Food and Agriculture Organization of the United Nations

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FOOD SYSTEMS PROFILE - PAPUA NEW GUINEA

Catalysing the sustainable and inclusive transformation of food systems

Papua New Guinea

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Catalysing the sustainable and inclusive transformation of food systems

Published by
the Food and Agriculture Organization of the United Nations
and
the French Agricultural Research Centre for International Development
and
the European Union
Rome, Montpellier, Brussels, 2023

Required citation:

FAO, European Union and CIRAD. 2023. *Food Systems Profile – Papua New Guinea. Catalysing the sustainable and inclusive transformation of food systems.* Rome, Brussels and Montpellier, France. https://doi.org/10.4060/cc7056en

ISBN 978-92-5-138007-9

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FOOD SYSTEMS PROFILE PAPUA NEW GUINEA

Key messages

The Independent State of Papua New Guinea (Papua New Guinea), the third largest island country in the world and the largest in the Pacific, is situated just north of Australia. The country has an area of 462 840 km^2, of which one-quarter has been classified as arable with low, medium and high agricultural potential. The country has an altitude range of from 0 to 4 509 m above sea level, which provides **various business and regional trade opportunities in agriculture, fishery and forestry as well as tourism** at its different elevational zones. **Papua New Guinea has one of the most rugged topographies in the world and a large geographical diversity with offshore islands, lowland forests, vast marshes, dry savannah lands and temperate highlands**. Only about 13 percent of the country is inhabited, while about 80 percent of the land is covered by forests, which are home to a huge biodiversity (Globalsecurity.org, 2020–2023). The country has an extensive fisheries zone of 2.4 million km^2, the largest in the South Pacific, which includes an extended reef system, numerous islands and an extensive coastline. **This diverse topography provides a base for a variety of agricultural production**. For instance, the rich highland soil is perfect for growing greens and root vegetables and for supporting game animals. The major foods produced in the less fertile coastal regions, on the other hand, are coconut, sago, fish and seafood. Foods produced in the Gulf Province are largely coconuts and vegetables. This significant wealth of natural resources and agroecologies, however, have not yet translated to socioeconomic prosperity for most of the country's population.

Some of Papua New Guinea's key challenges in its transition to a sustainable agrifood system, as identified by the four Key Sustainability Questions (KSQs) in this assessment, include:

- **Current agrifood system reinforces the patterns of territorial and gender disparities**. The territorial inequalities in Papua New Guinea are primarily manifested in the wide socioeconomic disparities between rural and urban areas. Beyond urban areas, the incidence of poverty is not significantly different across regions and provinces; a rural household in the highlands is likely to be as poor as that in the islands. Territorial inequalities are accompanied with stern gender inequities in the country, with its value for UNDP's Gender Inequality Index worsening over the last few years to 0.725 in 2019 from 0.580 in 2015 (see KSQ 1), ranking it at 161 out of 162 countries.

- **Inability of the agrifood system to address food insecurity and triple burden of malnutrition**. As per the government's Demographic and Health Survey (DHS) of 2016–2018, more than 56 percent of the households were worried about not having enough to eat. About half of the children (49.5 percent) were stunted (very high category), 14.1 percent suffered from wasting, 13.7 percent were overweight and 48 percent were anaemic (FAO *et al.*, 2021). The rate of chronic malnutrition (stunting) in children under five years (CUFs) have remained unchanged since 1983. In addition, the prevalence of overweight and obesity among adults has increased

and reached about 53 percent in 2016 from 42 percent in 2000 (FAO *et al.,* 2021), contributing to increasing incidences of non-communicable diseases (NCDs), making the country vulnerable to the triple burden of malnutrition (see KSQ 2).

- **Agrivalue chains are unable to tap into the country's agricultural potential and contribute to fostering economic growth and poverty reduction**. The agrifood value chains in the country lack efficiency, evident in terms of low productivity, low quality of produce and high levels of post-harvest losses generating low or negative returns to food systems actors, especially smallholder farmers; high food import dependency and poor food and nutrition security outcomes (see KSQ 3).

- **Agrifood system is increasingly vulnerable to natural hazards and climate change impacts**. Papua New Guinea is at a high risk of exposure and vulnerability to natural hazards, with a ranking of 10 out of 171 countries in 2016. It lies along the 'Pacific Ring of Fire' and is prone to environmental disasters induced by natural hazards, such as volcanic eruptions, earthquakes, tsunamis, cyclones, a rising sea level, heavy rainfall and floods, landslides, and the El Niño. Recurrent damage to infrastructure, upland forests and habitats, as well as to gardens of residents, especially in the highlands, and even loss of human lives are common occurrences. The situation is aggravated by increasing climate change impacts. The rise in maximum and minimum temperatures is expected to be significantly faster than the average temperature, intensifying risks to human health and ecosystems. Rainfall projections are less certain, however, and hazards such as landslides, flash floods and coastal flooding are expected to escalate; and the damage to both population and the economy is projected to double by 2030 (see KSQ 4).

Some of the key cross-cutting drivers contributing to the identified challenges are:

1. **High population concentration in rural areas**. In Papua New Guinea, more than 80 percent of the population live in rural areas, which are characterized by poor connectivity and lack of access to basic infrastructure and services (roads, electricity, education, healthcare, and WASH facilities). The situation has several implications on the agrifood system outcomes in the country:

    - Low human capital formation, while exacerbating women's conditions in rural areas;
    - Lack of access to agricultural input/ output markets and extension services restrict overall development of the agricultural sector, leading to low and poor quality of produce with high levels of post-harvest losses, generating low or negative returns to food system actors; and reducing food availability and affordability;
    - Isolated rural communities lack productive employment opportunities and, thus, low potential for income generation;
    - High dependence on natural resources and, thus, high vulnerability to natural hazards and climate change impacts.

2. **Dominance of customary land tenure system**. In Papua New Guinea, approximately 97 percent of the land is under customary land ownership, which poses a key constraint to the agricultural and rural development of the country, limiting the access of value chain actors to credit. This discourages capital investments by farmers due to lack of security of title as well as private sector participation, thereby limiting the flow of investments and sometimes leading to conflicts among indigenous communities. It impedes overall economic growth and worsens the food and nutrition security situation in the country.

3. **Ineffective implementation of relevant policy initiatives**. There are a number of policy initiatives reflecting the intention of the government to promote an inclusive development, improve the administration of customary land, improve the situation of food and nutrition security, and promote mitigation and adaptation capacity to natural hazards and climate change impacts.

   Some of the country's relevant policy documents include the PNG Government Vision 2050 (2010–2050), PNG Development Strategic Plan (2010–2050), Medium Term Development Plan (MTDP) II (2011–15), MTDP III (2018–2022), the National Nutrition Policy (NNP) 2016–2026, the Nutrition Strategic Action Plan 2018–2023 (NSAP), the National Land Development Plan (NLDP) and several measures exhibiting the government's commitment to adapt and mitigate climate-related hazards at the national and international platforms over the years. However, the implementation of these initiatives remains ineffective, as evident from the poor performance of the relevant indicators. Some of the major challenges include lack of funds and human capital, poor coordination among government units, poor leadership, lack of monitoring and evaluation mechanisms, absence of basic infrastructure and a weak information system.

In view of the some of the key drivers mentioned here, in addition to several others discussed in this assessment, the following **systemic levers have been proposed under the four KSQs**:

1. **In the area of territorial and gender disparities**

   - Strong policy and investment support with adequate implementation to enhance rural accessibility to allow better delivery of services like education and health, improve market access and create potential for better livelihood opportunities to rural communities.
   - Develop an enabling environment to empower women.

2. **In the area of food insecurity and triple burden of malnutrition**

   - Introduce and promote public education and advocacy about dietary diversity, food preparation and diet-related diseases.
   - Enable effective implementation of the relevant policies.

3. **In the area of weak and underdeveloped agrivalue chains**

   - Promoting and strengthening farmer cooperatives/organizations.
   - Creating an enabling environment for value chains actors.

4. **In the area of increasing vulnerability to natural hazards and climate change**

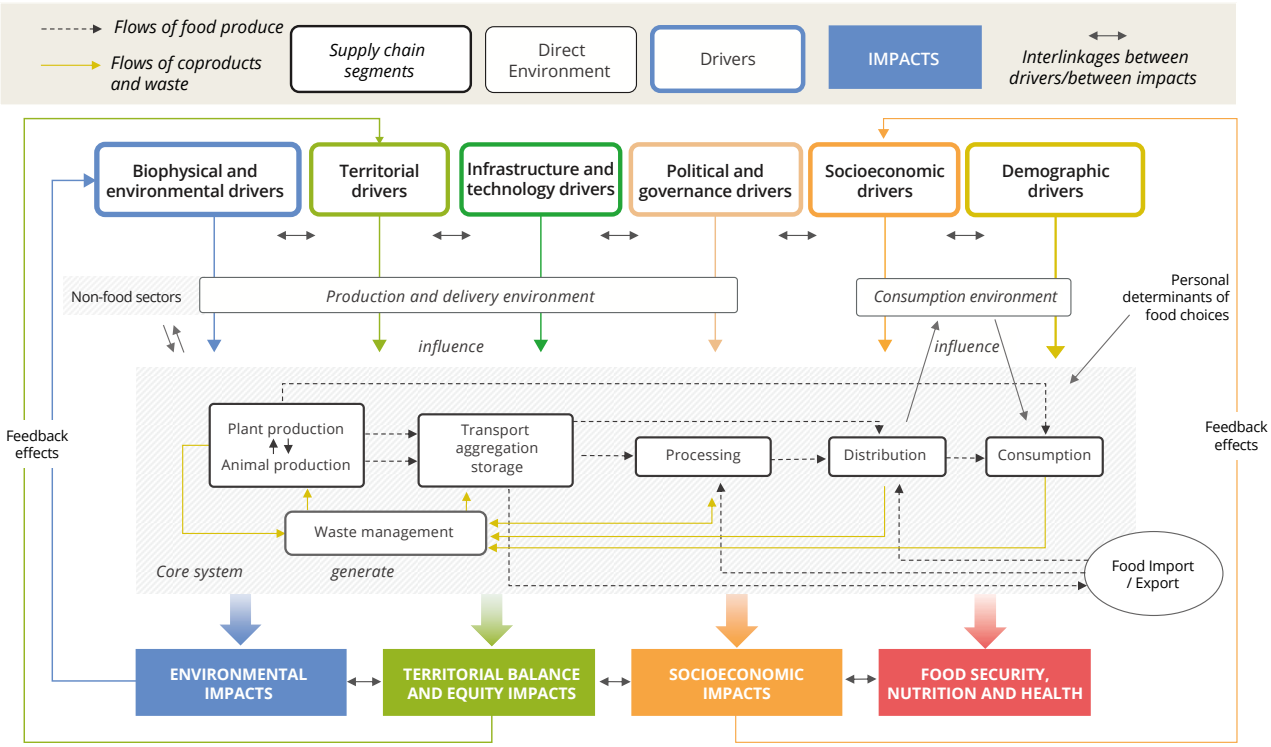
   - Strong policy and regulatory framework for an efficient and sustainable utilization of natural resources, and collaboration with different stakeholders to increase adaptation and mitigation capacity of local communities.
   - Increase national disaster finance and support the creation of a strong national database/ information system for disaster and climate related information.

Methodology and process

This brief is the result of a collaboration between the Government of Papua New Guinea, its Department of Agriculture & Livestock (DAL), the National Agricultural Research Institute (NARI), the Food and Agriculture Organization of the United Nations (FAO) and the European Union, in close collaboration with FAO experts. It was implemented in Papua New Guinea between October 2021 and July 2022. The methodology used for preparing this brief is the result of a global initiative of the European Union, FAO and CIRAD to **support the sustainable and inclusive transformation of food systems**. This assessment methodology is described in detail in the 2021 joint publication entitled, *Catalysing the sustainable and inclusive transformation of food systems: conceptual framework and method for national and territorial assessment* (David-Benz *et al.*, 2022).

The assessment integrates qualitative and quantitative data analysis with participatory processes by mobilizing public, private and civil society stakeholders. The approach includes interviews with key stakeholders and a consultation workshop to refine systemic understanding of the food system and discuss potential levers to improve its sustainability. The assessment process thus initiates participatory analysis and stakeholder discussion on the strategic opportunities and constraints to sustainable transformation of food systems. The approach assesses the actors and their activities at the core of the system, together with their interactions along the food chain as well as the environments directly influencing their behaviour. Conditioned by long-term drivers, these actors generate impacts in different dimensions that in turn influence drivers via a number of feedback loops (see **Figure 1**).

