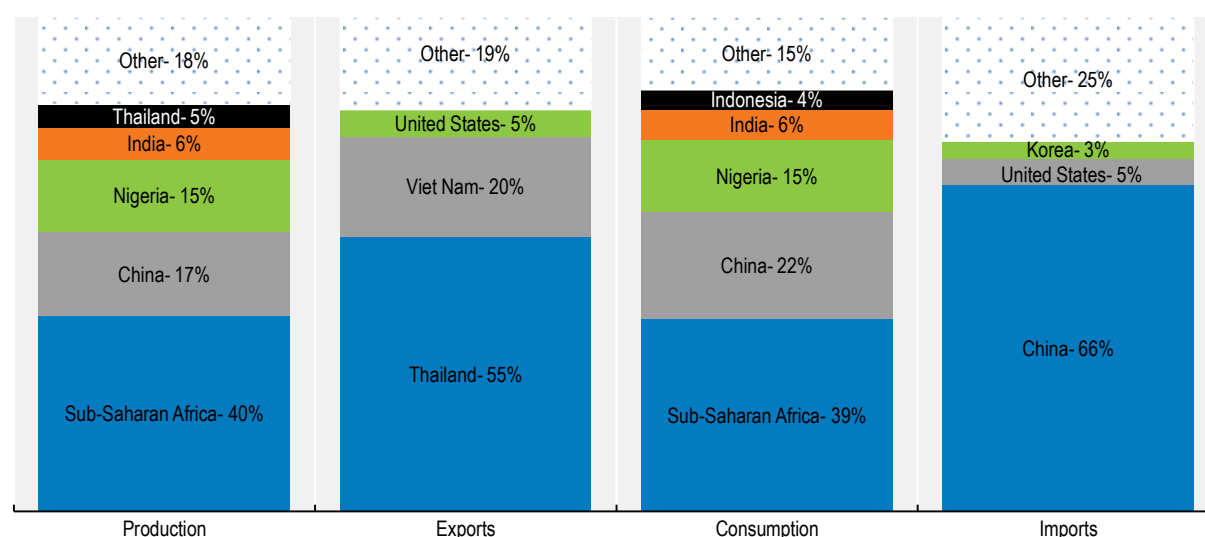
Note: Presented numbers refer to shares in world totals of the respective variable
Source: OECD/FAO (2021), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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International trade in roots and tubers comprises about 6% of the global market production. Over the medium term, this share is expected to remain constant. Exports from Thailand and Viet Nam are growing and are expected to reach a combined total of 13 Mt, mainly to supply the growing biofuel and starch industries in China.

Given the substitutability between roots and tubers and cereals on food and feed markets, prices of roots and tubers are projected to follow a similar path to cereal prices in the medium term; namely, an increase in nominal prices but a decline in real terms.

11.2. Pulses

11.2.1. Market overview

Pulses are the edible seeds of plants in the legume family. Commonly, eleven types are recognised.[1] They provide protein, dietary fibre, vitamins, minerals, phytochemicals, and complex carbohydrates. Apart from the nutritional benefits, pulses help to improve digestion, reduce blood glucose, minimise inflammation, lower blood cholesterol, and prevent chronic health issues such as diabetes, heart disease, and obesity. However, their consumption levels differ from region to region depending on the dietary patterns, availability and prevailing conditions.

Cultivation of pulses has a long tradition in almost all regions of the world. For centuries, legumes have played a fundamental role in the functioning of traditional agricultural systems. Prior to 2000, global production of pulses stagnated due to the widespread disappearance of small farms in developing countries which led to a decline of traditional farming systems that included pulses in their crop rotation. Production was further hampered because of their weak resilience to diseases due to a lack of genetic diversity, limited access to high-yield varieties, and the lack of policy support to pulses growers. The sector began to recover in the early 2000s and has since seen an annual increase of about 3% globally, led by Asia and Africa. These two regions combined accounted for about 63% of the 18 Mt production increase in the past decade.

Global per capita consumption of pulses started to decline in the 1960s (Figure 11.2) due to slow growth in yields and resulting increases in price. Income growth and urbanisation shifted preferences away from pulses as human diets became richer in animal proteins, sugar, and fats. Nonetheless, pulses have remained an important source of protein in developing countries, and average global per capita consumption has increased to about 8 kg/year to date. This growth has been driven mainly by income gains in countries were pulses are an important source of protein; this particularly true of India where vegetarians account for about 30% of the population.

Pulses can be processed into different forms such as whole pulses, split pulses, pulse flours, and pulse fractions like protein, starch and fibre. The flour and fractions have diverse applications in industries related to meat and snack food, bakery and beverages, and batter and breading.

11.2.2. Current market conditions

India is by far the largest producer of pulses, accounting for about 24% of global production in the past decade. Canada (8%) and the European Union (5%) are the next largest producing countries. The Asian market accounts for more than half of all consumption, but only about 45% of production, making it the most significant import destination. About 12% of global production is traded internationally with Canada (38% of global trade) by far the largest exporter and India the largest importer (29% of global trade). Africa has further expanded its production and consumption in the past decade, and has remained largely self-sufficient.

In 2020, the global pulses market reached a volume of 92 Mt, after an average annual growth of 3% p.a. during the previous decade; this growth was led by Asia and Africa. Growth between 2019 and 2020 was high in the European Union (+10%). World trade volumes were registered at 18 Mt, 0.5 Mt higher than in 2019. Due to an ample supply situation, international prices for pulses, approximated by the Canadian field pea price, have dropped to USD 186/Mt, its lowest value since 2009.

11.2.3. Main drivers for projections

As pulses are associated with various health benefits, health-conscious consumers are increasingly integrating these in their daily diets, which in turn is propelling the growth of the global pulses market. Rapid urbanisation, changing lifestyles, and hectic work schedules are also making healthy snack foods popular amongst the working population, and pulses are increasingly used in the processing of ready-to-eat (RTE) food products.

Health and environmental benefits are reasons why governments of pulses-producing countries are providing assistance to farmers, and thus supporting growth of this market. Support to the production of pulses production plays an important role in the Protein Strategy of the European Union, and are a major ingredient in products such as meat substitutes. Depending on the future dynamics of demand for such products, this could significantly change the future importance of pulses in the agricultural production mix.

11.2.4. Projection highlights

Pulses are expected to regain importance in the diets in many regions of the world. This *Outlook* foresees the global trend in this area to continue and projects global average annual per capita food use to increase to 9 kg by 2030. Per capita consumption is projected to level off in Latin America and Africa at around 12 kg/year, but is expected to increase in many other regions over the coming decade. (Figure 11.2)

Global supply is projected to increase by 22 Mt. Almost half of this increase is expected to come from Asia, particularly India, the world's largest producer. Sustained yield improvements are projected to raise India's domestic production by an additional 6.6 Mt by 2030. India has introduced high-yielding hybrid seeds, supported mechanisation, and implemented a minimum support price aimed at stabilising farmer's income. In addition, the central government and some state governments have included pulses in their procurement programmes, although not with the same geographical coverage as in the case of wheat and rice.

This expected production expansion is driven by the assumption of continued intensification of the pulses production systems due to improved yields and intensified land use. About 70% of production growth can be attributed to yield improvements during the projection period, and the remaining 30% to land use intensification, mainly in Asia, Africa and Europe. Particularly in Africa, a combination of area expansion and yield growth is estimated to add about 0.5 Mt annually to the regional production.

