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 (2023-32) 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 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 (102 Mt) and Africa (100 Mt). In Sub Saharan Africa, roots play a significant role as a staple crop. Globally, about 130 Mt are used as food, 57 Mt as feed, and 33 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 15 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 251 Mt (dry matter) in the base period (2020-22); 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) increased again significantly in 2022 as demand was strong, in particular in China. 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.

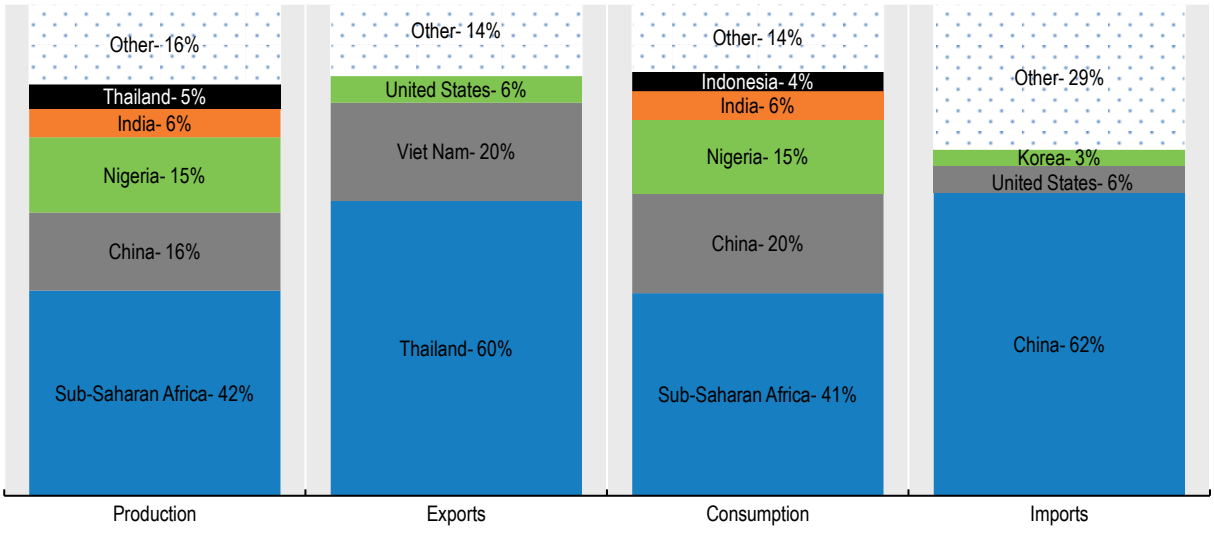
Potatoes are generally confined to food use and are a substantial component of diets in developed regions, particularly in Europe and North America. As overall food intake of potato in these regions is very high and may have reached saturation, the scope for consumption increases to outpace population 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 2.6% p.a. while supply in high-income countries should grow at only 0.3% annually. Global land use is projected to increase by 6 Mha to 71 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. Moreover, many farmers in Thailand shifted from Cassava to rice which had better production incentives. 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.

Figure 11.1. Global players in roots and tubers markets in 2032



Note: Presented numbers refer to shares in world totals of the respective variable
Source: OECD/FAO (2023), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

StatLink https://stat.link/w863k0

By 2032, an additional 1.4 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 41 kg per year. Biofuel use, albeit from a low basis (3% of use), is expected to grow by 37% 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 10% and 15% respectively, over the outlook period.

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 15 Mt, mainly to supply the growing biofuel and starch industries in China.

After a moderate decrease expected in 2023 due to high pressure on cassava markets in Thailand and the shortfall of potato production in Ukraine, prices of roots and tubers are projected to follow a similar path to cereal prices in the medium term given the substitutability between roots and tubers and cereals on food and feed markets; 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 high level of 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 average annual increase of about 3% globally, led by Asia and Africa. These two regions combined accounted for more than half of the 12 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 food consumption has increased to about 7 kg/year to date. This growth has been driven mainly by income gains in countries where 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 25% of global production in the past decade. Canada (9%), China (6%) and the European Union (5%) are the next largest producing countries. The Asian market accounts for 52% of all consumption, but only about 43% of production, making it the most significant import destination. About 21% of global production is traded internationally with Canada (35% of global trade) by far the largest exporter and India the largest importer (19% of global trade). Africa

has further expanded its production and consumption in the past decade and has remained largely self-sufficient.

In 2022, the global pulses market reached a volume of 93 Mt, after an average annual growth of 1.7% p.a. during the previous decade; this growth was led by Asia and Africa. World trade volumes were registered at 19.5 Mt, 0.5 Mt higher than in 2021.International prices for pulses, approximated by the Canadian field pea price, have started to fall from their peak value of 2021 to USD 359/Mt in 2022, following the production recovery in Canada.