Figure 1. Analytical representation of the food system



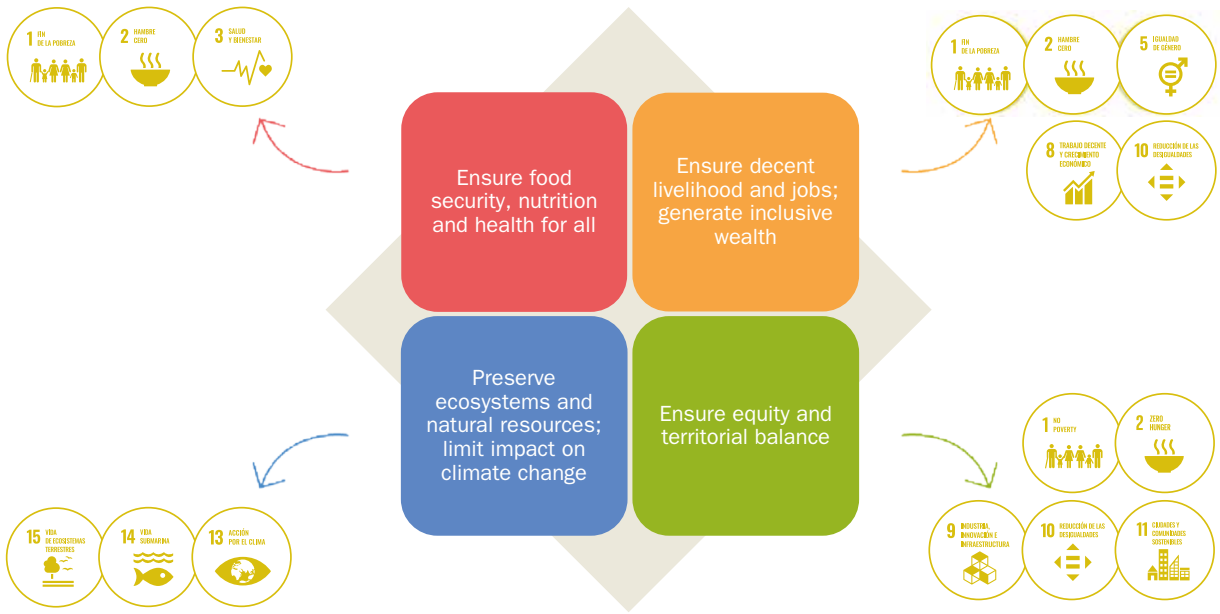
Source: David-Benz, H., Sirdey, N., Deshons, A., Orbell C. and Herlant, P. 2022. *Catalysing the sustainable and inclusive transformation of food systems: conceptual framework and method for national and territorial assessment*. Rome, Brussels and Montpellier. FAO, European Union and CIRAD.

The approach involves a detailed understanding of the key challenges along the four dimensions of sustainable and inclusive food systems: (i) food security, nutrition and health; (ii) inclusive economic growth, jobs and livelihoods; (iii) sustainable natural resource use and environment; and (iv) territorial balance and equity. Aimed at identifying critical issues affecting the sustainability and inclusivity of food systems, the assessment is both qualitative and quantitative in nature. Critical challenges and key food systems dynamics are specified in the form of Key Sustainability Questions, whose answers (see schematic representations for all KSQs) help identify systemic levers and areas of action that are essential to bring about desired transformations in food systems.

This approach is designed as a preliminary rapid assessment for food systems and can be implemented over a period of 8–12 weeks. The methodology has been applied in more than 50 countries as a first step to support the transition towards sustainable food systems.

The Papua New Guinea team comprised three groups: (i) the core team of three national consultants and the global support team – FAO, EU–JRC (EU Joint Research Centre) and CIRAD; (ii) the FAO country office; and (iii) the country team – EU Delegation, NARI and DAL. The process involved extensive internal discussions, followed by the validation of the KSQs, the drivers and levers/entry points to transforming the food systems. In addition, four workshops were held (one virtual and three onsite at Port Moresby, Lae and Mount Hagen). The objective was to get additional insights from stakeholders on the KSQs and the proposed levers, and to stimulate discussions on the transformation of the food systems in Papua New Guinea.

Figure 2. Approach centered around four goals



National context: key figures

Papua New Guinea had a population in 2021 of about 9.1 million (World Bank – IDA, 2022a); people below the age of 25 years comprise about 60 percent of that population (UNFPA PNG, 2022). The country's economy is dominated by two sectors. First, the agriculture, forestry and fishery sectors, which comprise more than half of the country's labour force – approximately 56 percent in 2019 (World Bank – IDA, 2022b); and second, the minerals and energy extraction sector that accounts for most exports earnings and GDP. Job opportunities in the formal sectors are very limited for the growing, relatively young population, alongside other prevalent challenges, such as environmental management, urbanization, political fragmentation, social exclusion, and inequality (World Bank – IDA, 2022c). **Table 1** provides some other important socioeconomic indicators.

Table 1. Country level data – Papua New Guinea

Indicators	2000	2010	2020	Sources (cited 10 March 2022)	Comments
Population growth rate (%)	2.43	2.39	1.95	https://worldpopulationreview.com/countries/papua-new-guinea-population	A fast-growing population, but a marginal decline in the rates
Rural population (% of total population)	86.8	86.9	86.6	https://www.macrotrends.net/countries/PNG/papua-new-guinea/rural-population	Large rural population that needs economic opportunities
Urban population growth rate (%)	0.99	2.16	2.73	https://www.macrotrends.net/countries/PNG/papua-new-guinea/urban-population	Growth rate of urban population between 2000, 2010 and 2020, an indication of rapid increase in rural to urban migration
GDP/capita (USD)	602	1 949	2 757	https://www.macrotrends.net/countries/PNG/papua-new-guinea/gdp-per-capita	GDP has increased fourfold between 2000 and 2020
GDP growth rate (%)	-2.49	10.13	-3.50 1.50 (2021)	https://www.macrotrends.net/countries/PNG/papua-new-guinea/gdp-growth-rate	Large fluctuations owing to macroeconomic factors, and drop in prices of minerals, oil and gas as well as the impact of the COVID-19 pandemic
Inflation rate (%)	15.6	6.01	4.87	https://www.macrotrends.net/countries/PNG/papua-new-guinea/inflation-rate-cpi	The average inflation rate in Papua New Guinea from 2000 to 2020 has been declining
Access to electricity (% of population) Rural Urban	7.6 1.8 (2001) 62.5	19.5 11.8 71.2	60.4 56.8 83.6	https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=PG	Significant improvement over the two decades, especially for rural areas

Access to safe drinking water (%) **Urban** **Rural**	NA	NA	40 (2018) 89 (2015) 33 (2015)	https://www.worldbank.org/en/news/feature/2018/03/20/papua-new-guinea-clean-water-access-to-end-the-walk-for-water-for-women-and-girls#:~:text=In%20Papua%20New%20Guinea%2C%20only,rates%20in%20the%20Pacific%20Islands https://www.unicef.org/png/what-we-do/water-sanitation-and-hygiene	National coverage of 40% is one of the lowest rates in the Pacific Islands. Stark difference between rural and urban areas
People using at least basic sanitation services (% of population) **Rural** **Urban**	18.2 12.1 57.2	18.6 13.3 54.5	19.2 14.7 49	https://data.worldbank.org/indicator/SH.STA.BASS.ZS?locations=PG	There has been a negligible improvement in sanitation services over the two decades nationally, and it has in fact declined in urban areas
Primary school enrolment rate (gross %)	65.32	80	116 (2018)	https://www.indexmundi.com/facts/papua-new-guinea/school-enrollment	There has been a steady increase. Only 35% of children complete primary education due to low school enrolment levels, low teaching quality and poor availability of inclusive education
Forest coverage (%)	80.1	79.6	79.2	https://data.worldbank.org/indicator/AG.LND.FRST.ZS?locations=PG	There has been a steady decline in forest cover

Key figures and trends in food production, consumption and trade

The history of Papua New Guinea's agriculture is about 10 000 years old. However, more is known about the recent past, especially since the 1870s and the onset of permanent foreign settlement in the country. In the 1870s, Papua New Guineans used more than 170 plant species for food, in addition to hundreds of other species used for other purposes like firewood, medicine, tools, home construction, decoration, etc. The most important staple foods included taro, banana, sago and yam. Several plant species that today are sources of carbohydrates, vegetables, fruit and nuts were either domesticated in the New Guinea region or introduced into Papua New Guinea thousands of years ago. Other plant species were domesticated in Asia or elsewhere in the Pacific and later introduced in Papua New Guinea several hundred or thousand years ago. Several other minor foods in Papua New Guinea that were likely to be of significance in the past have now been displaced by more recent introductions (Bourke, 2009).

With the onset of foreign settlement (particularly, Europeans, Asians and other Pacific islanders) from the 1870s onwards, the introduction of new crops and cash cropping have led to the beginning of an important new era in Papua New Guinea's agriculture. Some of the new crops adopted by the villagers had created a significant impact on village agriculture. Sweet potato, which came from Indonesia, had become the main food crop for almost all highlanders by around the 1920s. Corn was widely grown in Eastern Highlands, Simbu and Western Highlands by the 1930s, after first being introduced into the coastal areas during the 1870s to 1880s. Another crop, the pumpkin, was also adopted quickly in the highlands (Bourke, 2009).

Copra was the most important cash crop in Papua New Guinea from the 1880s to the 1970s. Thereafter, the significance of coffee and cocoa increased in the 1960s and 1970s. Other crops like oil palm, tea, tobacco, corn, sorghum and peanut were also grown by individual foreign settlers and large plantation companies. Village cash cropping increased in significance from the 1950s, followed by a decline in the plantation sector after the 1980s.

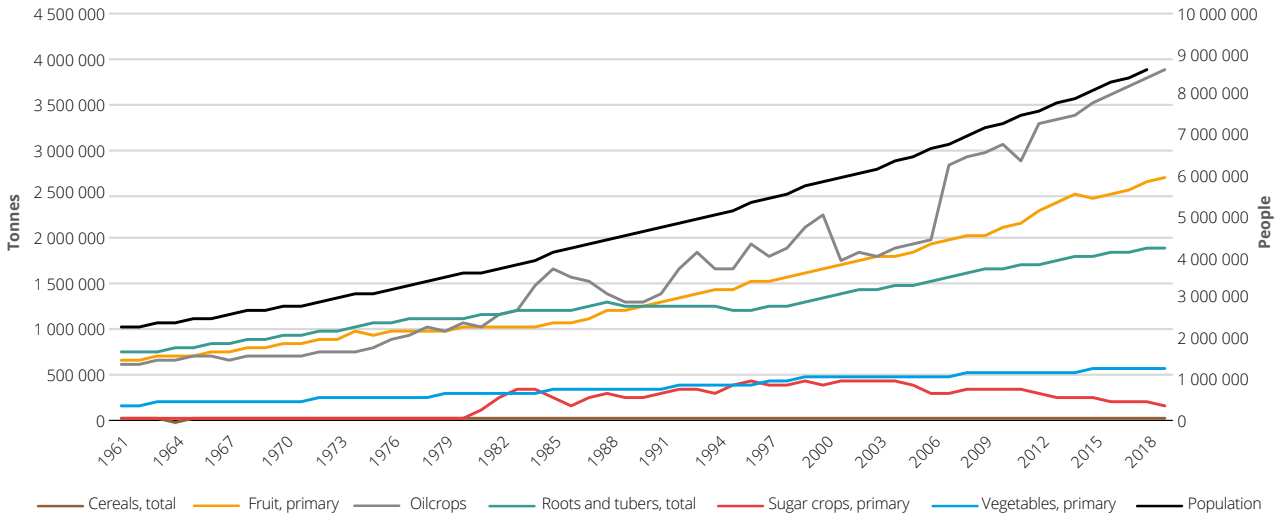
The rate of change in the country's agriculture increased significantly after the 1940s because of factors like the increase in population and pressure on land; cash cropping of cocoa, coffee and coconut, etc., by smallholders; and rise of plant diseases, especially taro blight. **Some of the major changes include**: (i) adoption of new crop species and their extensive production expansion, such as that of sweet potato and cassava, as well as other emerging food crops such as corn, peanut, Chinese taro and Irish potato in different parts of the country; (ii) adoption of more productive crop varieties like sweet potato and banana; (iii) more intensive land use with shorter fallow periods and longer cropping periods; (iv) development or adoption of techniques to maintain soil fertility; and (v) development of new agricultural systems with the integration of export cash crops into the food crop system (Bourke, 2009). **In the discussion below, we focus on trends in agricultural production, consumption and trade in the country over the period 1961–2009**.