This *Outlook* assumes that growth will be sustained by increased intercropping of pulses with cereals, in particular in Asia and Africa where smallholder farmers represent a large share of producers. The projected yield improvements of pulses will continue to lag cereals and oilseeds because in most countries pulses are not included in the development of high-yielding varieties, improved irrigation systems, and agricultural support policies.

World trade of pulses grew from 13 Mt to 17 Mt over the past decade and is projected to reach 19 Mt by 2030. India's recent efforts to become self-sufficient in pulses are the major factor driving the anticipated slowdown in global pulses trade. After a continued increase in the near term, imports by India are expected to level off by 2030 when they are projected to reach 5 Mt.

Canada remains the main exporter of pulses, with volumes expected to grow from 6.7 Mt at present to 8 Mt by 2030, followed by Australia with 2.4 Mt of exports by 2030. However, given that Canada's major

trading partner is India, which is expected to slow its import growth, they will need to diversify their export markets.

International prices are expected to increase in nominal terms over the coming decade, while real prices will decline slightly.

Figure 11.2. Per capita food consumption of Pulses per continent
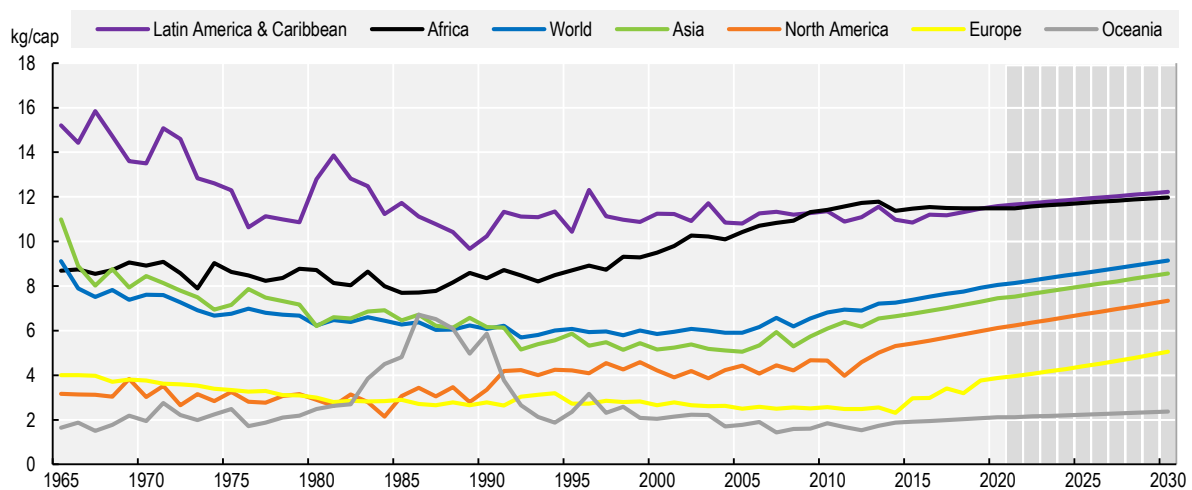
Source: OECD/FAO (2021), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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11.3. Bananas and major tropical fruits

11.3.1. Market overview

Bananas and the four major fresh tropical fruits – mango, pineapple, avocado, and papaya – play a vital role in world agricultural production, and especially in securing the nutrition and livelihoods of smallholders in producing countries. In recent decades, income growth and changing consumer preferences in both emerging and high-income markets, alongside improvements in transport and supply chain management, have facilitated fast growth in international trade in these commodities. Against this backdrop, export quantities of the four major fresh tropical fruits have experienced some of the fastest average annual growth among internationally traded food commodities, while export quantities of bananas have increased to unprecedented heights.

Based on 2019 figures, the global banana and major tropical fruit export industries respectively generate around USD 9.1 billion and USD 10 billion per year. Although only approximately 15% of global banana production and 5% of global major tropical fruit production are traded in international markets, in exporting countries, which are mostly low-income economies, revenue from production and trade can weigh substantially in agricultural GDP. For instance, banana represented about 42% of agricultural export revenue in Ecuador in 2018, and 17% in Guatemala. As such, trade in bananas and major tropical fruits has the potential to generate significant export earnings in producing countries. For all these underlying reasons, it is important to assess the potential future market development of these agricultural commodities.

11.3.2. Constraints under COVID-19

Since the onset of the COVID-19 pandemic, a smooth continuation of global supplies of bananas and major tropical fruits has been jeopardized by the impact of the disease itself as well as by the disease mitigation measures that have been implemented. Both of these factors discernibly affected the production, transport, distribution, marketing and consumption of fresh bananas and major tropical fruits in 2020, with disruptions and contractions widely reported. At the same time, surges in consumer demand for vitamin-rich fruits have facilitated fast growth in trade for some commodities in some markets.

On the supply side, the adverse effects of not only the disease spread but also of the physical distancing measures have tended to be more immediate and pronounced for the relatively labour-intensive production and trade of fruits and vegetables than for most other food commodities, particularly staple foods. Given their typically high perishability, fresh fruits and vegetables require timely and well-coordinated harvesting and post-harvest handling, as well as uninterrupted cold chains. Some major tropical fruits, such as fresh mangoes, furthermore, partly rely on airfreight for export. In many producing countries, quarantine-related delays at ports and borders, border closures, as well as extreme shortages of reefer containers and airfreight belly-capacity, have slowed trade, while market closures have interrupted producers' access to local and national distribution outlets. Reports of produce remaining unsold and going to waste have been widespread, particularly for more perishable varieties such as papayas and pineapples. With input factories and import routes disrupted, reduced availability and higher costs of key inputs for production and distribution have further jeopardized a smooth continuation of supply. Under these circumstances, the profitability of many farms and plantations has been severely affected, with industry sources reporting difficulties arising from cancelled orders, particularly for small- to medium-sized producers.

On the demand side, the rapid decline in global economic activity has resulted in negative impacts on the global incidence of unemployment, poverty, inequality and undernourishment. Reduced consumer incomes have resulted in reports of reduced demand in the major tropical fruits sector globally, given the high income elasticities of demand for the majority of these high-value commodities. In addition to income effects, the closure of schools, canteens, restaurants, bars and hotels around the world has severely affected food consumption patterns. While precise figures are not currently available, away-from-home consumption of tropical fruits, especially avocados and pineapples, can account for a substantial share of total consumption in key import markets.[2] This has most notably been observed in the United States and the European Union, where distributors reported difficulties in selling produce, most notably pineapples, throughout the duration of lockdowns.

Up to this point, in the presence of significant delays and discrepancies in data reporting, the short-term impact of COVID-19 continues to be difficult to gauge. The medium-term impact is similarly uncertain as it depends on the recovery path following the current pandemic, and since projections of trade in tropical products would be sensitive to different economic growth assumptions. Adverse weather and climate-related factors, given their mostly unpredictable nature, bring additional uncertainty to the outlook, as further discussed below. However, despite these uncertainties, global production and trade of bananas and major tropical fruits are projected to expand solidly over the medium term. Demand growth in high-income countries, where nutritional awareness is becoming stronger, and increasing demand also in emerging countries such as China and India, are expected to drive investments and expansion in banana and major tropical fruit production zones. The outlook accordingly indicates that bananas and major tropical fruits would continue to be among the fastest growing and most valuable agricultural industries in terms of their international trade prospects.