11.2.3. Main drivers for projections

As pulses are associated with various health benefits and represent an important meat substitute due to their high protein content, health and environmentally 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 8.6 kg by 2032. Per capita food consumption is projected to increase in all regions over the coming decade, with the largest increase expected in Europe (+4% p.a.) (Figure 11.2).

Global supply is projected to increase by 29 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 11 Mt by 2032. 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.

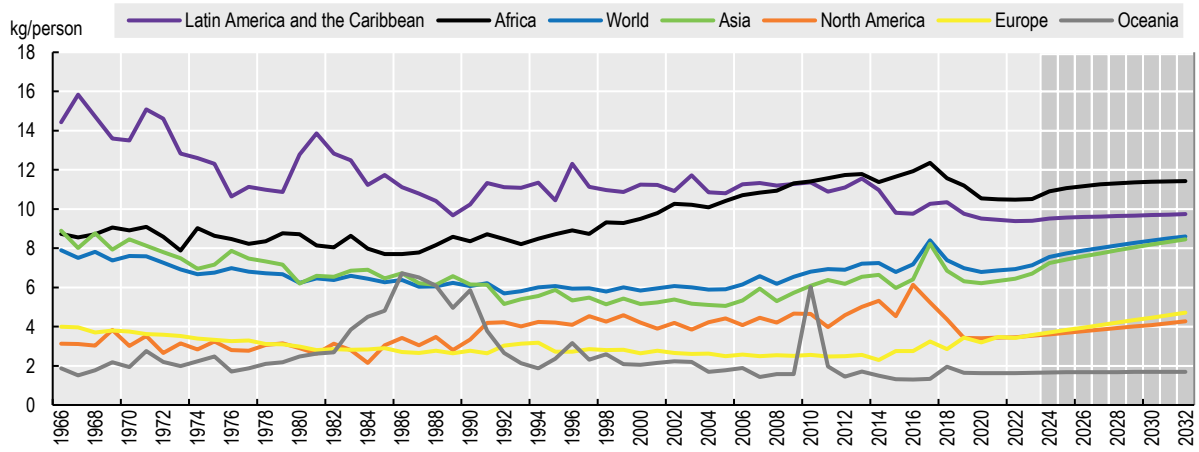
This expected production expansion is driven by the assumption of continued intensification of the pulses production systems due to improved yields and intensified land use. About 60% of production growth can be attributed to land use intensification during the projection period, and the remaining 40% to yield improvements.. Particularly in Africa, a combination of area expansion and yield growth is estimated to add about 0.6 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 15 Mt to 19 Mt over the past decade and is projected to reach 23 Mt by 2032. Canada remains the main exporter of pulses, with volumes expected to grow from 6.8 Mt at present to 9.9 Mt by 2032, followed by Russia and Australia with 2 Mt and 1.9 Mt of exports by 2032, respectively.

International prices in nominal terms are expected to decrease further until 2025 then increase slightly over the coming decade, while real prices will decline.

Figure 11.2. Per capita food consumption of Pulses per continent



Source: OECD/FAO (2023), "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

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, rising incomes 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. Based on provisional 2022 figures, the global banana and major tropical fruit export industries respectively generate around USD 10 billion and USD 11 billion per year. Although only approximately 16% of global banana production and 7% of global major tropical fruit production are traded in international markets (provisional 2022 figures), in exporting countries, which are mostly low- or middle-income economies, revenue from production and trade can weigh substantially in agricultural GDP. For instance, bananas represented about 50% of agricultural export revenue in Ecuador in 2021, while combined exports of pineapples and bananas accounted for some 40% of agricultural export revenue in Costa Rica. 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.

11.3.1. Market Situation: Overview

According to preliminary data and information, global trade in bananas and major tropical fruits continued to be negatively affected by several factors on the supply side in 2022, which induced rising producer costs and consequent supply shortages, against relatively stable demand in key import markets. Industry sources reported that the high prices for fertilisers and their reduced availability in 2021 and throughout the first half of 2022 resulted in a reduced application by farmers, hampering the productivity and quality of banana and major tropical fruit cultivation in key producing areas. Adverse weather conditions, including abnormally cold weather related to the *La Niña* phenomenon as well as the passing of yet another severe

tropical storm through the Caribbean further impacted the quantities available for export. Shortages in refrigerated containers stemming from the prolonged lockdowns implemented in some Asian countries during 2022, alongside high global transportation costs in the first half of the year, posed additional obstacles to export growth.