Figure 3 represents trends in annual **crop production** in the country from 1961 to 2019, along with the increase in population. The production of oil crops and fruits increased greatly over the period, from about 0.61 million tonnes and 0.65 million tonnes (1961) to about 3.9 million tonnes and 2.7 million tonnes (2019), respectively. Roots and tubers, which dominated production in 1961 at about 0.75 million tonnes, grew at a slower rate and reached 1.9 million tonnes by 2019. Similarly, in the case of vegetables there was a gradual increase, from 0.16 million tonnes in 1961 to 0.56 million tonnes in 2019. The production of sugar started increasing around 1980, reaching about 0.45 million tonnes by the mid-2000s, declining thereafter. This was because the country's largest sugar grower, Ramu Agri Industries, was acquired by New Britain Palm Oil Limited in 2008. Consequently, approximately 2500 ha of sugarcane land was converted to oil palm (Booker Tate Limited, 2022). Currently, oil palm is the largest agricultural commodity in Papua New Guinea, contributing about 40 percent to Papua New Guinea's annual export revenue in the agriculture sector (*Papua New Guinea Today*, 2022).

In case of cereals, although the total production remained the lowest throughout, it increased from 1850 tonnes in 1961 to 0.018 million tonnes in 2019. The cereals grown in Papua New Guinea are maize, rice and sorghum. Maize is the dominant product among cereals with 0.012 million tonnes in 2019 (FAO, 2022a). It is widely grown at altitudes of up to 2500 m in Papua New Guinea as a subsistence food crop and sold in fresh food markets; it is primarily important in locations with seasonal dry climate, like parts of Eastern Highlands (Bourke and Sar, 2020). It is

also widely used for animal feed and commercial starch production (Knoema, n.d.). Moreover, the share of sorghum production was 0.0047 million tonnes in 2019. Rice, which is the staple crop of the country, stood lowest at about 870 tonnes in 2019 (FAO, 2022a). Currently, Papua New Guinea imports about 0.4 million tonnes of rice, valued at around PGK 600 million (about USD 171 million) annually, consisting of about 85 percent of the country's domestic rice demand. There are no large-scale rice farming projects in Papua New Guinea, due to a lack of interest by local and foreign investors in committing to large-scale, highly mechanized, commercial farming in Papua New Guinea. However, the government acknowledges the situation and has introduced measures to boost domestic rice production with its 'PNG Rice Policy 2015–2030' and has also been collaborating with the private sector and development partners (*The National*, 2021).

Figure 3. Agricultural growth (volume in tonnes) over population growth

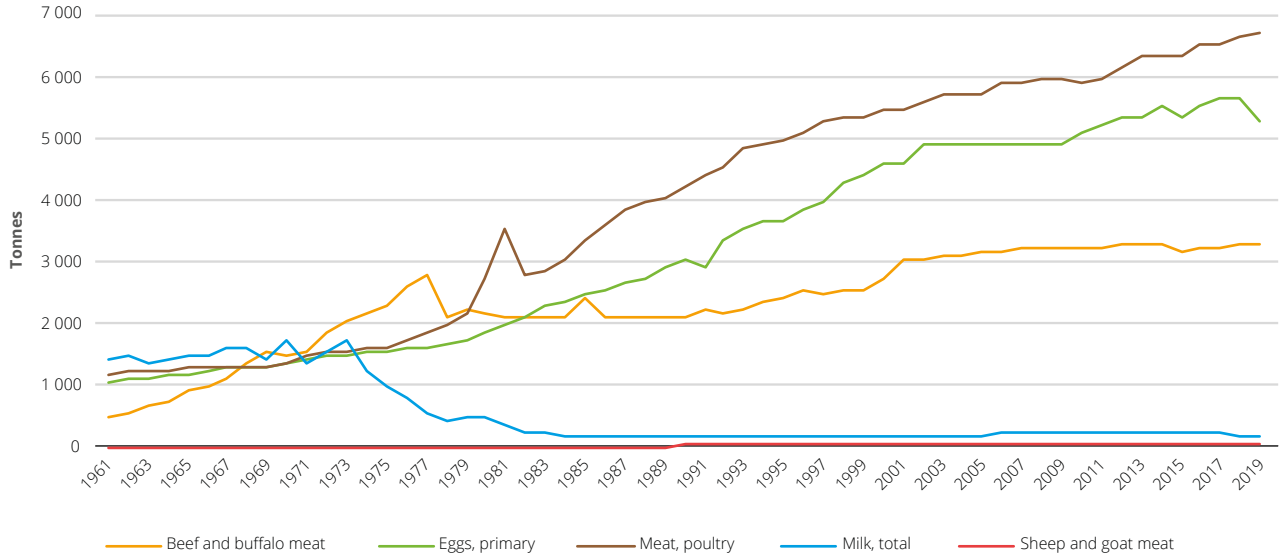


Source: FAO. 2022. FAOSTAT Database. Production [online]. Rome. https://www.fao.org/faostat/en/#data/QCL

The mandate of the Livestock Development Corporation (LDC) in Papua New Guinea includes cattle, pigs, sheep, goats, poultry, rabbits, apiculture (honey bees) and aquaculture. There is no significant commercial production and export of livestock products, except for pigs and poultry. Pigs are extremely valuable commodities in this part of the world, as they are used as bride price, in general commerce and trade, in important ceremonies and feasts, and pig ownership is a status symbol (Lawry, 2022).

Figure 4 reflects the evolution of animal production in tonnes from 1961 to 2019. Milk production started at the highest, but collapsed during the 1970s as the local milk industry could not compete with imported milk. On the other hand, the production of eggs, beef and buffalo meat grew by more than five times during the period. The production of poultry meat grew the most (sevenfold), and has continued to dominate the animal production system since the late 1970s. The production of sheep and goat meat remained the lowest, for reasons which are not clear because of a lack of relevant literature (but most likely due to a lack of policy initiatives in this direction).

Figure 4. Evolution of livestock production (volume in tonnes)

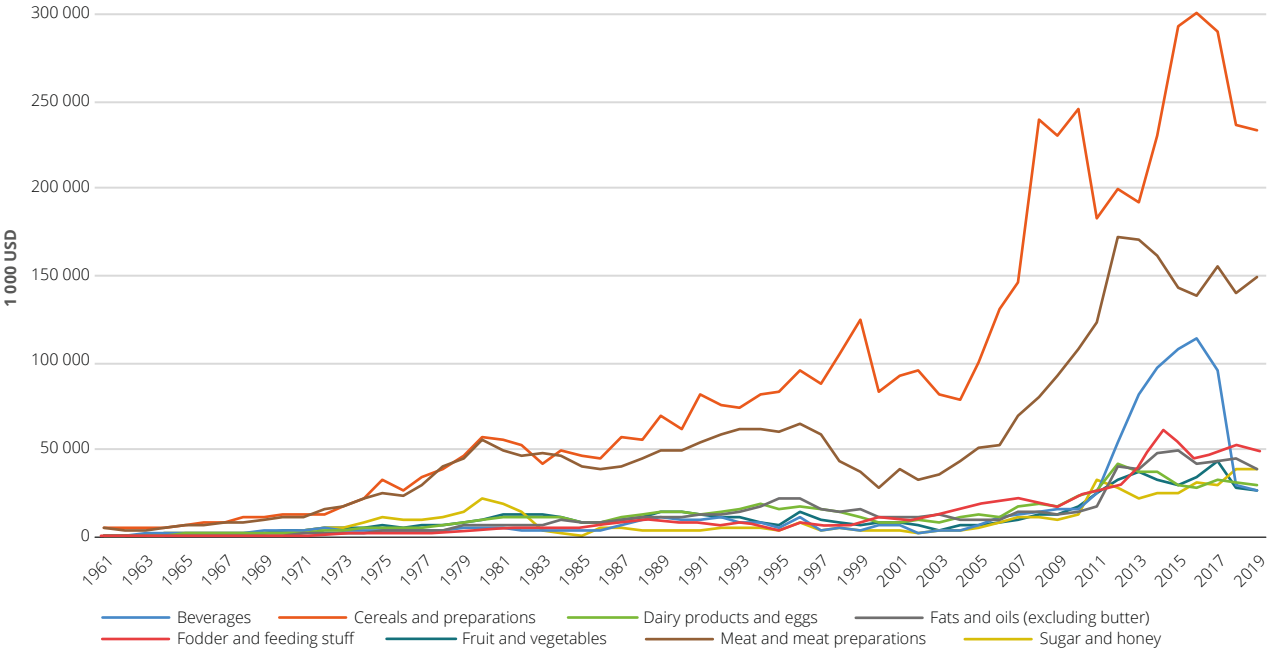


Source: FAO. 2022. FAOSTAT Database. Production [online]. Rome. https://www.fao.org/faostat/en/#data/QCL

Fishery sector: Papua New Guinea has an extensive and valuable fisheries sector varying from inland river fisheries, aquaculture and coastal beche-de-mer (sea cucumber) to reef fisheries, prawn trawl and large-scale deepwater tuna fisheries. The country's fisheries zone of 2.4 million km^2 is the largest in the South Pacific and includes an extended reef system, numerous islands and an extensive coastline. The fisheries potential of the country, however, is yet to be fully utilized. Besides export earnings, the fisheries are important to the local markets and subsistence economy as well, but there is a lack of reliable data on these markets (National Fisheries Authority, 2023).

The estimated total market value of catch in Papua New Guinea is PGK350 million to PGK400 million (roughly USD 99.5 million to USD 113.6 million) on average. The true value, however, is difficult to assess as cyclical factors, commodity price movements, especially for tuna, cause huge value swings on yearly basis. Tuna is the largest fishery product, found throughout the country's fisheries zone, but especially to the north and east. Being a species that is migratory based on climatic conditions, the quantity of tuna found in the Papua New Guinea zone may vary from year to year. The catch is usually around 150 000 million tonnes to 200 000 million tonnes per year, however it is estimated that the resources could sustain higher annual catches up to 250 000 million tonnes to 300 000 million tonnes. The tuna catch in Papua New Guinea comprises 20–30 percent of the regional catch and about 10–15 percent of the global catch percent of the global catch. There are now concerns that yellowfin and bigeye tuna may be nearing an overfished state (National Fisheries Authority, 2023).

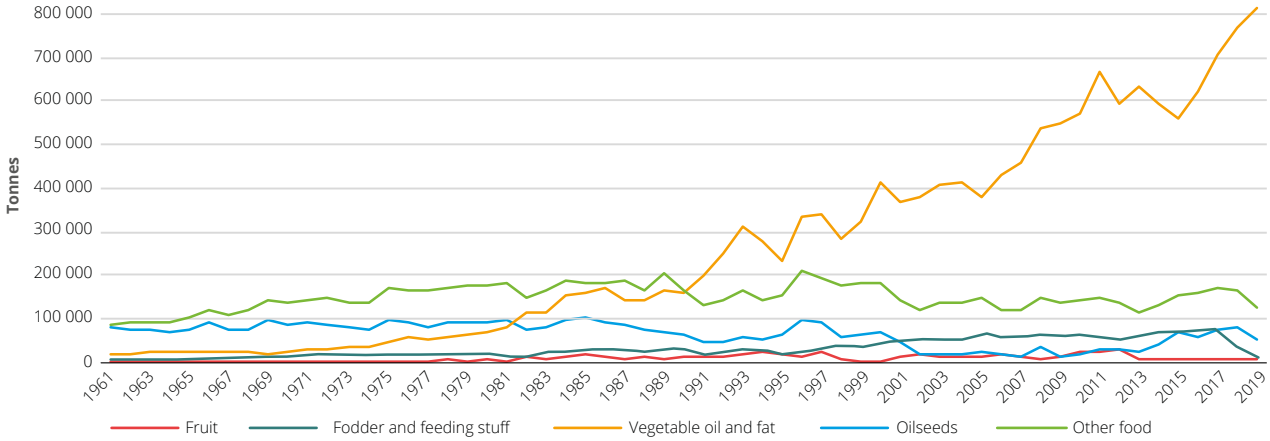
Figure 5. Main products imported in value (USD 1 000)



Source: FAO. 2022. FAOSTAT Database. Trade [online]. Rome. https://www.fao.org/faostat/en/#data/QCL

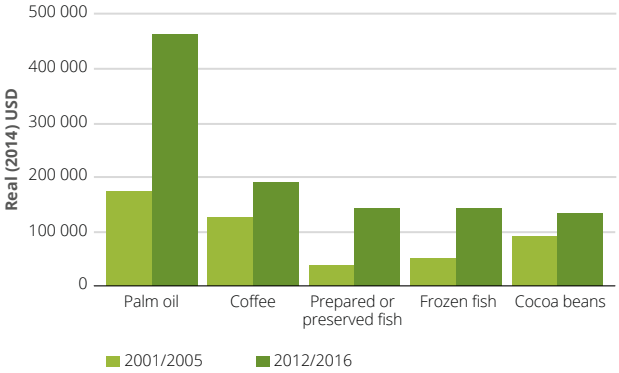
Figure 5 reflects the main product imports in volume terms against the population rise. There has been an increase in imports over the years with increasing population. Cereals formed the dominant share of food imports, followed by meat and meat preparations. The value of beverage imports grew sharply between 2011 and 2016 but declined thereafter. Rice had the major share among cereals, as discussed above. The cereal import dependency ratio was recorded to be as high as 96 percent during the period 2017–2019 (FAO, 2022b). Among meat and meat preparations, poultry meat imports comprised about a 49 percent share in terms of quantity, followed by sheep meat (22 percent), bovine meat (13 percent), pig meat (12 percent) and other meat (4 percent) in 2019.