11.3.3. Bananas

Market situation

Preliminary estimates indicate that global exports of bananas, excluding plantain, reached a new record high of 22.2 Mt in 2020, an increase of 1.7% compared to 2019. Strong supply growth in Ecuador, Costa Rica, and Colombia, three of the five leading exporters, was chiefly accountable for this rise. All three countries reportedly implemented disease mitigation strategies in their plantations at early stages of the pandemic and were thereby able to minimize disruptions to their ability to supply bananas to world markets. Meanwhile, exports from the Philippines, the second leading global exporter, were affected by severe difficulties arising from the impact of the pandemic on the country's banana production, which reportedly had a particularly detrimental effect on small-scale producers. Preliminary data and information accordingly indicate a contraction of 14% in Philippine banana exports in 2020.

On a provisional basis, global net import quantities of bananas stood at approximately 18.9 MT in 2020, a mere 0.2% increase from 2019, reflecting pandemic-induced strains on global supply chains as well as strains on demand in several key import markets. While demand in the European Union reportedly remained strong, preliminary data indicate a contraction in imports of 0.1% in the United States, the second largest importer behind the European Union, due to reduced demand. More drastically, imports by China, the third largest importer of bananas globally, contracted by an estimated 10% on account of the supply disruptions experienced in the Philippines. However, it needs to be noted that reported trade data for bananas currently display a large discrepancy between exports and imports for 2020, which may also be caused by data reporting lags or errors. FAO is continuously monitoring global trade flows of bananas and will correct these estimates in the event that more precise data become available.

Projection highlights

Assuming normal weather conditions and no further spread of banana plant diseases, the current baseline projections expect world production of bananas to grow at 1.4% p.a., to reach 138 Mt in 2030. As in previous projections, demand for bananas is forecast to become increasingly saturated in most regions and primarily driven by population growth. However, in some rapidly emerging economies – principally in India and China – fast income growth is anticipated to stimulate changing health and nutrition perceptions and support demand for bananas beyond population growth. Accordingly, Asia is expected to remain the leading global producing region at a quantity share of 53%, with India projected to reach 36 Mt and a per capita consumption of 24 kg in 2030. Production from the leading exporting region of Latin America and the Caribbean is expected to reach 36 Mt, encouraged by rising demand from key importing markets, most importantly the European Union, the United States, China, and the Russian Federation. The largest exporters from the region – critically Ecuador, Guatemala, Colombia, and Costa Rica – all continue to be well positioned to benefit from this rise, assuming that production growth can be shielded from the adverse effects of erratic weather events and disease outbreaks. Rising import demand is similarly expected to benefit some Caribbean exporters, most notably the Dominican Republic and Belize, as well as exports from Africa, which are projected to expand at 1% p.a. over the outlook period – led by Ivory Coast –, to reach a total quantity of approximately 750 000 t in 2030.

Figure 11.3. World banana outlook: Exports by the five major exporters
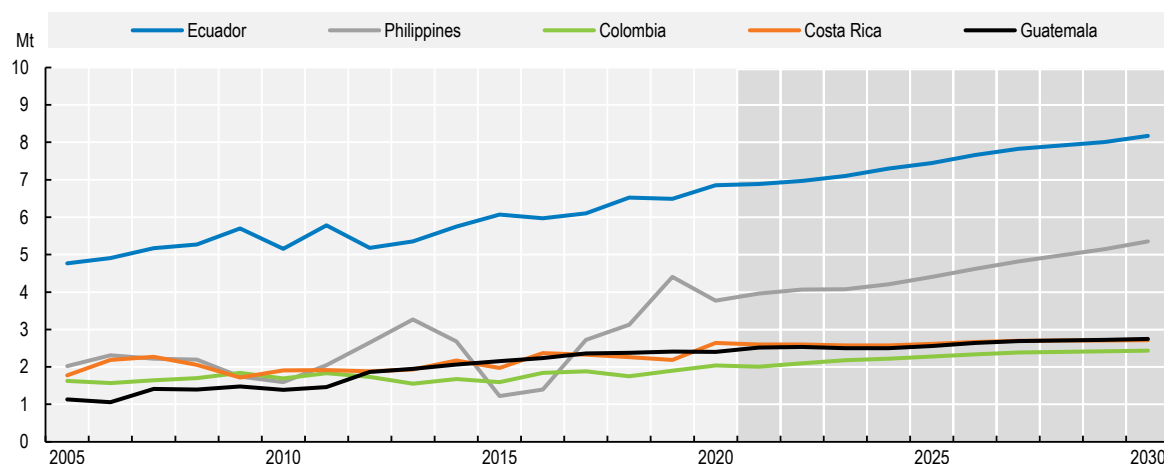
Source: FAO (2021). FAOSTAT Trade Indices Database, http://www.fao.org/faostat/en/#data/TI; OECD/FAO (2021), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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11.3.4. Mango, mangosteen and guava

Market situation

Global exports of fresh mangoes, mangosteens, and guavas[3] grew to an estimated 2.3 Mt in 2020, an increase of 5.1% from the previous year, according to preliminary data. This places the commodity cluster as the second fastest growing group among the major tropical fruits in 2020, behind papaya. The main driver is an approximate 12% expansion in exports from South American suppliers, which reached an estimated 530 000 t in 2020. Favourable production conditions in Brazil and Peru resulted in strong supplies, which in turn facilitated growth in exports of 12.8% and 11.4% for these countries, respectively. Exports from Mexico, the leading supplier of mangoes globally, meanwhile registered growth of 3% in 2020. All three of these suppliers benefited from ample import demand from the United States of America, which accordingly reported an estimated increase in imports by 10.7% in 2020. Exports from Thailand, meanwhile, contracted by 18% on account of COVID-19-related supply chain disruptions affecting shipments to China, the main recipient of Thai mangosteens. With an average export unit value of USD 1 700 per tonne for shipments from Thailand to China in 2020 – approximately 30% higher than in 2019 – mangosteens are among the most valuable tropical fruits traded at the global level. Imports by the European Union were similarly constrained by COVID-19-related supply disruptions and experienced an estimated decline of 10.6% compared to 2019. As such, preliminary data indicate a total global import quantity of fresh mangoes, mangosteens, and guavas of 2.1 Mt in 2020. This preliminary estimate may be revised as more data become available.

Projection highlights

Global production of mangoes, mangosteens and guavas is projected to reach 84 Mt by 2030, increasing at 3.3% p.a. over this period. Asia, the native region of mangoes and mangosteens, is expected to account for 75% of global production in 2030 compared to 73% in the base period. This will be primarily due to strong growth in domestic demand in India, the leading producer and consumer of mangoes globally, where rising incomes and associated shifts in dietary preferences will be the main drivers of production growth. Mango production in India is accordingly projected to account for 43 Mt in 2030, or 51% of global production, destined largely for local informal markets. As such, India is expected to experience increases

in per capita consumption of 3% p.a. over the outlook period, reaching 28.4 kg in 2030, while average per capita consumption in Asia overall is expected to reach 14.6 kg in 2030, compared to 10.4 kg in the base period. Global exports of mangoes, mangosteens and guavas are projected to reach almost 3 Mt in 2030, compared to 2.1 Mt in the base period, on account of rising import demand in established and emerging import markets. China, whose domestic mango production is comparatively low at a projected 2.2 Mt in 2030, is expected to experience a growth in imports of 4.9% p.a. This will be mainly due to a strong income-driven increase in Chinese demand for mangosteen, which is expected to be predominantly met by an increase in imports from Thailand, the largest global exporter of mangosteen. Mexico, the leading supplier of mangoes globally, is expected to benefit from further growth in import demand from its major market, the United States, and register 4% p.a. growth in exports over the outlook period, to reach a 22% share of world exports in 2030. Thailand and Brazil, the second and third largest exporters, are projected to have market shares of around 12% by 2030, but will be matched by rising exports from Peru.