The difficult operating environment in 2022 was further complicated by the depreciation of many currencies against the United States dollar, which affected operations all along the value chain since transactions in the banana and tropical fruits industries, including the purchasing of inputs, are habitually conducted in United States dollars. This exerted additional upward pressure on costs to producers, exporters and importers. Although prices along the respective value chains for bananas and major tropical fruits displayed a tendency to increase in response to firm demand in major import markets in 2022, in most cases this was not sufficient to compensate for the substantially higher costs. While producer costs reportedly ranged some 40-50% above their pre-pandemic levels, prices at export, import, wholesale and retail level rose by only some 10 to 20% on average, leaving concerns about heavily reduced profit margins a key topic for the industry in 2022.

11.3.2. Bananas

Market situation

Preliminary estimates indicate that global exports of bananas, excluding plantain, experienced a decline of 4% in 2022, marking another year of disruption to the fast-paced growth experienced in pre-pandemic years. Total export quantities were thereby estimated to have fallen from 20.5 Mt in 2021 to approximately 19.6 Mt in 2022. The persistently high costs of fertilisers, which had already led to a reduction in use in 2021, were quoted as the key obstacle affecting producers' ability to supply bananas in adequate quantities and to the quality standards expected in export markets in all regions. Adverse weather conditions affecting production and yields additionally continued to be of concern during the first nine months of 2022, while high costs for land transport and long-distance shipping impeded exporters' capacity to supply international markets. Severe concerns about the spread of plant diseases, importantly the devastating spread of the Banana Fusarium Wilt Tropical Race 4 (TR4) disease in the Philippines and its alarming presence in Peru and Colombia, further continued to cause substantial strain on the industry through the additional costs associated with disease prevention and production losses. Moreover, in view of the ongoing pandemic, the persisting necessity to apply elevated sanitary measures and physical distancing to protect workers from COVID-19 continued to cause additional costs to producers and operators along the supply chain, especially during the first half of 2022.

Global net import quantities of bananas, meanwhile, declined by an estimated 2.5% in 2022, a reduction of nearly 0.5 Mt from the previous year, to just below 19 Mt. While demand in most import markets reportedly remained constant, growth over the first seven months of the year was hindered by a reduced availability of export supplies as well as continuing bottlenecks in global shipping, which posed obstacles to supplies reaching their destination. These factors particularly affected the level of import quantities received over this period by the European Union, the United States, Japan, the United Kingdom and Canada, which jointly account for some 60% of global imports. On the other hand, imports by China, the third largest importer of bananas globally, continued to expand at a fast rate over the first seven months of 2022, facilitated by strong domestic demand and ample availability of export supplies from emerging producers in Southeast Asia.

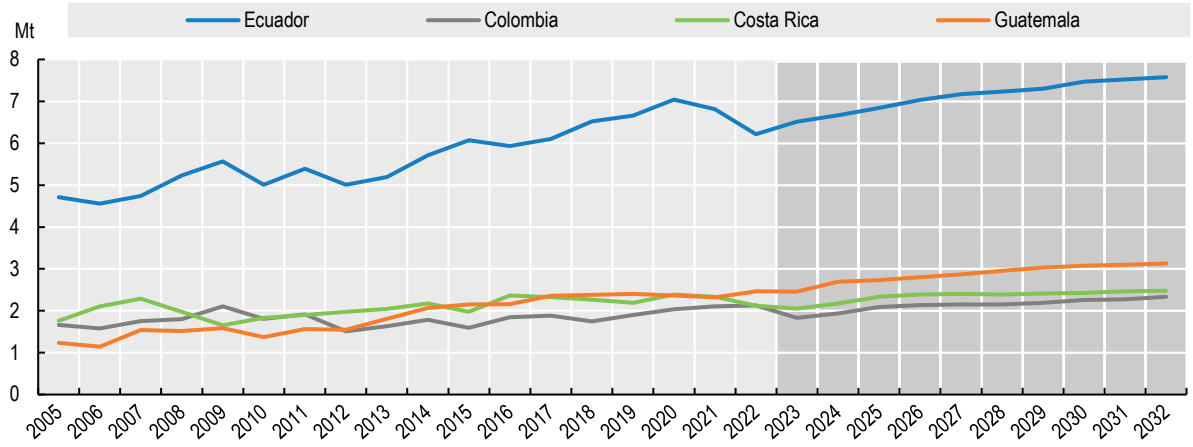
Projection highlights

As per capita demand for bananas is becoming increasingly saturated in most regions, growth in global production and consumption is expected to be primarily driven by population dynamics. In line with slowing world population growth, the current baseline projections therefore expect world production and

consumption of bananas to expand at a moderate 1.5% p.a. over the outlook period. Assuming normal weather conditions and no further spread of banana plant diseases, global banana production will reach 141 Mt by 2032. At the same time, 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 which is already the leading producing region is anticipated to remain so at a quantity share of 50%, with India projected to reach an output of 35 Mt by 2032.