Figure 6. Main products exports in volume (tonnes)



Source: FAO. 2022. FAOSTAT Database. Trade [online]. Rome. https://www.fao.org/faostat/en/#data/QCL

Figure 7. Real value of largest agrifood exports (real USD 2014)



Source: Schmidt, E. & Fang, P. 2021. *Papua New Guinea Agrifood Trade Trends: Dietary Change and Obesity*. International Food Policy Research Institute (IFPRI) Discussion Paper 02028. June 2021. https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/134433/filename/134647.pdf

Figure 6 reflects the main product **exports** in terms of volume. Vegetable oil and fats formed the dominant share, increasing exponentially over the years, followed by other food commodities. The key agrifood export commodities that the country has invested in over the last several decades include palm oil, coffee and cocoa beans. This increase in cash crop exports is suggested by the production patterns within the country (see **Figure 3**). For instance, the increase in area under palm oil expanded by 6 percent per year on average between 2001 and 2016. Agrifood exports formed an important share in the country's economy, accounting for more than 10 percent of its total exports (2012–2016), making Papua New Guinea a net exporter of agricultural goods. Besides cash-crop development, agrifood exports benefited from the country's suitable geographic location for maritime fishing. There was an increase in exports of prepared or preserved fish during the period 2001–2005 to 2012–2016, with most exports destined to Europe, the Kingdom of Thailand and the United States of America during 2012–2016. The exports of frozen fish also increased by about 10 percent per year. **Figure 7** reflects the real value of the largest agrifood exports in 2012–2016 over 2001–2005 (real USD 2014) (Schmidt and Fang, 2021).

Furthermore, a strong growth was seen in the vanilla sector in the country over the last decade. In December 2017, Papua New Guinea and the European Union discussed developments in a global vanilla market when a kilogram of vanilla was costlier than a kilogram of silver. Being the third-largest vanilla producer in the world, Papua New Guinea experienced a vanilla boom in the Sepik province, the hub of vanilla beans production in the country. Vanilla exports grew from about 75 metric tonnes in 2011 to more than 350 metric tonnes in 2020, fetching export earnings of about USD 40 million. With this trend, vanilla has become a more important crop than copra (coconut) in the country and is catching up with cocoa (USD 70 million export earnings) (World Bank, 2022). Though the vanilla value chain is smaller than the country's major exports, it contributes to poverty reduction for about 17 000 smallholder producers in remote areas. In addition, the domestic value chain supports numerous informal traders, exporters and service providers such as freight forwarders and airlines (European Commission, 2020).

The **dietary patterns** of the country's population are influenced by several factors including their living locations and their accessibility, topography, soil and climate, economic status, degree of adoption of 'Western' versus traditional lifestyles and access to government assistance. The country's traditional diet staples include fish, seafood, sago, sweet potato, taro, taro leaf, cassava, cassava leaf, breadfruit, edible leafy greens, coconut and fruits. The traditional meat is pork, which is often eaten on special occasions (Diversicare, 2012).

There are regional variations. For instance, coastal regions traditionally use coconut milk/cream as a cooking liquid, but not in the highland regions. The highland soil is rich and fertile for green vegetables and root vegetables, beside supporting game animals that form a significant part of the people's diets. In coastal regions, the soil is not as fertile and, thus, the major

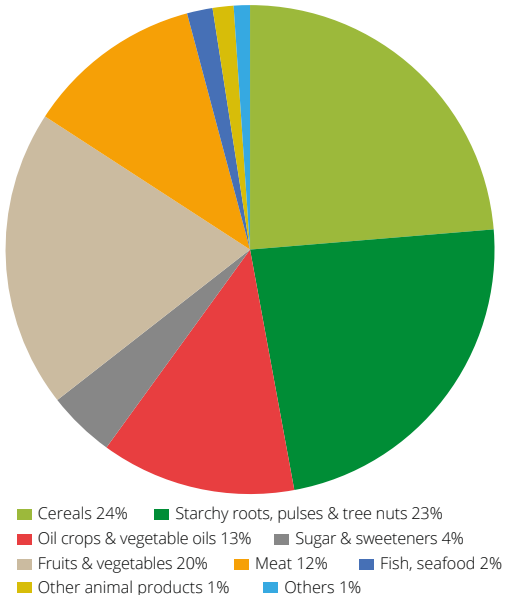
sources of nutrition are coconut, sago plants, fish and seafood. In the Gulf region, meat is often unavailable and, thus, diets consist largely of coconut and vegetables. In urban areas, imported food products are available for those with access to money and fresh local produce can be purchased from daily markets. In remote areas, with minimal external influence and the absence of commerce or employment prospects, bartering food is a common practice (Diversicare, 2012).

Over the years, the foods eaten in Papua New Guinea have changed substantially, with the use of land for cash-crop cultivation and rise in the use of imported foods. Purchased food now make up about one-fifth of the energy intake in people's diets. Common food imports include rice, flour, vegetable oil, tinned meat and tinned fish (State of Queensland, 2017). **Figure 8** shows the food availability by commodity groups in terms of calories in 2018. Overall, it represents a diversified food consumption pattern.

A study comparing the agrifood trade trends in Papua New Guinea during the five-year periods of 2001–2005 and 2012–2016 suggests that agrifood imports made up 14 percent of the total imports between 2012 and 2016, and are important to support food security and dietary diversity. Rice imports formed the largest share (15 percent) of food imports on an average during 2012–2016, which is crucial to maintain food security, especially in peri-urban and urban areas. Since about only half of the country's households consume rice, the estimated annual rice consumption of this segment is relatively high at 67.0 kg/capita, comprising about 30 percent of the minimum daily calorie requirement. Further, the growth in other agrifood imports suggests a shift in demand towards rising consumption of protein-rich foods. Poultry imports (primarily from Australia) increased and grew about thirtyfold on average between 2001–2005 and 2012–2016. Preserved and prepared fish imports also increased considerably by 21 percent per capita during this period, with the Kingdom of Thailand providing the largest share of demand in the form of tinned mackerel for domestic consumption, which is cheaper than the tinned tuna that Papua New Guinea directs towards export markets. Imports of sheep and goat meat was the second highest in terms of value after rice, growing at an average rate of 4.0 percent during 2001–2016. The total imported value of animal feed increased by 11 percent on average over the period (Schmidt and Fang, 2021).

Overall, agrifood imports have led to both healthy and unhealthy food consumption patterns in the country. For instance, annual imports of protein-rich, animal-source foods grew by 8.0 percent per capita during 2001–2016. This indicates a positive transition, providing for a limited livestock sector in the country and low levels of protein consumption across both poor and non-poor households. However, on the other hand, imports of sugary beverages also increased by 12 percent, which represents the largest growth in processed agrifood imports over the analysis period (2001–2016) (Schmidt and Fang, 2021).

Figure 8. Food availability by commodity group (calories)



Source: FAO. 2022. FAOSTAT Database. Trade [online]. Rome. https://www.fao.org/faostat/en/#data/TCL

Characterization of the dominant actors of the food system

In Papua New Guinea agriculture accounts for approximately a third of GDP and employs about 80 percent of the country's workforce, predominantly in smallholder farming. Low yields and weak value chains discourage small farmers from increasing production. It is estimated that only 4.0 percent of the country's land is under commercially oriented agriculture (IFAD, 2017).

Cash-crop production is mostly **centred on plantations** but **significant smallholder production** among rural communities also exists. Small-scale farmers either sell their produce to the plantations, or to the various **community boards acting as centralized buyers and sellers**, established to stabilize prices and increase bargaining power (PwC, 2022). **Coffee and cocoa, two of the main cash crops, together employ nearly half of the total labour force** in the country (IFAD, n.d.).

Oil palm covers a land area of about 58 000 ha (33 000 ha of estate farms and 25 000 ha of smallholder farms, involving about 7000 families). The estates produce 65 percent of the total output and 35 percent is produced by smallholders. The oil palm industry supports about 4.5 percent of rural households. Three major schemes (Hoskins, Bialla and Popodentta) produce the bulk of oil palm in the country. All three operate their own mills producing crude palm oil entirely for exports. The Oil Palm Industry Corporation (OPIC), under the Department of Agriculture, is responsible for providing extension services to the smallholders, out-growers and settlers within the surroundings of nuclear estates of oil palm growing provinces. Its key role is to provide efficient delivery programmes and develop market infrastructure for its smallholders and outgrowers (Papua New Guinea Environment Data Portal, online).

More than 95 percent of the rural population produce **staple food crops** like sweet potato, banana, sugarcane, corn (maize) and **colocasia** taro. Crops such as yam species, Chinese taro and cassava are grown by more than half of the rural population, while other crops such as sago and coconut are grown by about a third of the rural population (Bourke and Allen, 2009). For rice, there are three big manufacturers and distributors – Trukai Industries Ltd (Trukai Rice), Goodman Fielders (Skel Rice) and Homestate Cooperative Ltd (Star Rice). In addition, there are about 12 902 smallholder farmers involved in rice production, using 3 663 ha of the land (*The National*, 2021).

Fresh food marketplaces in Papua New Guinea were largely dominated by producer–sellers[1] until around the 1990s. **Intermediary traders** were slow to emerge and only started to become prominent since the beginning of the 2000s. There is now a growing number of both market intermediaries (who transport fresh produce often from multiple rural producers to urban markets) as well as smaller-scale resellers who buy and sell within a town, either in the same marketplace or in urban corner markets. The prominence of market intermediaries varies considerably from one marketplace to another (Sharp *et al.*, 2022).

Since the 2000s, **four main vegetable wholesalers** have been established: Hilans Fres (Tininga Ltd), NKW Fresh, Innovative Agro Industry (IAI), and the Gembogl Vegetable Wholesaler Group. They have increased their production and/or buy from growers and market fresh foods across the country, and also export them overseas. They have all been established under the Public–Private Partnership (PPP) arrangement.[2]

[1] Producer–sellers are people who sell fruits and vegetables that they have grown themselves, or with their immediate family, directly to the end-consumer.

[2] The information is not available in published sources but has emerged from discussions with the key stakeholders and the experts in the country.

The **gender composition of vendors** in the country's marketplaces has also changed over time, with an increasing number of women vendors. They now form at least 80 percent of the main urban markets. However, in parts of the rural highlands with good access to urban markets, fresh food has become important for men's income, although it is often sold in the marketplaces by female members of the household. Men's participation in the marketplace is often concentrated on particular commodities – such as crops that are generally conceptualized as masculine or of higher value than indigenous one. For instance, in Kimbe, men are more likely to sell store goods than fresh food (Sharp *et al.,* 2022).

The three main stores dealing in agricultural supplies, including fertilizers, seeds, tools, livestock feed and other inputs in Papua New Guinea are Farmset Ltd, Chemica Ltd and Agmark Ltd.[3]

Livestock and poultry sector: the Poultry Industry Association (PIA) estimates that there are up to **10 000 individual micro, small and medium enterprise (SME)[4] chicken growers** in the country (Tom, 2022). They range in size and frequency of operations. Most of the time, it is a family operation and women look after the birds. They are usually the ones selling at the market as well. There were approximately 250 commercial chicken growers registered in 2022. There are four large poultry companies: Mainland Holding Ltd, Zenag, IAI and CLTC. In 2022, the poultry industry was measured to be worth between Kina 950 million (USD 269 million) and Kina 1 billion (USD 283 million) annually. If stock feed is included, then one can add another Kina 300 million (USD 85 million) to the value.

There are more than 36 300 heads of cattle in the formal cattle industry, of which about 645 heads are officially slaughtered every month, equalling about 150 525 kg of carcasses. The large cattle herds are operated by NBPOL as Ramu Agri Industries Ltd. (>24 000 heads), Bulolo Forests Products (1 300 heads), Rumion P/L (5 000 heads) and Sialum (Morobe) (>6 000 heads). There are three abattoirs currently operating in the country.

There are 3 400 sows in total in the formal pig industry, owned by four large piggeries, namely Boroma, Radho, Rumion and Pelgens. As well as these four piggeries, they own three feed mills and four abattoirs, where they officially slaughter about 3900 pigs per month, equalling 239 tonnes of pork.[5]

Forestry: There are between 10 000 and 12 000 people known to be actively involved in the forestry sector. The majority are in logging operations. It is estimated that 4 000 to 5 000 walkabout (portable)[6] sawmills exist in the country. It is hard for the Papua New Guinea Forestry Authority (PNGFA) to give the actual figure because over 95 percent of these sawmills are not registered with PNGFA. They operate on their own, producing timber for themselves or to be sold from the forest. A total of 185 logging companies actively operate in the country. The forestry sector drives over 10 percent of the country's total GDP annually (PNG Forest Authority, March 2022)[7].