11.3.5. Pineapple

Market situation

Global exports of pineapples were strongly impacted by the adverse effects of the COVID-19 pandemic in 2020. Preliminary data suggest a total export quantity of 2.9 Mt in 2020, corresponding to a 13.4% decline compared to 2019. The two main global exporters of pineapples, Costa Rica and the Philippines, both experienced sharp declines in shipments, at -17% and -8%, respectively. Costa Rican exports were primarily affected by lower demand from the European Union and the United Kingdom, where imports declined by 25% and 15% compared with 2019, respectively. Widely implemented closures of the hospitality sector significantly impeded the typical distribution structure for pineapples. The Philippines, meanwhile, experienced substantially lower demand from China and Korea, two major importers of Filipino pineapples. Both of these importing countries had introduced strict lockdowns early in the year, hampering import routes, as ports and warehouses operated at drastically reduced capacity. Amidst these difficulties, global imports of pineapples decreased to an estimated 2.8 Mt in 2020, an approximate decline of 9% compared to 2019.

Projection highlights

Global production of pineapple is projected to grow at 2% p.a., to reach 37 Mt in 2030, on account of a 1.8% expansion in harvested area. Asia is expected to remain the largest producing region and account for 40% of global production; pineapple production being sizeable in the Philippines, Thailand, India, Indonesia, and China. Pineapple cultivation in Asia will continue to cater predominantly to domestic demand and is expected to grow in response to changing demographics and income growth. Only the Philippines, the second leading exporter after Costa Rica, is anticipated to export approximately 20% of its production. Similarly, pineapple production in Latin America and the Caribbean, the second largest producing region at a projected 38% of world production in 2030, will be primarily driven by the evolving consumption needs of the region's growing and increasingly affluent population. Global exports of pineapple are expected to grow at 1.4% p.a., to 3.5 Mt in 2030, predominantly driven by import demand from the United States. With projected imports of 1.3 Mt in 2030 – equivalent to a 37% global share – the country is expected to remain the largest importer, ahead of the European Union, which is expected to account for 22% of global imports. In both key import markets, demand for pineapples is expected to benefit from low unit prices and to some degree also from the introduction of more premium novelty varieties.

11.3.6. Avocado

Market situation

Preliminary data suggest that global exports of avocado declined slightly in 2020, by 0.8% compared to 2019, at a total quantity of approximately 2.3 Mt. The main factors hampering the overall potential of this previously buoyant market, which had seen fast and uninterrupted expansion for more than a decade, were the impact of COVID-19 on global supply chains as well as a poor harvest in Mexico, the largest supplier of avocados globally. Accordingly, Mexico experienced an estimated 8.1% fall in exports in 2020, to 1.3 Mt. Meanwhile, favourable weather and successful investments in production expansion stimulated significantly higher supplies from Peru, Colombia, and Kenya, three emerging avocado exporters. All three suppliers were thus able to achieve double-digit growth in exports in 2020, and together accounted for about 25% of total global exports. Imports by the United States, the largest importer of avocados globally, declined by an estimated 14.3% in 2020, due to the combination of lower demand from the hospitality sector and lower supplies from Mexico. Imports into the European Union, where out-of-home consumption similarly accounts for a substantial share of total avocado consumption, declined by an estimated 2.5% in 2020 due to the impact of COVID-19. Provisional data accordingly indicate a contraction of 0.6% in global imports in 2020, to 2.1 Mt. However, this preliminary estimate may be revised as more data become available.

Projection highlights

Avocado has the lowest production level among the major tropical fruits but has experienced the fastest growth in output in recent years and is expected to remain the fastest growing commodity of the major tropical fruits over the outlook period. Production is accordingly projected to reach 12 Mt by 2030 – more than three times its level in 2010. Ample global demand and lucrative export unit prices continue to be the main drivers of this growth, stimulating substantial investments in area expansion in both major and emerging production zones. Avocado production has been so far concentrated in a small number of regions and countries, with the top ten producing countries currently accounting for almost 80% of global output, but new growing areas are emerging rapidly. Nevertheless, about 74% of avocado production is expected to remain in Latin America and the Caribbean, given the favourable growing conditions in this region. In response to rapidly growing global demand, avocado is expected to become the most traded major tropical fruit by 2030, reaching 3.9 Mt of exports and overtaking both pineapples and mangoes in quantity terms. Given the high average unit prices of avocado, the total value of global avocado exports would thus reach an estimated USD 8.3 billion in constant 2014-16 value terms, thereby placing avocado as one of the most valuable fruit commodities. Output in Mexico, the world's largest producer and exporter, is expected to grow by 5.2% p.a. over the next ten years due to continued growth in demand in the United States of America, the key importer of avocados from Mexico. As such, and despite increasing competition from emerging exporters, Mexico is expected to further increase its share of global exports, to 63% in 2030. The United States and the European Union, where consumer interest in avocados is fuelled by the fruit's assumed health benefits, are expected to remain the main importers, with 40% and 31% of global imports in 2030, respectively. However, imports are also rapidly rising in many other countries such as in China and some countries in the Middle East, and, as measured by the Herfindahl-Hirschman Index of all importers, the concentration of imports is gradually decreasing.

### 11.3.7. Papaya

Market situation

Preliminary data indicate an increase in global exports of papayas of 17.5% in 2020, to approximately 400 000 t. The key reasons behind this significant expansion are substantially higher supplies from Brazil

and a continued recovery from the weather-related production declines experienced in Mexico in 2017 and 2018. Brazil, an expanding exporter, thus reached second place in global supplies of papayas in 2020, at a total quantity of 96 000 t, following growth in exports of more than 115% from 2019. Mexico, the largest global exporter of papayas, meanwhile expanded shipments by an estimated 4.6% in 2020, to approximately 170 000 t. Virtually 99% of Mexican papaya supplies are exported to the United States, which accordingly ranks as the largest importer of papaya globally, at an estimated import quantity of 180 000 t in 2020, an increase of 1.1% from 2019. Imports by the European Union, meanwhile, declined by an estimated 4% in 2020, to approximately 35 000 t, in light of the COVID-19-induced disruptions to international air transport, which proved particularly detrimental to the long-distance shipment of highly perishable papayas.

Projection highlights

Global papaya production is projected to rise by 2.5% p.a., to 18 Mt in 2030. The strongest growth is expected to be experienced in Asia, the leading producing region globally. Asia's share of world production is set to rise to 60% by 2030. The world's largest producer, India, is projected to increase its papaya production at a rate of 3.0% p.a., thereby expanding its share of global output to 49% by 2030. Income and population growth will be the main factors behind this rise, with Indian per capita consumption of papayas expected to reach 5.9 kg in 2030, up from 4.5 kg in the base period. Global exports will predominantly be shaped by production expansion in Mexico, the largest global exporter of papayas, and higher demand from the key importers, the United States and the European Union. However, a major obstacle to a significant expansion in international trade remains the fruit's high perishability and sensitivity in transport, which makes produce problematic to supply to far afield destinations. Innovations in cold chain, packaging and transport technologies promise to facilitate a broader distribution of papaya, particularly in view of rising consumer demand for tropical fruits in import markets.