Production from the leading exporting region of Latin America and the Caribbean is projected to reach 37 Mt by 2032, encouraged by rising demand from key importing markets, most importantly the European Union and the United States. With inflationary pressures expected to continue in 2023 and potentially beyond, demand for bananas in these markets is likely to be supported by the fruit's relative affordability. Rising import demand from China, where domestic production is likely to continue to decline, is assumed to be an additional factor driving production growth in Latin America and the Caribbean. The largest exporters from the region – critically Ecuador, Guatemala, Colombia, and Costa Rica – all continue to be well positioned to benefit from this growth, assuming that it can be shielded from the adverse effects of erratic weather events and disease outbreaks. Rising import demand from the European Union and the United Kingdom is further 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 1.8% p.a. over the outlook period – led by Ivory Coast – to reach a total quantity of approximately 0.85 Mt in 2032. Against this background, world exports of bananas are projected to reach some 23.7 Mt by 2032.

Figure 11.3. Exports of bananas by the four major LAC exporters



Source: FAO data.

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11.3.3. Mango, mangosteen and guava

Market situation

Preliminary data indicate that global exports of mango, mangosteen and guava declined to approximately 2.1 Mt in 2022, a decrease of 5%, or some 0.12 Mt, from the previous year. The main reasons behind this were a substantial drop in exports of mangosteen from Thailand, as well as lower exports of mangoes from Brazil and Peru, which could not be offset by higher exports from Mexico, the leading exporter of this commodity group. In terms of export quantities by type at the global level, mango accounted for around

83% of global shipments and mangosteen for around 16%. As previously, guava continued to display a low availability in import markets, in particular due to its lower suitability for transport.

Total global import quantities of fresh mangoes, mangosteens, and guavas fell by an estimated 1% in 2022, to some 2 Mt, as suggested by available monthly trade data up to August 2022. The United States and the European Union remained the two leading global importers, with approximate import shares of 26% and 18%, respectively. In both markets industry sources reported higher consumer demand for mangoes, despite prices and inflationary pressures being high, in line with a generally higher nutritional awareness of the assumed health benefits of these fruits. However, import growth in the United States over the first eight months of the year were somewhat constrained by the difficult supply situation in Peru and Brazil, the second and third leading origins for mangoes in the United States, which seemingly could not be fully offset by higher imports from Mexico. Overall, imports into the United States thereby remained largely at their previous year's level of approximately 0.56 Mt in 2022. Imports into the European Union, meanwhile, declined by an estimated 5% in 2022, to some 0.39 Mt, similarly on the back of supply shortages in Brazil and Peru, the two primary origins of mangoes imported to the European Union.

Projection highlights

Global production of mangoes, mangosteens and guavas is projected to increase at 3.3% p.a. over the next decade, to reach 84 Mt by 2032. As with most other tropical fruits, growth in mango production will mainly respond to income-driven demand growth in producing countries, additionally supported by population dynamics. Asia, the native region of mangoes and mangosteens, will continue to account for some 70% of global production in 2032. 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 expansion. Mango production in India is accordingly projected to account for nearly 38 Mt in 2032, or 45% of global production, destined largely for local informal markets. As such, India is projected to experience increases in per capita consumption of 2.4% p.a. over the outlook period, reaching 24.8 kg in 2032, compared to 18.3 kg in the base period. By contrast, in Mexico and Thailand, the leading exporters of this commodity cluster to world markets, production growth will primarily be driven by expanding global import demand. Exports are accordingly anticipated to reach a 31% share of production in Mexico by 2032, and 26% in Thailand. However, at projected production quantities of 3.2 and 1.8 Mt in 2032, respectively, Mexico and Thailand will account only for comparatively small shares in global production.

Global exports of mangoes, mangosteens and guavas are projected to reach 2.8 Mt in 2032, compared to 2.2 Mt in the base period, on account of higher procurements from the United States, China, and the European Union. Mexico, the leading supplier of mangoes, is expected to benefit from further growth in import demand from its major market, the United States, and reach a 35% share of world exports in 2032. Shipments from Thailand, almost exclusively mangosteens, will cater mainly to rising import demand from China, while supplies from Peru and Brazil, two emerging exporters, will be mostly mangoes destined for the European Union. Both Thailand and Peru are projected to reach a share in global exports of 15% each by 2032, followed by Brazil at some 11%. China, whose per capita mango, mangosteen and guava consumption of 2.6 kg in the base period is relatively low compared to other Asian countries, is expected to experience a rise in imports of 3% p.a., to some 0.36 Mt in 2032. This will be mainly due to a strong income-driven increase in Chinese import demand for mangosteen, as domestic production of this fruit remains low in China.