Fishery: The range of participants in the fisheries sector covers from artisanal communities and tuna longline operators to large international purse seine fleets in the deepwater tuna fishery (National Fisheries Authority, 2023). There are

[3] The information is not available in published sources but has emerged from discussions with the key stakeholders and experts in the country.

[4] For more information on the SME criteria in Papua New Guinea, please refer to https://www.pwc.com/pg/en/publications/sme-bulletin/sme-bulletin-png-sme-policy-commentary.pdf

[5] The information is not available in published sources but has emerged from discussions with the key stakeholders and the experts in the country

[6] A remote Papua New Guinea forest tribe has a new "walkabout" sawmill to cut logs for exports to Australia as "ecotimber", rather than admit destructive foreign logging companies.

[7] The information is not available in published sources but has emerged from discussions with the key stakeholders and experts in the country.

more than 500 000 people participating in both coastal and **inland subsistence fisheries**. There are **172 SMEs currently** in the fisheries sector. There are six fish canneries and 32 fish cooling/freezer rooms for the fresh fish market in the country (National Fisheries Authority, March 2022).

The tuna industry in the country has evolved from licensed harvesting by international fishing vessels to now include in-country production and canning operations. Papua New Guinea delivers 10–15 percent of the world's tuna percent of the world's tuna catch and has an existing agreement with the EU to allow duty-free exportation of tuna to the region (PwC, 2022). There are now five countries participating in the International Bilateral Fishing Agreement on Harvesting Tuna Stocks in PNG Waters and the Pacific. They are the Republic of the Philippines, Japan, Taiwan Province of China, the People's Republic of China, and the Republic of Korea. A multilateral treaty arrangement exists with the United States of America (National Fisheries Authority, 2023).

Since agrifood system is a broad phenomenon, the **other important actors in the country's agrifood system** include various ministries, i.e., for agriculture and livestock, health, fisheries and marine resources, environment and climate change, transport and infrastructure, rural development, lands and physical planning, commerce and industry, etc. In addition, the National Agricultural Research Institute (NARI) is also an important actor in Papua New Guinea's agrifood system.

Key challenges to the achievement of the core sustainable food systems goals

Key Sustainability Question 1: How does the current food system in Papua New Guinea reinforce patterns of territorial and gender disparities?

This KSQ highlights the strong spatial component associated with disadvantages to rural areas over urban areas in Papua New Guinea. Isolation, lack of productive employment opportunities and a difficult geography appear to be the crucial factors that hinder the socioeconomic development of rural communities. The territorial inequalities are accompanied by stark gender inequities in the country. Women have less access to resources and limited representation in economic and political spheres. Gender-based violence is also a prevalent phenomenon. The discussion below presents the indicators, analyses the drivers and the potential impacts of the current situation and, accordingly, proposes the systemic levers.

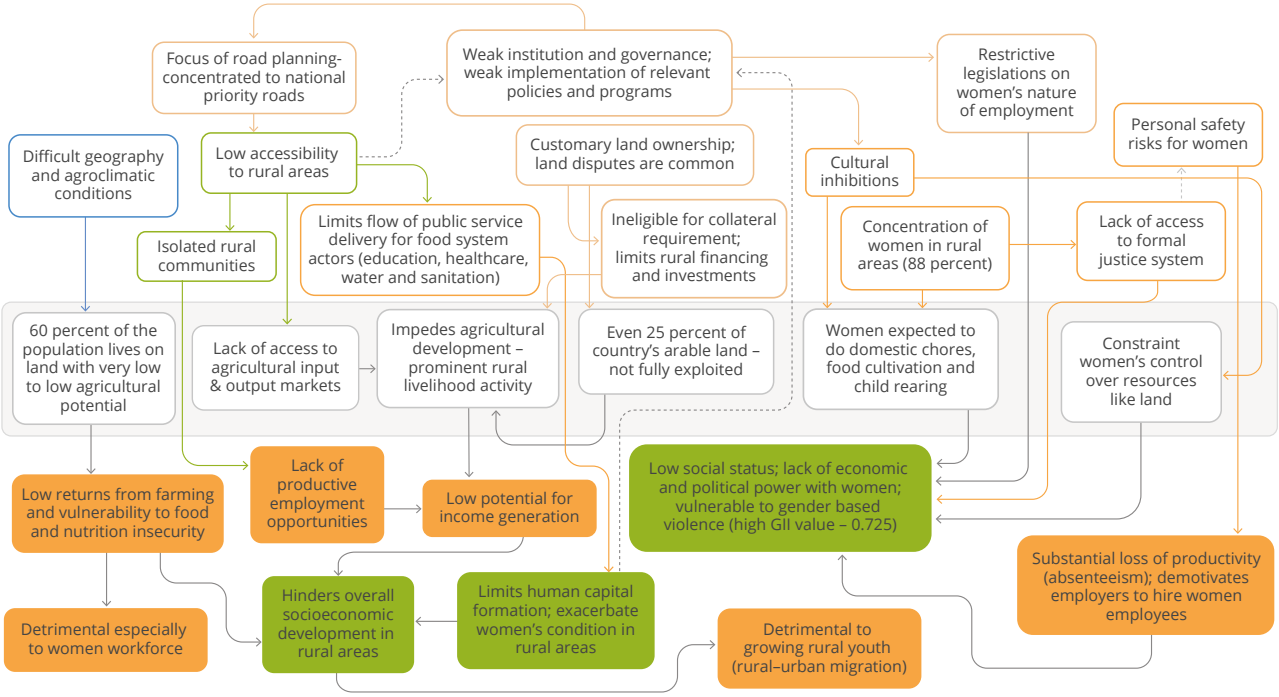
The territorial inequalities in Papua New Guinea are primarily manifested in rural–urban differences. The workforce engaged in agricultural activities is much more likely to be poor as compared to the rest. Beyond urban limits, the incidence of poverty is not significantly different across regions and provinces, and a rural household in the highlands is likely to be as poor as one in the islands. The disparities in the living conditions of rural and urban areas are wide. Today's Port Moresby would be unfamiliar to those who witnessed Independence in 1975, whereas life in rural areas, which is home to over 80 percent of the population, has changed very little. Overall, the consumption inequality, as measured by the Gini coefficient, remains high at 0.42, similar to other countries in East Asia and the Pacific (World Bank, 2018).

As per 2015 data, nationally, the access to safe drinking water was at 40 percent and improved sanitation at 19 percent, which indicates a difficult situation. However, it is to be noted that there is a glaring rural–urban divide. The access to clean water in urban areas stands at 88 percent compared to 33 percent in rural areas, whereas the respective percentages for access to improved sanitation facilities are 56 percent versus 13 percent. Contaminated water and poor sanitation are the primary causes of diarrhoea and dysentery, which in turn are prominent factors behind child undernutrition and mortality. This indicates that rural communities are more prone to such risks than urban communities (World Bank, 2018).

In case of gender inequity, the country's value for UNDP's Gender Inequality Index worsened over the last few years to measure 0.725 in 2019, ranking it at 161 out of 162 countries (UNDP, 2020), up from 0.580 in 2015 (UNDP, online). Women in Papua New Guinea experience gender inequity in terms of access to education and health, access to economic opportunities, voice and agency. Gender-based violence is also a prominent phenomenon in the country. The estimates of a survey revealed that about 70 percent of women have suffered some degree of physical or sexual assault in their lifetime (World Bank, 2018). The share of women in wage employment (38 percent) is little more than half of that of men (66 percent); about 46 percent of the women workforce participate in the informal sector as compared to 15 percent of men, and only 8.0 percent of SMEs have female owners across urban, rural and remote locations. Further, only about 12 percent of women out of the 37 percent of adults maintain bank accounts. In the political sphere, Papua New Guinea is among the five countries in the world with no women members

in its parliament. Despite the fact that the number of women contesting national elections has been rising since 1972, only eight women have been elected so far as representatives to the National Parliament down the years. Thus, women's participation in political decision-making remains marginal at national, provincial and local levels (PNG MTDP III).

Figure 9. Systemic representation of the drivers and impacts of the current patterns of territorial and gender disparities in Papua New Guinea's food systems



Source: Authors own elaboration, 2022.

Key drivers

Low accessibility to rural areas: The higher incidence of poverty in rural areas is aggravated by their comparatively lower access to infrastructure and other services. The country's peculiar geography with its dispersed highlands, coastal areas and islands, dense forests and often rough terrain, makes the provision of connectivity infrastructure a critical factor. Despite this criticality, road access is often limited to low-lying coastal areas and major towns. Rural accessibility is low, with about one-third of the population living more than 2 km away from all-season roads. The situation hinders required service delivery, holds back agricultural development in rural areas and, thus, reinforces high poverty levels (World Bank, 2018).

The communities living in remote rural areas are isolated. The farmers lack access to input and output markets to urban centres and other regions, which impedes agricultural development. Combined with the lack of employment opportunities in other sectors, the situation leads to low potential for income generation for rural communities. The lack of connectivity also limits the flow of government services like health, education, safe drinking water and improved sanitation facilities. Furthermore, it demotivates public servants to accept their postings in rural areas, which leads to absenteeism of the required workforce even from essential public services. These factors combine to deter the formation of human resource capital and reinforce the socioeconomic underdevelopment in rural areas (Palzkill, 2017; Rogers *et al.*, n.d.).

The territorial inequities also exacerbate the disadvantaged position of women. For instance, since 88 percent of the country's women are concentrated in rural areas, the quality and reach of healthcare services to women is a serious concern. Only one-third of women have access to modern contraceptive methods; 66 percent of pregnant women are able to attend four or more antenatal care visits (World Bank, 2018) and only 56 percent of child births were delivered under the assistance of skilled health practitioners during 2014–2019 (UNFPA, online).

Difficult agroclimatic conditions for agriculture development: As mentioned earlier, only 25 percent of the country's land is suitable for agriculture (approximately 115 710 km^2), with only 18 percent of this cultivable land to have medium and high potential (approximately 20 828 km^2). About 50 percent of the total land area is mountainous, 20 percent is seasonally or permanently flooded, combined with high rainfall, a long dry season and excessive cloud cover. The mentioned agroclimatic conditions pose major constraints for the agricultural sector's development, which is a prominent livelihood activity in rural areas. Agriculture employs about 57.8 percent (2020 est.) of the total workforce but its share in the country's GDP is only about 18.4 percent (2021 est.) (UN, online). This indicates poor returns from agriculture and, thus, hinders the country's overall socioeconomic development. This is particularly detrimental to the female workforce, who is mainly employed in informal and subsistence crop production (World Bank, 2018).

Only 40 percent of the country's population has access to its limited, medium to high potential agricultural land (about 4.5 percent of the total land area). Lands with high production potential are found in places such as the Gazelle in East New Britain Province (volcanic soils), the Wahgi Valley in Western Highlands, Jiwaka Provinces and Goroka Valley in Eastern Highlands Province (volcanic/alluvial soils). Soils with low agricultural potential are found in most parts of the country, including Simbu Province (hilly soils), Gulf and Western Provinces with swamp inundation. Naturally, the crop diversity (more legumes) and productivity are higher in rich soils. The remaining 60 percent of the population who live on land with very low to low agricultural production potential for most food and cash crops suffer from low incomes, and food and nutrition insecurity. They also forms a large share of the population living below the poverty line. (Komolong, *et.al.* 2011).

Customary land ownership: In Papua New Guinea, 97 percent of land is under customary ownership, i.e. owned by its traditional familial owners (see **Table 2**). Given this, instances like land disputes or land alienation by threats that can turn violent can create tension among communities (Yala, 2006). Even the limited 25 percent of the country's arable land cannot be completely used for agriculture.

Customarily held land is often considered ineligible to fulfil collateral requirements, given the uncertainty around the land tenure regime and constitutional restrictions on land ownership. In development projects that involve large acquisitions of land, the process of making land assessments, and identifying and compensating landowners can turn out to be costly and time-consuming. Factors such as the non-registration of land ownership, the need for social mapping followed by public notification, and exaggerated compensation claims by customary owners are all well known to create constraints on the country's land supply. This situation acts as a significant obstacle to development in rural areas and consequently limits the potential for productive employment opportunities. The result is particularly detrimental to the growing youth population and leads to increased rural–urban migration (World Bank, 2018).