Figure 11.4. World major tropical fruit outlook: Global exports
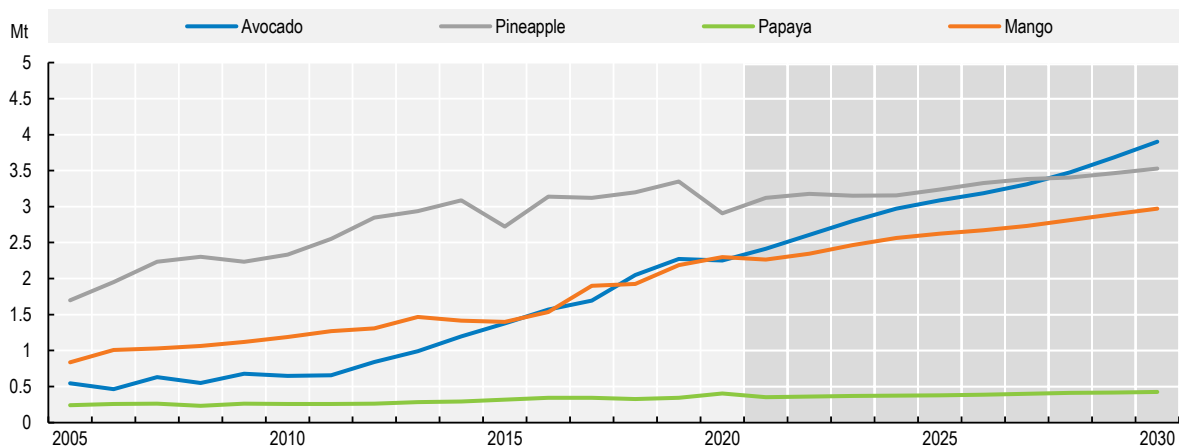
Source: FAO (2021). FAOSTAT Trade Indices Database, http://www.fao.org/faostat/en/#data/TI; OECD/FAO (2021), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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11.3.8. Uncertainties

Beyond the impact of COVID-19, several significant threats to global production, trade and consumption of bananas and major tropical fruits are present. The effects of global warming are resulting in a higher occurrence of droughts, floods, hurricanes and other natural disasters, which render the production of bananas and major tropical fruits increasingly difficult and costly. Given the perishable nature of tropical

fruits in production, trade and distribution, environmental challenges and insufficient infrastructure continue to jeopardise production and supply to international markets. This is a particularly acute difficulty since the vast majority of tropical fruits are produced in remote, informal settings, where cultivation is highly dependent on rainfall, prone to the adverse effects of increasingly erratic weather events and disconnected from major transport routes.

In the face of rising temperatures, more rapid and more severe spreads of plant pests and diseases are additionally being observed, as for example is the case with the plant fungus Banana Fusarium Wilt. The currently expanding strain of the disease, described as Tropical Race 4 (TR4), poses particularly high risks to global banana supplies as it can affect a much broader range of banana and plantain cultivars than other strains of Fusarium wilt. Furthermore, despite some recent breakthroughs in the engineering of resistant varieties, no effective fungicide or other eradication method is currently available. According to official information, TR4 is currently confirmed in 23 countries, predominantly in South and Southeast Asia, but also in the Middle East and Latin America, with Colombia reporting the first infection in August 2019 and Peru in April 2021. A recently conducted assessment of the potential economic impact of the TR4 disease on global banana production and trade showed that a further spread of TR4 would, *inter alia*, entail considerable loss of income and employment in the banana sector in the affected countries, as well as significantly higher consumer costs in importing countries, at varying degrees contingent on the actual spread of the disease.[4] Appropriate re-specifications of the model could similarly be employed to investigate the effects of climate-driven changes on global tropical fruit area, changes in actual and attainable yields, as well as the impact of increased frequencies of extreme weather events on production and trade.

Notes

[1] Pulses types: dry beans, dry broad beans, dry peas, chickpeas, cow peas, pigeon peas, lentils, Bambara beans, vetches, lupines and minor pulses (not elsewhere specified).

[2] For example, in France, the largest avocado consuming country in the European Union, one-third of total avocado supply is reported to be consumed out of the home (www.fruitrop.com/en/Articles-by-subject/Direct-from-themarkets/2020/The-impact-of-covid-19-measures-on-fruit-and-vegetablesdistribution-in-France).

[3] International commodity classification schemes for production and trade do not require countries to report the fruits within this cluster separately, thus official data remain sparse. It is estimated that, on average, mango accounts for approximately 75% of total production quantity, guava for 15%, and mangosteen for the remaining 10%.

[4] An alternative simulation was run in 2019 to assess the potential economic impact of the Banana Fusarium Wilt Tropical Race 4 disease on global banana production and trade. The results of this scenario were published in the November 2019 issue of FAO's biannual publication, *Food Outlook* (http://www.fao.org/3/CA6911EN/CA6911EN.pdf).

Annex A. Glossary

Aquaculture	The farming of aquatic organisms including fish, molluscs, crustaceans, aquatic plants, etc. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding and protection from predators. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms that are harvested by an individual or corporate body that has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms that are exploitable by the public as a common property resource, with or without appropriate licenses, are the harvest of capture fisheries. In this *Outlook*, data relating to aquatic plants are not included.
African Swine Fever (ASF)	ASF is a highly contagious hemorrhagic disease of pigs, warthogs, European wild boar and American wild pigs. It is not a human health threat. The organism that causes ASF is a DNA virus of the Asfarviridae family. (For more information on this topic: http://www.oie.int/doc/ged/d13953.pdf)
Atlantic beef / pigmeat market	The Atlantic market for production and trade of beef and pigmeat consists of countries that are Foot and Mouth Disease (FMD) free with vaccination or contain FMD free zones. Most countries in this market are located around the Atlantic Ocean and typically trade grass-fed beef and grain-fed pigmeat. See also Pacific beef/pigmeat market.
Avian Influenza (AI)	AI is a highly contagious viral infection which can affect all species of birds and can manifest itself in different ways depending mainly on the ability of the virus to cause disease (pathogenicity) on the species affected (for more information on this topic, see http://www.oie.int/doc/ged/D13947.PDF)
Baseline	The set of market projections used for the *Outlook* analysis, also used as benchmark to analyse the impact of different economic and policy scenarios. A detailed description on how this baseline was generated is provided in the methodology section
Biofuels	In the wider sense, biofuels can be defined as all solid, fluid or gaseous fuels produced from biomass. More narrowly, the term comprises fuels that replace petroleum-based road-transport fuels. Ethanol is produced from sugar crops, cereals and other starchy crops, and can be used as an additive to, in a blend with, or as a replacement of gasoline. Biodiesel is produced mostly from vegetable oils, but also from waste oils and animal fats.
Biomass	Biomass is defined as any plant matter used directly as fuel or converted into other forms before combustion. Included are wood, vegetal waste (including wood waste and crops used for energy production), animal materials/wastes and industrial and urban wastes, used as feedstock for producing bio-based products. In the context of the *Outlook*, it does not include agricultural commodities used in the production of biofuels (e.g. vegetable oils, sugar or grains).
Blend wall	The term blend wall refers to short run technical constraints that act as an impediment to increased biofuel use in transportation fuels.
BRICS	Refers to the emerging economies of Brazil, the Russian Federation, India, the People's Republic of China, and South Africa.
Bt cotton	A transgenic cotton variety that contains one or more foreign genes derived from the bacterium *Bacillus thuringiensis*. Bt cotton is resistant against some insect pests, but the fiber of BT cotton plants is shorter than that of traditional varieties.