11.3.4. Pineapple

Market situation

Based on preliminary trade data, global exports of pineapples fell by an estimated 1.5% in 2022, to just below 3.2 Mt, determined largely by reduced supplies from Costa Rica, the world's largest exporter at a market share of almost 70%. According to industry information, cold weather conditions, high energy costs and container problems negatively affected production and export supplies from Costa Rica in 2022. Shipments from the country were accordingly expected to fall by some 2% in 2022, equivalent to a drop of some 0.05 Mt, to just below 2.2 Mt, in strong contrast with the 11% expansion experienced in 2021. In terms of leading destinations, pineapple shipments from Costa Rica continued to be almost exclusively destined to the United States and the European Union.

Preliminary trade data point to a decline of global imports of pineapples to 2.9 Mt in 2022, a fall of an estimated 1% compared to 2021, on account of supply shortages from the main global supplier, Costa Rica. As demand in the United States and the European Union continued to be solid over the first nine months of the year, indicative average import unit values in both key destinations displayed a tendency to increase. Aided by a strong dollar and an upswing of sales in the hospitality sector, imports by the United States increased by an estimated 4% in 2022, to 1.1 Mt. Conversely, imports by the European Union, the second largest importer, fell by an estimated 8% as supply shortages and shipping issues reduced the quantities that could be received throughout at least the first nine months of the year. Weaker economic conditions and a lower value of the euro against the US dollar posed further difficulties. Over the full year, imports by the European Union were anticipated to drop to approximately 0.76 Mt, some 17% below their previous five-year average. Estimates thereby suggest that the United States procured about 39% of global export supplies over the full year 2022, and the European Union some 26%.

Projection highlights

Over the next decade, global production of pineapple is projected to grow at 2% p.a., to reach 32 Mt in 2032, on account of a 1.7% expansion in harvested area. Asia is expected to remain the largest producing region and account for some 44% of quantities produced globally, with pineapple production being sizeable in the Philippines, Thailand, India, Indonesia and China. Cultivation in Asia will continue to largely cater to domestic demand and is projected to grow solidly in response to changing demographics and income growth, especially in India, Indonesia and China. Similarly, pineapple production in Latin America and the Caribbean, the second largest producing region at a projected 34% of world production in 2032, will be primarily driven by the evolving consumption needs of the region's growing and increasingly affluent population. Only Costa Rica and the Philippines, two important global producers and leading exporters to world markets, are anticipated to see additional stimulation from rising import demand, with exports expected to account for approximately 68% of fresh pineapple production in Costa Rica and 18% in the Philippines in 2032.

Global exports of fresh pineapple are set to grow at 1.3% p.a., to 3.5 Mt in 2032, predominantly driven by import demand from the United States and the European Union. With projected imports of 1.1 Mt in 2032 – equivalent to a 34% global share – the United States are expected to remain the largest importer, ahead of the European Union, which is expected to account for some 26% of global imports. In both key import markets, demand for fresh pineapples is assumed to benefit from the fruit's continuously low unit prices and to some degree also from the introduction of more premium novelty varieties. Rising import demand from China, where consumption growth has been outpacing production expansion in recent years, is expected to additionally drive expansion in global exports. By 2032, China is projected to reach import quantities of some 0.39 Mt per year, with supplies likely to be primarily sourced in the Philippines.

11.3.5. Avocado

Market situation

Global exports of avocado declined by an estimated 6% in 2022, to below 2.4 Mt, on account of severe weather-induced supply shortages in Mexico, the world's leading exporter. Although preliminary data and information indicate that exports from most alternative origins continued to grow at comparatively fast rates, these increases seemingly did not fully offset the unprecedented shortfall in supplies from Mexico. Available monthly data for exports from Mexico for the period January to August 2022 indicate a year-on-year fall in shipments of 32%, pointing to a full-year estimate of 1 Mt, some 0.38 Mt below the previous year's level.

Global imports of avocados similarly fell by an estimated 6% in 2022, to approximately 2.3 Mt. Despite continuously strong demand in the two major import markets, the United States and the European Union, which were estimated to respectively account for 45% and 25% of global imports in 2022, overall growth in global imports was curtailed by the supply shortages experienced in Mexico. As such, imports by the United States declined by an estimated 11% in 2022, to approximately 1 Mt. The United States are particularly susceptible to changes in the supply situation in Mexico since they typically import some 90% of avocados from this origin. Meanwhile, imports into the European Union seemingly remained relatively stable at some 0.58 Mt, displaying only a very slight tendency to contract. Like the situation in the United States, consumption across the European Union continued to gain in popularity among an increasingly health-conscious population, with avocados widely perceived as a highly nutritious fruit.