Table 2. Broad divisions of land tenure structure in Papua New Guinea

Titles	Customary Title	Alienated Land		Total Area (ha)
		State Land	Private Freehold*	
Land area (ha)	46 310 400	870 200	435 100	47 615 700
Proportion of total	97%	2%	1%	100%

*Includes conditional freeholding

Source: Armitage, L. 2001. *Customary Land Tenure in Papua New Guinea: Status and Prospects*. Queensland University of Technology, Brisbane, Australia. https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/589/armitage.pdf .

Key drivers for gender inequity: These include cultural dynamics, restrictive legislations and personal safety risks. As mentioned earlier, about 88 percent of the country's women live in rural areas. In a traditional village, a woman is often expected to perform domestic duties, including food cultivation, gardening, cooking and child rearing. At some places, ongoing traditions like 'bride price' lead to women being treated as a tradable property (AUS–PNG Network, 2022). The societal norms are reinforced by related legislative restrictions on women in Papua New Guinea, for example, not to engage in work that involves night hours, or in work that is considered to be physically strenuous or need working underground. This hinders women from taking up opportunities in higher-paying industries, such as mining and manufacturing. According to the World Bank (2016), Papua New Guinea has the most gender-based differences legally (World Bank, 2018).

Cultural inhibitions constrain women's control over resources. Customary laws allow women to have limited rights over customary lands. They are most often not permitted to claim rights over land and property, nor to enforce any income from cash crops or land leases, extractive or logging activities. These aspects are crucial for women's economic empowerment, to earn a sense of self-esteem, to gain respect in the family and society, for mobility, or to step outside their homes, and to have decision-making powers. Further, a higher vulnerability to sexual assault, burglary, and extortion majorly limits economic opportunities for women. These risks also cause substantial loss of productivity because of associated absenteeism and lack of timely support from fellow workers in case of gender-based violence. A poor security environment also discourages employers from hiring women employees. Furthermore, the lack of representation of women in political affairs worsens the situation and also suggests the way the present justice

system deals with this matter. The courts in villages would normally follow customary principles, which may not favour women, and it is often difficult to access the formal justice system in rural areas, especially for women (World Bank, 2018).

Weak implementation of relevant policies and programmes: As shown in the relevant policy documents (e.g., the PNG Government Vision 2050 (2010–2050); PNG Development Strategic Plan (2010–2050); MTDP II (2011–15); and MTDP III (2018–2022)) the Government of Papua New Guinea clearly acknowledges the importance of inclusive development. These policies, which are crucial for the whole country, aim to bring prosperity to rural areas by improving transport infrastructure and other services like education, health, electricity and business opportunities. In doing so they should ensure an equal opportunity to each and every citizen, irrespective of gender, to reach their potential.

The need to spread awareness about the roles of women and men in development is recognized (PNG DSP, 2010). MTDP III (2018–2022) estimated that bridging the gender gap in formal employment could increase the country's household income by 14 percent by 2020. However, these goals seem far-fetched, as there is little sign of progress. MTDP III aimed to bring down the Gender Inequality Index (GII) value from 0.58 in the base year to 0.40 by 2020. However, in reality the GII increased to reach 0.725 in 2019. In the 2018 Logistics Performance Index Global Ranking, Papua New Guinea's overall ranking was 148 out of 160 countries and the score for infrastructure was 1.97 (on the scale of 1 to 5). This shows only minor difference from 2010, when the overall rank was 124 out of 155 countries and the score for infrastructure was 1.91 (World Bank, 2022).

Although these principal documents outline the country's policy ambitions, there is a lack of concrete targets to mainstream these issues across sectors and programmes. Furthermore, there are some critical constraints on inclusive growth in Papua New Guinea. They include weaknesses in governance and institutions, especially those linked to public service delivery, the maintenance of law and order, combating corruption, and managing land and land titles (ADB, 2012). Using World Bank data, in terms of governance effectiveness Papua New Guinea scores -0.85 (on a scale of -2.5 weak to +2.5 strong) in 2020 compared with an average of -0.03 for 192 countries. In addition, there is a dearth of skilled manpower due to poor and unequal access to quality education. An absence of adequate infrastructure and quality health services creates a road block by preventing people from accessing relevant opportunities and adversely affecting productivity (ADB, 2012).

Potential impacts

The inclusion of 'Gender Equality' and 'Reduced Inequality' as two of the 17 SDGs highlight the importance of these issues for the country's economic growth and development. A majority of the country's population (about 87 percent) live in rural areas (UN, online) and this includes 88 percent of the women in the country. In view of this, if rural areas remain outside the focus of the country's development trajectory, the resultant growth will be both highly skewed and much slower. Papua New Guinea has a young and growing working-age population, with a larger proportion of those born and growing up in rural areas. Thus, without adequate infrastructure and basic services like health, education and WASH facilities, the country will be failing to take advantage of its human wealth, which otherwise could bring about a major transformation in the country's food systems. Given the subsistence nature of most agriculture and the lack of other productive livelihood opportunities, the youth (mostly unskilled and less educated) will continue to migrate from rural to urban areas in search of better employment prospects. However, this would leave them with little choice but to join the informal economy in urban areas, where they continue to be underemployed and relatively unproductive (World Bank, 2018). In the case

of women, if they continue to be deprived of opportunities and remain the target of social evils, the country's route out of poverty would remain a steep challenge. An educated and empowered woman can potentially play a crucial role in reducing household poverty and ensuring food and nutrition security for her family.

Proposed systematic levers

1. **Strong policy and investment support with adequate implementation to enhance rural accessibility to allow better delivery of services like education and health, improve market access and create potential for better livelihood opportunities to rural communities**: The target should be to improve feeder road infrastructure and build new roads for transport connectivity to rural areas, with commitment to maintenance of current airstrips and wharves and jetties as needed. Also, to improve communication exchange with more rural Digicel/B mobile towers. Enhanced connectivity will allow delivery of basic services to rural communities like education and health. Improved roads will facilitate access to agricultural input–output markets, which will contribute to the sector's development. This could also stimulate other business start-ups like eco-tourism, food-based cottage industries and fish and livestock farming, etc., and provide private investors with better access to rural districts with economic potential.

2. **Develop an enabling environment to empower women**: There is a need for women to have access to resources, economic opportunities and basic services (like education and healthcare), facilitate them with new agricultural information and life skills training. Also, it is important to have female role models and to sensitize men to advocate for their girl children and wives. Having women in positions of power in business or public offices, will earn them a great deal of respect by their family and community in general. It will allow them to have decision making powers in financial matters at the household level or in running a business. An educated mother and a wife can take care of the nutrition requirements of her family. This will also contribute in addressing the grave issue of gender-based violence.

Key Sustainability Question 2: Why does Papua New Guinea's agrifood system fail to address the issues of food insecurity and the triple burden of malnutrition across the country?

This KSQ attempts to better understand and obtain insights on the main drivers of food insecurity and issues related to the triple burden of malnutrition (undernutrition, overnutrition and micronutrient deficiencies) in rural and urban Papua New Guinea, including, climate variability, limited infrastructure, policy implementation gaps, as well as limited awareness and nutrition education.

Despite being endowed with abundant natural resources (factors of production such as land, natural forest, and water resources), the country faces huge food security challenges, leading to hunger and malnutrition for the majority of the population. According to Papua New Guinea's Household, Income and Expenditure Survey (HIES) of 2009/2010 (NSO, 2010), on average about 42 percent of the population are considered food poor, i.e., not meeting the daily recommended energy intake of 2250 kcal/person. The same study reported that about 40 percent of the population is considered to live below the national poverty line of Kina 1449 (around USD 410). The government's Demographic and Health Survey (DHS) of 2016–2018 confirms the enduring persistence of food insecurity in the country (NSO and ICF, 2019). As shown in **Table 3**, about 56 percent were worried about not having enough to eat; 44 percent ran out of food; and 32 percent said they went at least one entire day without food over the last 12 months.

Food insecurity and hunger lead to various manifestations of malnutrition and serious health and livelihood issues affecting many households in the country. Malnutrition is severe and labelled as a "silent emergency" by UNICEF (2014). It denotes an incongruous situation in which large shares of the national population are either hungry, suffering from micronutrient deficiencies (hidden hunger), or dealing with the consequences of overweight and obesity, or more than one of these conditions (overnutrition, undernutrition and micronutrient deficiencies) simultaneously (UNICEF, 2021a). Thus, the country suffers from the chronic "triple burden of malnutrition", or the coexistence of undernutrition (stunting, wasting and underweight), overnutrition (obesity and overweight) and micronutrient deficiencies. Moreover, a recent UNICEF (2021b) report highlighted that malnutrition is the main underlying cause of most deaths of CUFs, contributing to 50 percent of all hospital admissions. More concerning still is that it not only limits children's growth outcomes but also their future learning and their overall life course, which perpetuates an intergenerational cycle of malnutrition and poverty.

Table 3. Papua New Guinea households with various forms of food insecurity, by residence (%)

		Urban	Rural	Total
Over the last 12 months, was there a time when you or any member of your household ...	... were worried about not having enough to eat?	50.5	57.1	56.3
	... were unable to eat healthy and nutricious food?	50.7	61.9	60.6
	... ate only a few kinds of food?	59.6	66.7	65.9
	... had to skip a meal?	51.4	56.1	55.5
	... ate less than you thought you should?	53.4	58.1	57.6
	... ran out of food?	41.7	43.9	43.6
	... were hungry but did not eat?	38.7	41.4	41.1
	... went without eating for a whole day?	30.4	31.8	31.6

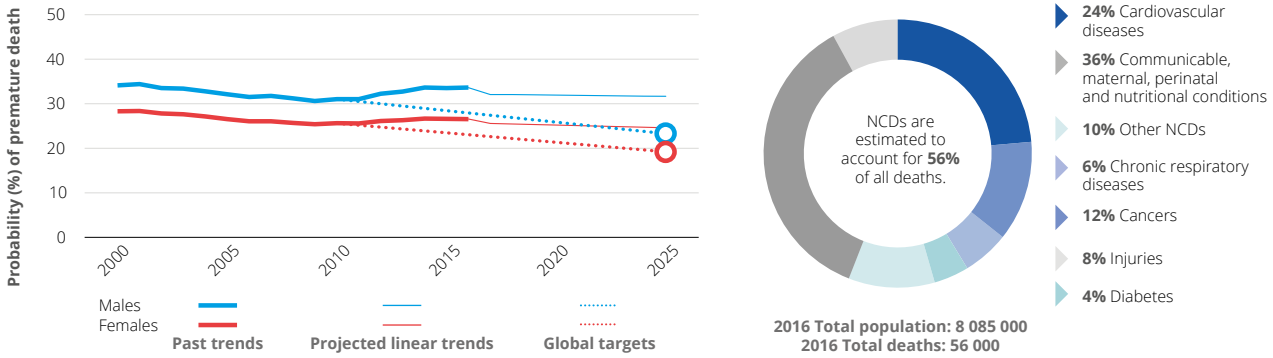
Source: National Statistical Office (NSO) and International Classification of Functioning, Disability and Health (ICF). 2019. *Papua New Guinea Demographic and Health Survey 2016–18*. Port Moresby, Papua New Guinea, NSO and ICF. Available at https://www.dhsprogram.com/pubs/pdf/FR364/FR364.pdf

The percentage of CUFs in the country who are not growing adequately (stunted, wasted or overweight) is 66 percent, the highest in Asia Pacific. About half of the children (49.5 percent) in the country are stunted (very high category), 14.1 percent are suffering from wasting, 13.7 percent are overweight and 48 percent are anaemic (FAO *et al.,* 2021). The rates of chronic malnutrition (stunting) in CUFs have remained unchanged since 1983 (Grundy *et al.,* 2019).

Poor nutrition not only causes health complications for children but adults as well. The prevalence of anaemia in women of reproductive age (WRA), taken to be 15–45 years of age) was 36 percent in 2016. The prevalence of overweight and obesity among adults in the country is still increasing, rising from 42 percent in 2000 to reach about 53 percent in 2016 (FAO *et al.,* 2021).