Capture fisheries	Capture fisheries refer to the hunting, collecting and gathering activities directed at removing or collecting live wild aquatic organisms (predominantly fish, molluscs and crustaceans) including plants from the oceanic, coastal or inland waters for human consumption and other purposes by hand or more usually by various types of fishing gear such as nets, lines and stationary traps. The production of capture fisheries is measured by nominal catches (in live weight basis) of fish, crustaceans, molluscs and other aquatic animals and plants, killed, caught, trapped or collected for all commercial, industrial, recreational and subsistence purposes. It should be noted that in this *Outlook* data relating to aquatic plants are not included.
Cereals	Defined as wheat, maize, other coarse grains and rice.
Common Agricultural Policy (CAP)	The European Union's agricultural policy, first defined in Article 39 of the Treaty of Rome signed in 1957
Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP)	CPTPP is a trade agreement between Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Viet Nam. It was signed in March 2018 and came into force for the first six countries in December 2018.
Comprehensive Economic and Trade Agreement (CETA)	CETA is a trade agreement between the European Union and Canada. CETA was signed in October 2016 and is in provisional application as of April 2017. Full ratification and implementation is still pending
COVID-19	COVID-19 is the infectious disease caused by the most recently discovered coronavirus. This new virus and disease were unknown before the outbreak began in Wuhan, China, in December 2019. COVID-19 is now a pandemic affecting many countries globally.
Decoupled payments	Direct payments which are not linked to current production of specific commodities or livestock numbers or the use of specific factors of production.
Developed and developing countries	See summary table at the end of the Glossary.
Direct payments	Payments made directly by governments to producers
Domestic support	Refers to the annual level of support, expressed in monetary terms, provided to agricultural production. It is one of the three pillars of the Uruguay Round Agreement on Agriculture targeted for reduction.
El Niño- Southern Oscillation	*El Niño*-Southern Oscillation (ENSO) refers to periodic but irregular variations in wind and sea surface temperatures in the tropical eastern Pacific Ocean. ENSO consists of a warming phase known as *El Niño* and a cooling phase known as *La Niña*, and occurs typically at intervals of two to seven years. The abnormal warm ocean climate conditions of *El Niño* are accompanied by higher local rainfall and flooding, and massive deaths of fish and their predators (including birds).
Energy Independence and Security Act (EISA) 2007	US legislation passed in December 2007 that is designed to increase US energy security by lessening dependence on imported oil, to improve energy conservation and efficiency, expand the production of renewable fuels, and to make America's air cleaner for future generations.
Ethanol	A biofuel that can be used as a fuel substitute (hydrous ethanol) or a fuel extender (anhydrous ethanol) in mixes with petroleum, and which is produced from agricultural feed-stocks such as sugar cane and maize. Anhydrous alcohol is free of water and at least 99% pure. Hydrous alcohol contains water and usually has a purity of 96%. In Brazil, this ethanol is being used as a gasohol substitute in flex-fuel vehicles.
Everything-But-Arms (EBA)	The EBA Initiative eliminates EU import tariffs for numerous goods, including agricultural products, from the least developed countries as of 2009-10.
Export subsidies	Subsidies given to traders to cover the difference between internal market prices and world market prices, such as the EU export restitutions. The elimination of agricultural export subsidies is part of the Nairobi Package adopted at the WTO's Tenth Ministerial Conference in December 2015.
Farm Bill	In the United States, the Farm Bill is the primary agricultural and food policy tool of the federal government.
Flexible-fuel vehicles (FFVs)	Vehicles that can run on either gasohol or on hydrous ethanol.

Fresh dairy products	Fresh Dairy Products contain all dairy products and milk which are not included in the processed products (butter, cheese skim milk powder, whole milk powder and for some cases casein and whey). The quantities are in cow milk equivalent.
G20	The G20 is an international forum made up of 19 countries and the European Union, representing the world's major developed and emerging economies. Together, the G20 members represent 85% of global GDP, 75% of international trade, and two-thirds of the world's population. Originally bringing together finance ministers and central bank governors, the G20 has evolved into a forum to address broader global challenges.
Gasohol	Fuel that is a mixture of gasoline and anhydrous ethanol.
High Fructose Corn Syrup (HFCS)	Isoglucose sweetener extracted from maize.
Intervention stocks	Stocks held by national intervention agencies in the European Union as a result of intervention buying of commodities subject to market price support. Intervention stocks may be released onto the internal markets if internal prices exceed intervention prices.
Isoglucose	Isoglucose is a starch-based fructose sweetener, produced by the action of the glucose isomerase enzyme on dextrose. This isomerisation process can be used to produce glucose/fructose blends containing up to 42% fructose. Application of a further process can raise the fructose content to 55%. Where the fructose content is 42%, isoglucose is equivalent in sweetness to sugar.
Least squares growth rate	The least-squares growth rate, r, is estimated by fitting a linear regression trend line to the logarithmic annual values of the variable in the relevant period, as follows: $\ln(x_t) = a + r * t$ and is calculated as $[\exp(r) - 1]$.
Live weight	The weight of meat, finfish and shellfish at the time of their capture or harvest. In the case of fish products it is calculated on the basis of conversion factors from landed to nominal weight and on rates prevailing among national industries for each type of processing.
Market access	Governed by provisions of the Uruguay Round Agreement on Agriculture which refer to concessions contained in the country schedules with respect to bindings and reductions of tariffs and to other minimum import commitments.
Marketing year	It is common to compare crop production across "marketing years," which are defined so that one season's harvest is not artificially split up across different calendar years. In this Outlook, international marketing years are mostly defined starting with their harvest in major supply regions, as follows: • Wheat: 1 June • Cotton: 1 August • Maize and other coarse grains: 1 September • Sugar, soybeans, other oilseeds, protein meal, vegetable oils: 1 October. • New Zealand meat: year ended September • Australia meat: year ended June Whenever the text refers to, for example, the marketing year 2020, this is short for 2020/21 for the above commodities. For all other commodities, the marketing year is equal to the calendar year.
North American Free Trade Agreement (NAFTA)	A trilateral agreement on trade, including agricultural trade, between Canada, Mexico, and the United States, phasing out tariffs and revising other trade rules between the three countries over a 15-year period. The agreement was signed in December 1992 and came into effect on 1 January 1994. In 2018, a new agreement between the United States, Mexico and Canada (USMCA) was signed. It is scheduled to come into effect on 1 July 2020 and replace NAFTA.
Other coarse grains	Defined as barley, oats, sorghum and other coarse grains in all countries except Australia where it includes triticale, and in the European Union where it includes rye and other mixed grains.
Other oilseeds	Defined as rapeseed (canola), sunflower seed, and groundnuts (peanuts).
Pacific beef/pigmeat market	The Pacific meat market consists of countries (or zones within countries) that produce and trade livestock free from Foot and Mouth Disease (FMD) without vaccination. FMD status is determined by the OIE according to strict guidelines (www.oie.int/en/animal-health-in-the-world/official-

disease-status/fmd/) and includes, *inter alia*, Australia, New Zealand, Japan, Korea, North America and the vast majority of Western Europe. The name "Pacific" refers to the fact that most of them are located around the Pacific Rim. See also Atlantic beef/pigmeat market.