Projection highlights

Avocado has the lowest production level among the major tropical fruits but has experienced the fastest expansion in output in recent decades and is expected to remain the most rapidly growing commodity of the major tropical fruits over the outlook period. Ample global demand, high returns per hectare and lucrative export unit prices continue to be the main drivers of this growth, stimulating investments in area expansion in both major and emerging production zones. By 2032, production is thereby projected to reach 12 Mt p.a. – more than three times its level in 2010. While new growing areas have been emerging rapidly in recent years, avocado production is likely to remain largely concentrated in a small number of regions and countries. The top four producing countries – Mexico, Colombia, Peru and the Dominican Republic – are projected to expand their production substantially over the coming decade, together accounting for over 50% of global production in 2032, with output in Colombia and Peru set to increase by some 60-70% from base period levels. As such, about 66% 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, and facilitated by fast output expansion, avocado is on track to become the most traded major tropical fruit by 2032, reaching 3.8 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 8.7 billion in constant 2014-16 value terms, thereby placing avocado as one of the most valuable fruit commodities. Despite increasing competition from emerging exporters, Mexico is expected to retain its leading position in global exports at a 40% share in 2032. This will be supported by output growth of 3.6% p.a. over the coming decade and continued growth in demand in the United States, the key importer of avocados from Mexico. Exports from Peru, the second leading exporter, will reach some 24% of global shipments, with supplies mainly catering to rising demand from the European Union.

The United States and the European Union, where consumer interest in avocados is fuelled by the fruit's claimed health benefits, are expected to remain the main importers, with 44% and 27% of global imports in 2032, respectively. However, imports are also set to rise rapidly in many other countries such as in China and some countries in the Middle East, on account of rising incomes and changing consumer preferences

in these markets. Similarly, in many producing countries, per capita consumption of avocados is expected to rise with income growth, notably in Colombia, the Dominican Republic and Indonesia. It is important to note, however, that in both domestic and import markets, demand for avocados may be susceptible to changes in the macroeconomic outlook. Given the typically high unit values of avocados, as well as their relatively high income and price elasticities of demand, changes in consumer incomes – or prices – may quickly affect demand. That said, import demand for avocados has exhibited relative resilience to changes in income in both major import markets, the United States and the European Union, where demand also appears determined by changes in consumer preferences, as demonstrated by the fruit's uninterrupted robust growth over the past decade.

11.3.6. Papaya

Market situation

Preliminary trade data indicate a rise in global exports of papayas by an estimated 1% in 2022, to some 0.37 Mt. Exports from Mexico, the largest global exporter of papayas, seemingly grew by some 4% over the full year, on account of further production expansion. Virtually all Mexican papaya exports are destined for the United States, which globally ranks as the largest importer of papayas, accounting for over half of global imports in 2022. The bulk of Mexican papaya production, however, is destined for domestic consumption, meaning that trade outcomes depend critically on developments in both domestic and foreign markets.

Global imports, meanwhile, remained largely stable at some 0.34 Mt in 2022, albeit displaying a slight tendency to contract by an estimated 0.3%. Available data indicate that imports by the United States grew by an approximate 1% in 2022, to some 0.19 Mt, facilitated by the ample supply situation in Mexico, the leading supplier of papayas to the United States. Although the estimated pace of growth was noticeably slower than in 2021, when imports by the United States grew by 5% year-on-year, industry sources stated that demand for papayas in the United States remained solid over the first nine months of 2022. The second leading importer globally continued to be the European Union, albeit with a much lower share in world imports of only 10%. Consumer awareness of papaya in the European Union remains low, mostly due to the fruit's fragility in transport, which renders a significant expansion in this market difficult to attain.