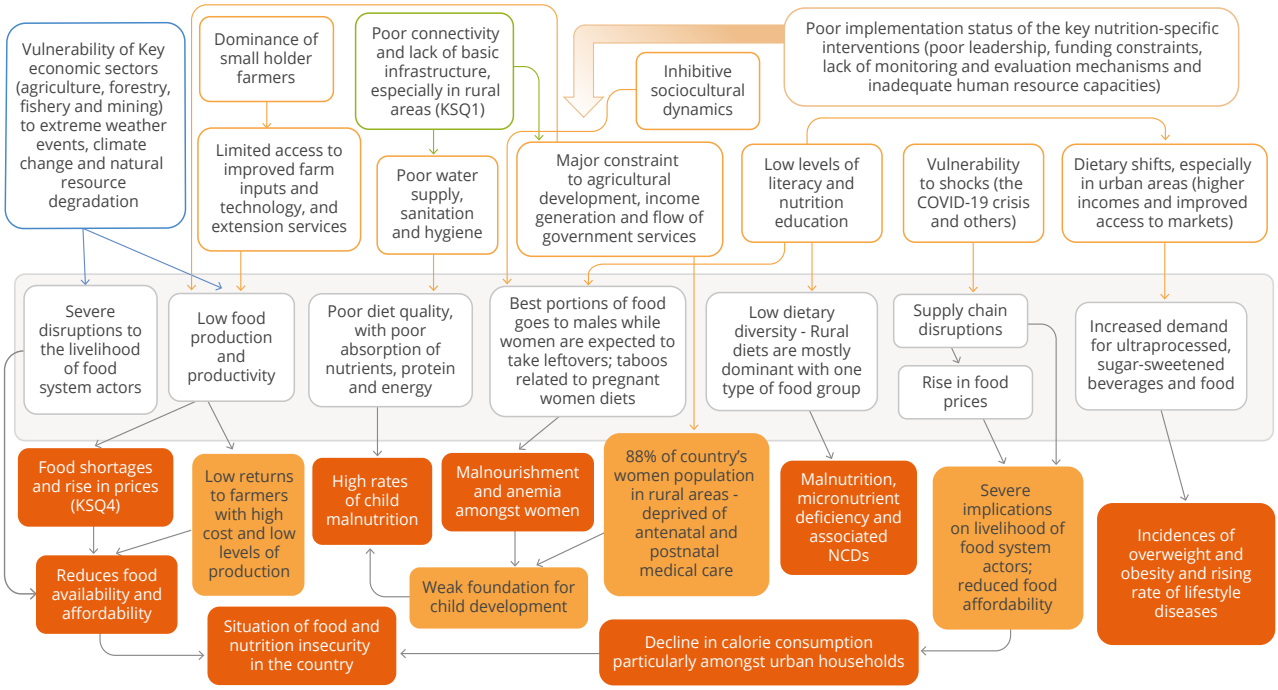
Over the years, the morbidity and mortality associated with lifestyle diseases has significantly increased, accounting for 56 percent of male and female deaths in 2016 (WHO, 2018). It is also well established in Papua New Guinea that processed foods that are high in fat, sugar and salt coupled with a sedentary urban lifestyle are among the leading causes of lifestyle diseases. **Figure 10** shows the risk of premature death from NCDs in the country and **Figure 11** presents a schematic representation of key drivers for food insecurity and the triple burden of malnutrition, their impacts and the different elements of the food systems.

Figure 10. Male and female premature deaths due to NCDs in Papua New Guinea (2016)



Source: World Health Organization. 2018. Papua New Guinea. Noncommunicable Diseases Country Profiles. https://cdn.who.int/media/docs/default-source/country-profiles/ncds/png_en.pdf?sfvrsn=d0c2b16f_38

Figure 11. Drivers and impacts of food and nutrition insecurity



Source: Authors own elaboration, 2022.

Key drivers

Vulnerability to extreme weather events, climate change and natural resource degradation: Papua New Guinea lies along the Pacific Ring of Fire and is prone to environmental disasters induced by natural hazards such as volcanic eruptions, earthquakes, tsunamis, cyclones, a rising sea level, heavy rainfall and floods, landslides, and the El Niño. The situation is aggravated by increasing climate change impacts (including rising temperature, increasing incidences of floods, droughts, landslides, pest infestation, etc.) and degradation of natural resources (rapid deforestation, declining soil fertility, ocean acidification, etc.). Papua New

Guinea is identified as one of the countries that are at maximum risk from climate change and natural disasters (World Bank Group, 2021). Natural resources and ecosystems provide a base to the key economic sectors in the country, including agriculture, forestry, fishery and mining. Thus, events related to natural disasters, climate change and natural resource degradation cause severe disruptions to local livelihoods and affect food production and productivity. The consequence is shortages of food, rises in food prices and reduced food affordability for most of the population in the country (see KSQ 4). In 2015 and 2016, climate-driven food shortages left over 300 000 people in need of food assistance and led to a sharp rise in prices of some staple foods in urban areas, putting significant pressure on household budgets of the poorest and most vulnerable (World Bank, 2018).

Dominance of smallholder farmers with limited access to extension services, improved farm inputs and technology: The country's agriculture sector is dominated by smallholder producers with limited access to manufactured fertilizers, pesticides, improved seed varieties and farm machinery, low levels of irrigation and use of poor crop management techniques. The agricultural extension services, a crucial policy tool for farmers' education, have been long suffering from inadequate funding, leading to declining service quality and limiting nationwide coverage. These factors lead to low agricultural productivity for most of the crops – well below their genetic potential (World Bank, 2018). This limits food availability and generates low returns to farmers with high cost and low levels of production, eventually leading to a situation of food and nutrition insecurity in the country.

Poor connectivity and lack of basic infrastructure, especially in rural areas: As most of country's population is concentrated in rural areas, the provision of basic infrastructure is crucial to mitigate the levels of food and nutrition insecurity in the country. In rural areas, only about one-third of the population has access to clean water and only about 13 percent have improved sanitation facilities (World Bank, 2018). Poor water supply, sanitation and hygiene are key contributing factors to malnutrition and poor health in the country's population. The evidence reflects that open defecation contributed to stunting in the country – not only by causing high rates of diarrhoea, but also through subclinical environmental enteropathy, which prevents absorption of nutrients and stunts growth. The high rates of stunting are primarily related to poor diet quality, with poor absorption of nutrients, protein and energy, instead of quantity of food (Government of Papua New Guinea. 2018a).

Furthermore, low connectivity to rural areas, as a result of the country's peculiar geography and poor road network, imposes major constraints on agricultural development, income generation and the supply of government services, including healthcare and education. Eighty-eight percent of the country's women are concentrated in rural areas, where limited access to healthcare deprives them of much-required antenatal and postnatal medical care, which is fundamental to create a strong foundation for a child's nutrition (see Key Sustainability Question 1; Government of Papua New Guinea. 2018a).

As discussed above, food may be available in some parts of the country but is less accessible in others owing to the underdeveloped distribution system. Low productivity, climate-driven food shortages and the high cost of transportation, among other factors, lead to **rises in food prices**. The prices for basic commodities such as bananas, sweet potatoes, rice, meat, and fish have increased over the past decade (Government of Papua New Guinea, 2018a). Urban residents, lacking access to cultivable land, are particularly vulnerable to food price shocks (World Bank, 2018).

Inhibitive sociocultural dynamics: The high concentration of women in rural areas and the prevalence of cultural practices like 'bride price' mean a high expectation for women to engage in

domestic duties including gardening, food cultivation, livestock keeping and child rearing (AUS–PNG Network, 2022). It is also expected that women give the best portions of food to their husbands and sons, while they take the leftovers, which leads to malnourishment and anaemia and a weak foundation for child development. In addition, there are traditional customs and taboos related to the diets of pregnant women, following a common belief that breaking taboos may cause deformities in the new born. The strength of beliefs varies significantly across regions. Most food items enlisted as taboos for pregnant women are rich in protein. Low levels of nutritional knowledge and awareness combined with restrictive food taboos lead to sub-optimal dietary practices (Kuzma *et al.,* 2013).

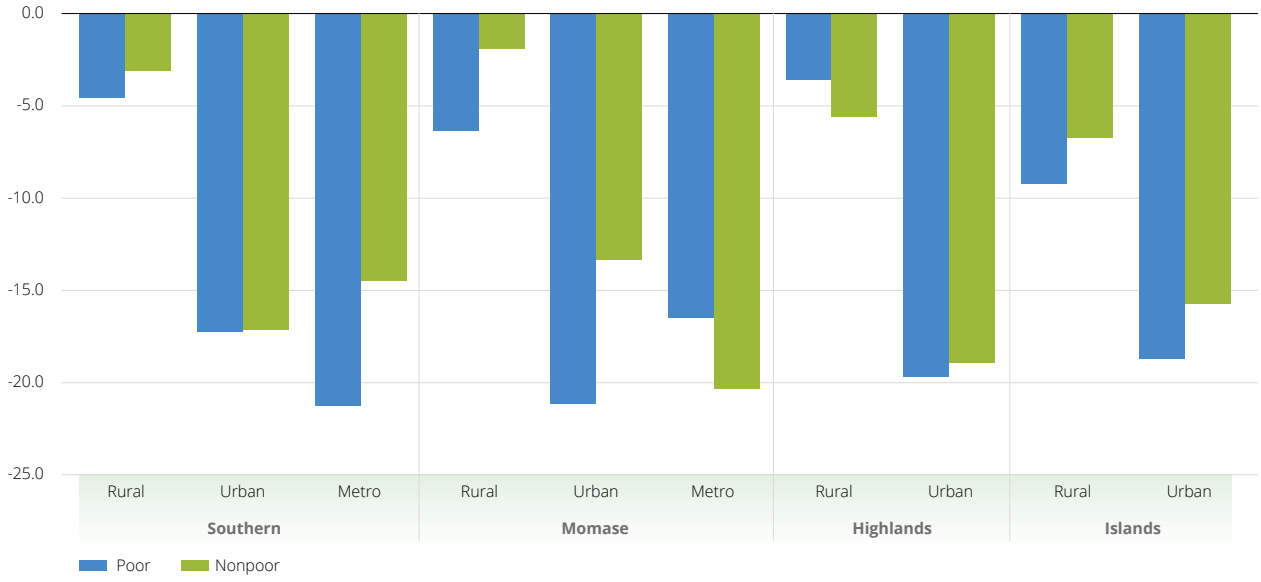
Low levels of literacy and nutrition education: More than a third of the population (37 percent) is illiterate, with majority of them living in rural areas (World Bank, 2016). The basic level of education is directly associated with dietary patterns of households. In 2017 only 29 percent of the children in households with no or only primary levels of schooling reached 'Minimum Dietary Diversity' levels, in contrast to the 42 percent in households with secondary or higher levels of schooling (Global Nutrition Report, 2022).

In addition, there is a lack of nutrition specific education and awareness among the country's population. In Papua New Guinea, the availability of diverse foods is not an issue. However, owing to low awareness, the diets of most rural families lack a mix of different food items, and are dominated by a single food group, which leads to low dietary diversity, resulting in malnutrition, micronutrient deficiency and associated NCDs. For instance, those in the highlands are likely to eat meals with only sweet potatoes, while in coastal areas, taro or banana with fish are staple diets. This is also applicable to farming techniques, where farmers tend to only plant one type of food or food group. Likewise, knowing how to prepare food correctly, or of different ways of cooking for better tasting or nutrient rich dishes are skill sets that are not widely available. Some families may only know how to boil food in pots or roast around the fire or *mumu* (ground oven) (KII, Bird *et al.,* 2022). The traditional customs and taboos associated with diets of pregnant women are also related to low nutrition education and awareness in the country (Kuzma *et al.*, 2013).

Vulnerability to shocks (COVID-19 pandemic and others): During the COVID-19 pandemic between 2020 and 2021 fresh food prices increased dramatically due to supply chain disruptions and low productivity across all food types. A recent IFPRI diagnostic study on the effects of the pandemic and other shocks on the country's food economy highlighted that poultry production reduced by 60 percent during the period 2020–2021 (Diao *et al.,* 2021). The same is experienced in all such shocks where productivity is impacted. For example, production of sweet potatoes reduced by 25 percent during the 2015/16 El Niño in the Highlands, and pork production was reduced by 50 percent by the African Swine Fever outbreak. In most such situations, the poor are disproportionally affected and often forced into multidimensional poverty, as many lose their jobs leading to other socioeconomic catastrophes as observed with the recent pandemic. It was obvious during the COVID-19 pandemic that those who depended on selling foods (informal markets) were severely impacted in terms of their basic income and livelihood (World Bank, 2021).

In their assessment, Diao *et al.* (2021) projected that urban households were particularly vulnerable to the impact of the COVID-19 pandemic and related social distancing policies. Urban poor and non-poor households experienced 19.8 percent and 15.8 percent decline, respectively, in calorie consumption due to lower economic activity (job loss), increases in marketing costs, and increased imported rice prices (see **Figure 12**). Rural households were less affected, but still experienced reductions in income and consumption within an already vulnerable socioeconomic environment (Diao *et al.,* 2021).

Figure 12. Percentage changes in daily total calorie intake/person (2020–2021)



Source: Diao, X., Dorosh, P. A., Fang, P. & Schmidt, E. 2021. *Effects of COVID-19 and other shocks on Papua New Guinea's food economy: a multi-market simulation analysis*. IFPRI Discussion Paper 2004. Washington, DC, International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/p15738coll2.134293 .