Producer Support Estimate (PSE)	Indicator developed and compiled by the OECD showing the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at farm gate level, and arising from policy measures (regardless of their nature, objectives or impacts on farm production or income). The PSE measures support arising from policies targeted to agriculture relative to a situation without such policies, i.e. when producers are subject only to general policies (including economic, social, environmental and tax policies) of the country. The percentage PSE is the ratio of the PSE to the value of total gross farm receipts, measured by the value of total production (at farm gate prices) plus budgetary support (see http://www.oecd.org/agriculture/topics/agricultural-policy-monitoring-and-evaluation/).
Protein meals	Defined as soybean meal, groundnut meal, rapeseed meal, sunflower meal, coconut meal, cottonseed meal and palm kernel meal.
Purchasing Power Parity (PPP)	Purchasing power parities (PPPs) are the rates of currency conversion that eliminate the differences in price levels between countries. The PPPs are given in national currency units per US dollar.
Renewable Energy Directive (RED)	EU directive legislating binding mandates of 20% for the share of renewable energy in all Member States' energy mix by the year 2020, with a specific target of 10% for the renewable energy share in transport fuels.
Renewable Fuel Standard (RFS and RFS2)	A standard in the United States for renewable fuel use in the transport sector in the Energy Act (EISA). RFS2 is a revision of the RFS program for 2010 and beyond.
Roots and Tubers	Plants that yield starch, either derived from their roots (e.g. cassava, sweet potato and yams) or stems (e.g. potatoes and taro). They are destined mainly for human food (as such or in processed form) but can also be used for animal feed or for manufacturing starch, ethanol and fermented beverages. Unless they are processed, they become highly perishable once harvested, which limits opportunities for trade and storage. Roots and tubers contain large amounts of water: all quantities in this publication refer to dry weight to increase comparability.
Scenario	A model-generated set of market projections based on alternative assumptions than those used in the baseline. Used to provide quantitative information on the impact of changes in assumptions on the outlook.
Stock-to-use ratio	The stock-to-use ratio for cereals is defined as the ratio of cereal stocks to its domestic utilisation.
Stock-to-disappearance ratio	The stock-to-disappearance ratio is defined as the ratio of stocks held by the main exporters to their disappearance (i.e. domestic utilisation plus exports). For wheat, the eight major exporters are considered, namely the United States, Argentina, the European Union, Canada, Australia, Russian Federation, Ukraine, and Kazakhstan. In the case of coarse grains, United States, Argentina, the European Union, Canada, Australia, Russian Federation, Ukraine, and Brazil are considered. For rice Viet Nam, Thailand, India, Pakistan and the United States enter this ratio calculation.
Support price	Prices fixed by government policy makers in order to determine, directly or indirectly, domestic market or producer prices. All administered price schemes set a minimum guaranteed support price or a target price for the commodity, which is maintained by associated policy measures, such as quantitative restrictions on production and imports; taxes, levies and tariffs on imports; export subsidies; and/or public stockholding
Tariff-Rate Quota (TRQ)	A two-tier tariff regime where imports within the quota enter at a lower ("in-quota") tariff rate while a higher ("out-of-quota") tariff rate is used for imports above this level, As part of the Uruguay Round Agreement on Agriculture, certain countries agreed to provide minimum import opportunities for products they had previously protected by tariffs.
Tel quel basis	Weight of sugar, regardless of its sucrose content (measured by polarisation).
Trade balances	Calculated as net trade : exports - imports

Uruguay Round Agreement on Agriculture (URAA)	An international agreement negotiated as part of the Uruguay Round of the General Agreement on Tariffs and Trade. The URAA entered into force simultaneously with the establishment of the World Trade Organization in 1995. The URAA contains commitments to improve market access, reduce distorting domestic support, and reduce export subsidies. A separate agreement covers sanitary and phyto sanitary measures known as the SPS Agreement.
Vegetable oils	Defined as rapeseed oil (canola), soybean oil, sunflower seed oil, coconut oil, cottonseed oil, palm kernel oil, groundnut oil and palm oil.
World Trade Organization (WTO)	Intergovernmental organisation regulating international trade, providing a framework for negotiating trade agreements, and acting as dispute resolution process. The WTO was created by the Uruguay Round agreement and officially commenced in 1995.

Annex B. Methodology

This section provides information on how the projections in the *Agricultural Outlook* are generated. First, a general description of the agricultural baseline projections and the *Outlook* report is given. Second, the compilation of a consistent set of the assumptions on macroeconomic projections is discussed in more detail. Section 3 provides reference to the underlying Aglink-Cosimo model, while the last section explains how a partial stochastic analysis is performed with the Aglink-Cosimo model.

The process of generating the OECD-FAO Agricultural Outlook

The projections presented are the result of a process that brings together information from a large number of sources. The projections rely on input from country and commodity experts, and from the OECD-FAO Aglink-Cosimo model of global agricultural markets. This economic model is also used to ensure the consistency of baseline projections. A large amount of expert judgement, however, is applied at various stages of the *Outlook* process. The *Agricultural Outlook* presents a unified assessment judged by the OECD and FAO Secretariats to be plausible given the underlying assumptions and the information available at the time of writing.

The starting point: Creation of an initial baseline

The data series for the historic values are drawn from OECD and FAO databases. For the most part, information in these databases has been taken from national statistical sources. Starting values for the likely future development of agricultural markets are developed separately by OECD for its member states and some non-member countries and by FAO for all remaining countries.

- On the OECD side, an annual questionnaire is circulated in November to national administrations. Through these questionnaires, the OECD Secretariat obtains information on how countries expect their agricultural sector to develop for the various commodities covered in the *Outlook*, as well as on the evolution of agricultural policies.
- On the FAO side, the starting projections for the country modules are developed through model-based projections and consultations with FAO commodity specialists.

External sources, such as the International Monetary Fund (IMF), the World Bank and the United Nations (UN), are also used to complete the view of the main economic forces determining market developments.

This part of the process is aimed at creating a first insight into possible market developments and at establishing the key assumptions which condition the *Outlook*. The main economic and policy assumptions are summarised in the overview chapter and in specific commodity tables. The sources for the assumptions are discussed in more detail further below.

As a next step, the OECD-FAO Aglink-Cosimo modelling framework is used to facilitate a consistent integration of the initial data and to derive an initial baseline of global market projections. The modelling framework ensures that at a global level, projected levels of consumption match with projected levels of production for the different commodities. The model is discussed in section three below.

In addition to quantities produced, consumed and traded, the baseline also includes projections for nominal prices (in local currency units) for the commodities concerned.[1]

The initial baseline results are then reviewed:

- For the countries under the OECD Secretariat's responsibility, the initial baseline results are compared with the questionnaire replies. Any issues are discussed in bilateral exchanges with country experts.
- For country and regional modules developed by the FAO Secretariat, initial baseline results are reviewed by a wider circle of in-house and international experts.

Final baseline

At this stage, the global projection picture starts to emerge, and refinements are made according to a consensus view of both Secretariats and external advisors. On the basis of these discussions and updated information, a second baseline is produced. The information generated is used to prepare market assessments for cereals, oilseeds, sugar, meats, dairy products, fish, biofuels and cotton over the course of the *Outlook* period.

These results are then discussed at the annual meetings of the Group on Commodity Markets of the OECD Committee for Agriculture, which brings together experts from national administrations of OECD countries as well as experts from commodity organisations. Following comments by this group, and data revisions, the baseline projections are finalised.

The *Outlook* process implies that the baseline projections presented in this report are a combination of projections and expert knowledge. The use of a formal modelling framework reconciles inconsistencies between individual country projections and forms a global equilibrium for all commodity markets. The review process ensures that judgement of country experts is brought to bear on the projections and related analyses. However, the final responsibility for the projections and their interpretation rests with the OECD and FAO Secretariats.