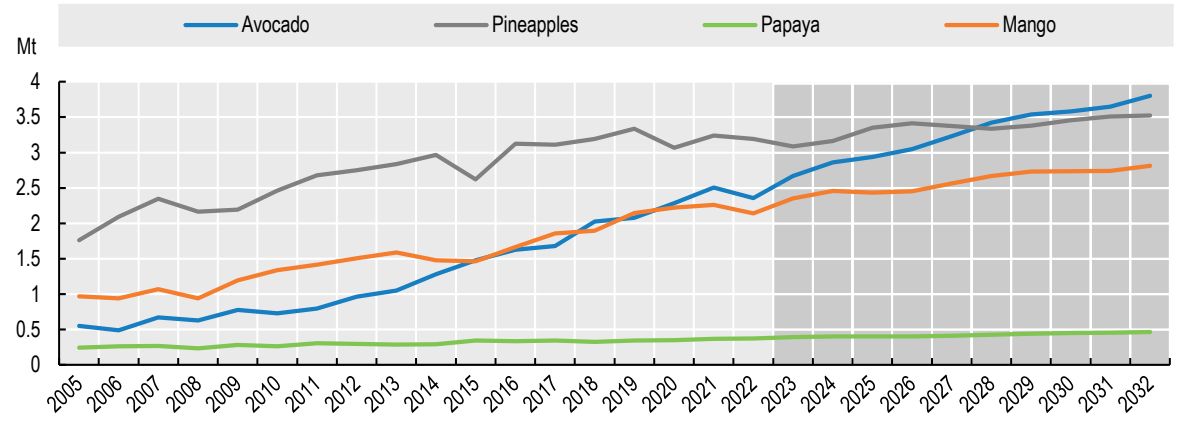
Projection highlights

Global papaya production is projected to rise by 1.9% p.a., to 18 Mt in 2032. As the share of exports in production is particularly low for papayas, at some 2.5% in the base period, production of this fruit is mostly driven by domestic demand due to population and income growth. Against this background, the strongest production expansion is expected to be experienced in Asia, the leading producing region globally, where both drivers are expected to have significant impact. Accordingly, Asia's share of world production is set to rise to 60% by 2032, from 58% in the base period. The world's largest producer, India, is projected to increase its papaya production at a rate of 1.6% p.a., thereby expanding its share of global output to 37% by 2032. Income and population growth will be the main factors behind this rise, with Indian per capita consumption of papayas expected to reach 4.4 kg in 2032, up from 4.1 kg in the base period. In Indonesia, meanwhile, production is projected to grow by 2.8% p.a. over the outlook period, primarily on account of increasing domestic demand as per-capita incomes are expected to expand at over 4% p.a.

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. At an expected average annual rate of 1.9%, global exports of papayas are projected to reach just over 0.46 Mt by 2032. 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. Global exports of the four major tropical fruits



Source: FAO data.

StatLink https://stat.link/on2ldj

11.3.7. Uncertainties

With regard to the outlook, several significant threats to global production, trade and consumption of bananas and major fresh tropical fruits are present. On the demand side, prevailing high inflation rates, high interest expenses and exchange rate fluctuations threaten to hinder the demand for bananas and tropical fruits, especially for consumers in poorer economic strata who need to spend a higher proportion of their income on food. Some analysts have also been predicting a global recession, and while recently released forecasts now seem to rule out this scenario, at least for 2023, should it nevertheless materialize, this may further restrain demand growth. The uncertainties surrounding Russia's war against Ukraine with regard to its impact on global supply chains, fertiliser markets, transport routes and access to export markets add further risks for the outlook.

On the supply side, 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 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 21 countries, predominantly in South and Southeast Asia, but also in the Middle East, Africa, Oceania and Latin America, with Colombia reporting the first infection in August 2019, Peru in April 2021, and Venezuela in January 2023. An indicative 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.

Given the popularity particularly of bananas, pineapples and avocados in import markets, their global value chains have been characterised by intense competition among market actors all the way to the retail level. For bananas and pineapples, this has exerted downward pressure on prices at each stage, which has resulted in producer prices remaining at low levels, with little fluctuation. Combined with rising production costs, low prices and tight profit margins greatly hinder the adequate remuneration of workers and smallholder farmers in these industries and act as a major obstacle for producers in coping with emerging challenges and supply chain disruptions. The prospects for production are therefore further threatened by an elevated risk of industry contraction, with producers discouraged to continue their operations by low or even negative producer margins, reducing supplies to world markets and consequently causing higher food prices. Data on developments in world export and import markets over the course of 2022 already point to this direction, with all key regions being affected.

Note

[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)

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: https://www.woah.org/en/disease/african-swine-fever/)
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 https://www.woah.org/en/disease/avian-influenza/)
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. There are two major forms of biodiesel: fatty acid methyl esters (FAME) and hydrogenated vegetable oil (HVO).
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 fibre of BT cotton plants is shorter than that of traditional varieties.
Caloric sweeteners	Defined as sucrose and high fructose syrup.
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 (milled).
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 for country grouping in the *Agricultural Outlook*.
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 feedstocks 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.
Fertiliser	Fertilisers provide essential nutrients for maintaining agricultural crop yields and quality, and for growth in production. The three most important nutrients are nitrogen (N), phosphorus (P), and potassium (K).
Flexible-fuel vehicles (FFVs)	Vehicles that can run on either gasohol or on hydrous ethanol.
Foot and Mouth Disease (FMD)	FMD is the most contagious disease of mammals and has a great potential for causing severe economic loss in susceptible cloven-hoofed animals (https://www.woah.org/en/disease/foot-and-mouth-disease/). International animal trade is linked to the FMD-status according to the World Organisation for Animal Health (WOAH).
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 Sweetener (HFS)	Starch-based sweetener extracted mainly from maize (high fructose corn syrup or HFCS).
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 market 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(xt) = 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; 1 October in Australia • Cotton: 1 August • Maize: 1 September; 1 March in Australia • Other coarse grains : 1 September; 1 November in Australia • Sugar, soybeans, other oilseeds, protein meal, vegetable oils: 1 October; 1 November in Australia. Whenever the text refers to, for example, the marketing year 2021, this is short for 2021/22 for the above commodities. For all other commodities, the marketing year is equal to the calendar year except for meat and dairy products in New Zealand and beef and dairy products in Australia: year ending June 30.
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. This agreement entered into force on 1 July 2020.
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).
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.
Sugar	Sucrose produced from sugar beet and sugarcane
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).
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 annex provides information on how the projections in the *Agricultural Outlook* are generated. First, it provides a general description of the different elements and timeline of the process leading to the agricultural baseline projections and the *OECD-FAO Agricultural Outlook* publication each year. Second, it discusses the consistent assumptions made on the projections of exogenous macroeconomic variables. Third, it provides reference to the underlying Aglink-Cosimo model. Finally, it explains how a partial stochastic analysis is performed with the Aglink-Cosimo model.