The revised projections form the basis for the writing of the *Agricultural Outlook*, which is discussed by the Senior Management Committee of FAO's Department of Economic and Social Development and the OECD's Working Party on Agricultural Policies and Markets of the Committee for Agriculture in May, prior to publication. In addition, the *Outlook* will be used as a basis for analyses presented to the FAO's Committee on Commodity Problems and its various Intergovernmental Commodity Groups.

Sources and assumptions for the macroeconomic projections

Population estimates from the 2019 Revision of the United Nations Population Prospects database provide the population data used for all countries and regional aggregates in the *Outlook*. For the projection period, the medium variant set of estimates was selected for use from the four alternative projection variants (low, medium, high and constant fertility). The UN Population Prospects database was chosen because it represents a comprehensive source of reliable estimates which includes data for non-OECD developing countries. For consistency reasons, the same source is used for both the historical population estimates and the projection data.

The other macroeconomic series used in the Aglink-Cosimo model are real GDP, the GDP deflator, the private consumption expenditure (PCE) deflator, the Brent crude oil price (in US dollars per barrel) and exchange rates expressed as the local currency value of USD 1. Historical data for these series in OECD countries as well as Brazil, Argentina, the People's Republic of China and the Russian Federation are consistent with those published in the *OECD Economic Outlook* No. 108 (December 2020). For other economies, historical macroeconomic data were obtained from the IMF, *World Economic Outlook* (October 2020). Assumptions for 2021 to 2030 are based on the recent medium term macroeconomic projections of the OECD Economics Department, projections of the *OECD Economic Outlook* No. 108, and projections of the IMF.

The model uses indices for real GDP, consumer prices (PCE deflator) and producer prices (GDP deflator) which are constructed with the base year 2010 value being equal to 1. The assumption of constant real exchange rates implies that a country with higher (lower) inflation relative to the United States (as measured by the US GDP deflator) will have a depreciating (appreciating) currency and therefore an increasing (decreasing) exchange rate over the projection period, since the exchange rate is measured as the local currency value of USD 1. The calculation of the nominal exchange rate uses the percentage growth of the ratio "country-GDP deflator/US GDP deflator".

The oil price used to generate the *Outlook* until 2019 is taken from the short-term update of the *OECD Economic Outlook* No. 108 (December 2020). For 2020, the annual average daily spot price is used, while the reference oil price used in the projections is assumed to follow the growth rate of the World Bank average oil price.

The underlying Aglink-Cosimo model

Aglink-Cosimo is an economic model that analyses supply and demand of world agriculture. It is managed by the Secretariats of the OECD and the Food and Agriculture Organization of the United Nations (FAO), and used to generate the *OECD-FAO Agricultural Outlook* and policy scenario analysis.

Aglink-Cosimo is a recursive-dynamic, partial equilibrium model used to simulate developments of annual market balances and prices for the main agricultural commodities produced, consumed and traded worldwide. The Aglink-Cosimo country and regional modules covering the whole world, and projections are developed and maintained by the OECD and FAO Secretariats in conjunction with country experts and national administrations. Several key characteristics are as follows:

- Aglink-Cosimo is a "partial equilibrium" model for the main agricultural commodities, as well as biodiesel and bioethanol. Other non-agricultural markets are not modelled and are treated exogenously to the model. As non-agricultural markets are exogenous, hypotheses concerning the paths of key macroeconomic variables are predetermined with no accounting of feedback from developments in agricultural markets to the economy as a whole.

- World markets for agricultural commodities are assumed to be competitive, with buyers and sellers acting as price takers. Market prices are determined through a global or regional equilibrium in supply and demand.

- Domestically produced and traded commodities are viewed to be homogeneous and thus perfect substitutes by buyers and sellers. In particular, importers do not distinguish commodities by country of origin as Aglink-Cosimo is not a spatial model. Imports and exports are nevertheless determined separately. This assumption will affect the results of analysis in which trade is a major driver.

- Aglink-Cosimo is recursive-dynamic, and outcomes for one year influence those for the next years (e.g. through herd sizes). Aglink-Cosimo models ten years into the future.

A detailed documentation of Aglink-Cosimo was produced in 2015 and is available on www.agri-outlook.org.

The model used to generate the fish projections is operated as a satellite model to Aglink Cosimo. Exogenous assumptions are shared and interacting variables (e.g. prices for cross-price reactions) are exchanged. The fish model went through substantial revision in 2016. The aggregated aquaculture supply functions of 32 components of the model were replaced by 117 species-specific supply functions with specific elasticity, feed ration and time lag. The main species covered are salmon and trout, shrimp, tilapia, carp, catfish (including Pangasius), seabream and seabass, and molluscs. A few other minor productions such as milkfish were also included. The model was constructed to ensure consistency between the feed rations and the fishmeal and fish oil markets. Depending on the species, the feed rations can contain a

maximum of five types of feed; fishmeal, fish oil, oilseed meals (or substitutes), vegetable oil and low protein feeds like cereals and brans.

The methodology of stochastic simulations with Aglink-Cosimo

The partial stochastic analysis highlights how alternative scenarios diverge from the baseline by treating a number of variables stochastically. The selection of those variables aims at identifying the major sources of uncertainty for agricultural markets. In particular, country specific macroeconomic variables, the crude oil price, and country- and product-specific yields are treated as uncertain within this partial stochastic framework. Apart from the international oil price, four macroeconomic variables are considered in all countries: the consumer price index (CPI), the gross domestic product index (GDPI), the gross domestic product deflator (GDPD) and the US-Dollar exchange rate (XR). The yield variables considered contain crop and milk yields in all model regions.

I The approach applied to determine the stochastic draws of these variables is based on a simple process which captures the historical variance of each single variable. The three main steps of the partial stochastic process are briefly explained below.

(i) The quantification of the past variability around the trend for each macroeconomic and yield variable separately

The first step is to define the historical trend of stochastic variables. Often a linear trend does not represent adequately observed dynamics. Consequently, a non-linear trend is estimated by applying a Hodrick-Prescott filter, which seeks to separate short-term fluctuations from long-term movements.[2] The filter is applied to the yield time series directly and to year-on-year changes for macro variables.

(ii) The generation of 1 000 sets of possible values for the stochastic variables

The second step involves generating 1 000 sets of possible values for the stochastic variables. For each year of the 2021-2030 projection period, one year of the historical period 1995-2020 is drawn. The relative deviation between the actual variable value of that year and the respective trend value estimated in step 1 is then applied to the value of the variable in the actual projection year. All variables thereby receive the value of the same historical year. The process, however, handles macro variables separated from yields, as both are not strongly correlated.

(iii) The execution of the Aglink-Cosimo model for each of these 1 000 possible alternative sets of values (uncertainty scenarios)

The third step involves running the Agink-Cosimo model for each of the 1 000 alternative "uncertainty" scenarios generated in step 2. When both macroeconomic and yield uncertainty were included, this procedure yielded 98% successful simulations. The model does usually not solve all stochastic simulations as the complex system of equations and policies may lead to infeasibilities when exposed to extreme shocks in one or several stochastic variables.

Notes

[1] Trade data for regions, e.g. the European Union or regional aggregates of developing countries, refer only to extra-regional trade. This approach results in a smaller overall trade figure than cumulated national statistics. For further details on particular series, enquiries should be directed to the OECD and FAO Secretariats.

[2] The filter was popularised in the field of economics in the 1990s in Robert Hodrick and Edward C. Prescott (1997), "Postwar U.S. Business Cycles: An Empirical Investigation", *Journal of Money, Credit, and Banking*, Vol. 29 (1), pp. 1–16. JSTOR 2953682.