The generating process of the agricultural baseline projections

The projections presented in the *Agricultural Outlook* 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. Significant expert judgement, however, is applied at various stages of the *Outlook* process. The OECD and FAO Secretariats publish in the *Agricultural Outlook* a unified and plausible assessment of the future developments of the main agricultural commodity markets given the underlying assumptions and the information available at the time of writing.

The starting point: Creation of an initial baseline

The historical data series for the consumption, production, trade[1] and international prices of the various commodities covered in the *Outlook* are mainly drawn from OECD and FAO databases. These databases are largely based on national statistical sources. For each publication, the baseline generating process begins in November of the year preceding the projected decade and ends in April of the following year. 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 addressed to national administrations is circulated in November to obtain countries' expectations of the medium term developments of their agricultural sector , as well as insights on the current status or recent changes of domestic agricultural policies.
- On the FAO side, the starting values for the country and regional modules are developed through model-based projections and consultations with FAO commodity specialists.

Macroeconomic factors obtained from 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 macroeconomic and policy assumptions are summarised in the first section of the Trends and Prospects 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 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.

The initial baseline results are then reviewed:

- For the countries under the responsibility of the OECD Secretariat, 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 experts. 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 in March, 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 experts 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 *Agricultural Outlook* delves into the finale baseline projections to provide an overview as well as more detailed analyses of the world agricultural markets over the medium term. The report 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

The *Outlook* uses the Medium Variant set of estimates from the United Nations Population Prospects database for the population data used for all countries and regional aggregates. 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. 112 (December 2022). For other economies, historical macroeconomic data were obtained from the IMF, *World Economic Outlook* (October 2022). Assumptions for 2023 to 2032 are based on the projections of the IMF *World Economic Outlook*, October 2022.

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 2021 is taken from the short-term update of the *OECD Economic Outlook* No. 112 (December 2022). For 2022, the annual average daily spot price is used, while the December average daily spot price is used for 2023. For the remainder of the projection period, the reference oil price used in the projections is assumed to remain constant in real terms. .

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 consistent baseline projections presented in the *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 cover the whole world. The OECD and FAO Secretariats in conjunction with country experts and national administrations are responsible for developing and maintaining the projections. 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 affects 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 or dynamic yield expectations). Aglink-Cosimo models ten years into the future.

The modelling framework is regularly improved to develop the *Outlook's* capacity to reflect future markets developments and to provide an enhanced analysis of beyond market outcomes (e.g. food security, land use and environmental outcomes).

As of the 2022-2023 *Outlook* cycle, the Secretariats have explicitly incorporated the use of the three main mineral fertilisers (Nitrogen, Phosphorus and Potassium) into the yield equations that determine the supply of crop commodities. This new feature separates the costs of fertilisers from those of other production inputs (energy, seeds, machinery, labour and other tradable and non-tradable inputs). Historical data series for fertiliser use per crop has been developed by combining existing information on total use from FAOSTAT with per crop estimates from the International Fertilizer Association.

Food loss and waste has been incorporated in the *OECD-FAO Agricultural Outlook 2023-2032*. Box 1.1 provides a more detailed overview of the definitions, global estimates and drivers. In terms of implementation in the data and Aglink-Cosimo, two shares have been added: one for distribution losses and one for waste. Consequently, three different values for food use of agricultural commodities are available. Firstly, food availability which was the value used in previous *Agricultural Outlooks*. Secondly, after subtracting losses food consumption is obtained. Currently, this is the main reference value used throughout the report and tables. Thirdly, food intake is the quantity after accounting for waste. The current values of loss and waste are preliminary, and this integration is still in progress.

The latest detailed documentation of Aglink-Cosimo model is available on the official website of the *Agricultural Outlook* 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.

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 2022-2031 projection period, one year of the historical period 1995-2021 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 Aglink-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.