Dietary shifts, especially in urban areas: An evaluation of data trends in agrifood imports from 2000 to 2018 and household consumption trends from 2018 and 2010 revealed that the demand for ultraprocessed, sugary beverages and foods has increased considerably over time in Papua New Guinea. Sugar-sweetened beverages recorded the highest annual growth in processed food imports (by 23 percent) over the study period. Secondly, the consumption probability of soft drinks increased with higher incomes and improved access to markets. Lastly, the probability of an overweight child is higher among households with higher food expenditure on sugary beverages (Schmidt and Fang, 2021). The incidences of overweight and obesity are found to be an issue, particularly in urban areas. About 90 percent of the food consumed in urban areas is purchased from stores and markets. There is a transition towards diets with more energy-dense foods along with sedentary lifestyles. This is leading to a rising rate of lifestyle diseases, including high blood pressure, diabetes, heart disease, diet related cancers and other NCDs (Government of Papua New Guinea, 2018a).

Ineffective policy implementation: The major reason for persistent high rates of stunting in the country is related to the poor implementation status of the key nutrition-specific interventions to address the situation (Government of Papua New Guinea, 2018a). The Government of Papua New Guinea (2018) developed the National Nutrition Policy (NNP) 2016–2026 and the Nutrition Strategic Action Plan (NSAP) 2018–2023 to address malnutrition, especially stunting among children in the country. The intention of the NNP 2016–2026 was to strengthen collaboration among key government agencies and partners, with the idea of pooling resources and capacities to mitigate the high burden of child stunting and undernutrition, as well as the increasing

incidence of obesity in the country. The successful delivery of NSAP activities is key to attaining the NNP's strategic directions, the Medium Term Development Plan (MTDP) and the SDGs in the country. However, since the launch of the NNP and NSAP, there seem to be a lack of momentum among government agencies in implementing NSAP activities (Apeng and Schuele, 2021).

The major barriers to successful implementation of NNP/NSAP are: (i) the lack of leadership and effective management at the political and senior managerial level, evident in terms of non-allocation of resources and not actively looking for support from development partners; (ii) a nutrition Project Monitoring Unit (PMU) was established to coordinate the NNP and NSAP across different sectors, but lack of funding, resources and staffing restricted the Unit's functioning; (iii) inconsistency in data collection and challenges in collating nutrition-sensitive intervention data, especially at subregional levels, affects programme implementation and procurement of supplementary foods for malnourished children; (iv) ineffective multisectoral and multilevel coordination and collaboration by different agencies in supporting PMU activities, mobilizing resources and a lack of empowerment of the private sector to support implementation of NSAP activities; and (v) the understaffing and lack of skilled and experienced personnel in the workforce (Apeng and Schuele, 2021).

The government recognizes the significance of the agriculture sector and for about two decades has been pursuing a high-level sectoral development strategy to improve the sector's productivity. One of its major efforts was the National Agricultural Development Plan 2007–2016, which was backed by substantial long-run funding commitments but faced challenges in implementation, associated with governance, capacity issues and monitoring of outcomes. Furthermore, the policy in the sector remained focused on four major export crops – cocoa, coffee, oil palm and copra – overlooking other agricultural crops important for domestic consumption (World Bank, 2018).

Potential impacts

Child undernutrition, especially during the first 1000 days of life, may cause permanent cognitive and physical impairments, limiting a child's education and later employment prospects, which results in both lower household incomes and lower national productivity. One of the highest rates of child stunting in the world, along with rising incidences of overweight and obesity and associated NCDs, has the potential to add significant burden on the country's healthcare system and strain on household incomes, hindering the overall socioeconomic development of the country (World Bank, 2018; Government of Papua New Guinea, 2018a).

Proposed systemic levers

Since food and nutrition security is a cross-cutting phenomenon, the systemic levers mentioned in the other three KSQs are crucial to addressing the issue and associated high regional disparities. The levers mentioned here should be considered as additional ones.

1. **Introduce and promote public education and advocacy about dietary diversity, food preparation and diet-related diseases.**

With few adult learning programmes available for training men and women on the importance of cooking and understanding nutritional values of food, the nutrition literacy rate is relatively low. There are active nutrition training programmes, especially for mothers on correct ways of mixing foods for balanced diets. Some of those programmes are sporadically available and supported by NGOs, churches, and the government. Such programmes need to be expanded and mainstreamed to wider communities across the country. Similarly, much could be gained through research to analyse nutrient contents of traditional and underutilized crops (such as Moringa plants) with the aim of developing nutritious food recipes to reduce malnutrition in rural communities. The main hurdle to this lever is funding and appropriate financial sources.

2. **Enable effective implementation of relevant policies**

Integrated and concerted efforts and investments are needed to reduce food and nutrition insecurity across Papua New Guinea in terms of resource mobilization, and to bring in an effective multisectoral and multilevel coordination and collaboration among different agencies. The two main departments – health and agriculture – could coordinate and mobilize their resources to bring positive resultant effects on food security and nutrition indicators. Thus, **promotion of interdepartmental collaboration–coordination and execution of activities across sectors helps to improve smallholder family food production, food safety and nutrition security**. It is also important that the government increases the share of the agriculture sector in its budget allocation to facilitate effective implementation of the relevant policy initiatives. Building the technical capacity of staff and improving governance are also crucial factors.

Key Sustainability Question 3: Why are Papua New Guinea's agrivalue chains unable to tap its agricultural potential and contribute to fostering its economic growth and poverty reduction?

Papua New Guinea has an abundance of natural resources and geographic proximity to rapidly growing Asian markets (IFAD, n.d.). In addition, the country benefits from a variety of topographical terrain that allows diverse and surplus agricultural production, and a crucial human capital to transform agriculture into a catalyst for economic growth in the country. The agriculture sector, inclusive of forestry and fishery contributed about 17 percent to the country's GDP, as of 2019. With downstream value-chain activities, such as processing, domestic food trade and transportation, and domestic food commodity sales, directly related to the agriculture sector, the larger agrifood system in the country generated over 25 percent of the country's overall GDP. Thus, maximizing efficiency throughout the agrifood value chain is critical to fostering economic growth and poverty reduction in the country (Kosec *et al.,* 2022). However, despite the immense potential and the significance of the agriculture sector, agrifood value chains in the country lack efficiency, as is evident from its low productivity, low quality of produce and high levels of post-harvest losses that generate low or negative returns to food system actors, especially smallholder farmers. This also results in high food import dependency and poor food and nutrition security outcomes. The discussion under this KSQ reflects upon relevant indicators, major drivers and the impacts associated with weak agrivalue chains in Papua New Guinea.

Over the last three decades, the agrifood sector has experienced only moderate growth and its international competitiveness has waned. Food production is estimated to have kept pace with population growth, but this is still far from the enormous potential of the sector (World Bank, 2018), with high food import dependency (see Section 2). Much of the country's fertile agricultural land is not employed in commercial production, while a significant amount of national produce is wasted (World Bank, 2018).

For instance, with the increasing demand for animal-sourced food in the country, the imports of poultry meat increased from USD 4.9 million to USD 27.2 million in terms of value over the period 2009–2019. One of the important reasons for this rapid increase in poultry imports was the comparatively high price of domestically produced poultry meat. This reflects a relative lack of efficiency in domestic poultry production, processing and marketing in the country – and thus an opportunity to improve. In the case of fresh vegetables, the value chains of highland produce are longer and face huge challenges in packaging, processing and transporting for commercial market retail. The major disadvantage to highland framers is their remote locations. This leads to high post-harvest losses, low quality of produce and lack of access of these commodities with distant domestic markets (Kosec *et al.,* 2022). Increasing post-harvest losses were identified as one of the major constraints under the post-harvest and marketing theme for various value chains (sweet potato, Irish potato and bulb onion) leading to low or negative returns to food systems actors and reducing domestic food supply (Okrupa *et al.,* 2019).

Currently, the development of domestic food value chains (including cold-chain transport–storage) that could add value to agricultural products **is still at an early phase of development**. Similarly, the agroprocessing of **local food crops** is underdeveloped. The potential of Papua New Guinea's extensive coastal zone and fisheries resources is underutilized (National Fisheries Authority, 2023). The diversity of domestic value chains in the country and summary of key issues are presented in **Table 4**.

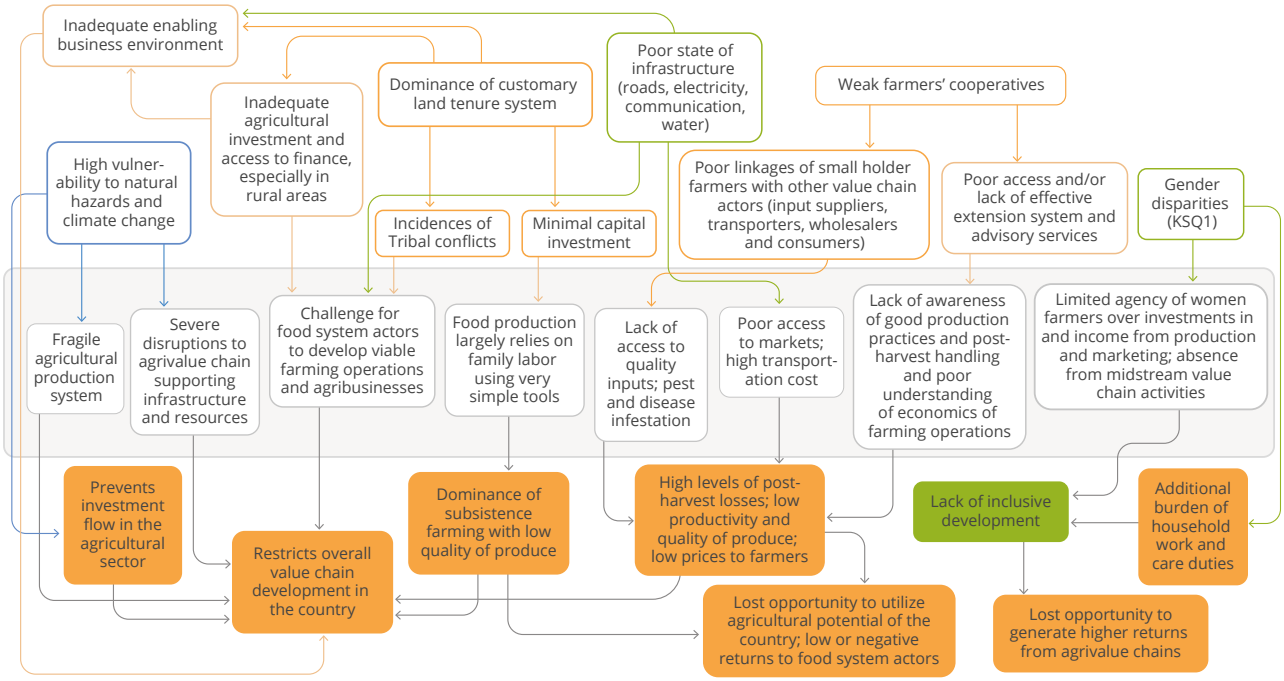
Table 4. Diversity of domestic food value chains and their characteristics in Papua New Guinea

Types of domestic value chains	Food categories	Main issues and constraints	Comments
Root and tuber crops (RTCs) value chain	Sweet potatoes, bananas, taro, cassava, yam, Irish potatoes	Low yield, lack of product and process upgrading, dominance of informal markets, price volatility	Dominate in highlands
Grains value chain	Rice, wheat	Imported, high price, little local production	Dominate in urban areas
Livestock value chain	Meat, milk, poultry, pork	Low quality, weak coordination, low yield, limited processing, animal diseases (including African swine fever)	Dominate in lowlands
Horticulture	Fresh vegetables	High post-harvest losses, low quality of produce, lack of access to distant markets	Dominate in highlands
Fisheries		Underutilized potential to generate income and improving food security	Dominate in coastal areas

Source: Authors own elaboration, 2022.

Figure 13 represents a schematic view of different drivers and the impacts of weak agrivalue chains with regard to Papua New Guinea's agrifood system.

Figure 13. Drivers and impacts of weak agrivalue chains in relation to Papua New Guinea's food systems



Source: Authors own elaboration, 2022.

Key drivers

High vulnerability to natural hazards and climate change impacts: Papua New Guinea is one of the countries with maximum risk to climate change and natural hazards (see KSQ 4). Most prominently, there are high risks of floods, droughts, landslides, earthquakes and sea level rise. About 18 percent of the country's total land area is regularly flooded or permanently inundated. Highlands having a long history of severe flooding, and the main drought affected regions include Southwestern plains, Central Province plains, the Cape Vogel area, Markham Valley, Bulolo Valley, the Maprik–Angoram area, and areas in the Eastern Highlands and Madang Provinces. This climate variation is further influenced by the El Niño Southern Oscillation, with El Niño events to be typically related with below average rainfall and drought. Further, the country is vulnerable to substantial seismic activity given its location along the Pacific Ring of Fire. Earthquakes have been the major cause of landslides across the country and tsunamis affect the country's islands and coastal regions. Consequently, recurrent damage to infrastructure, upland forests and habitats, and gardens of residents, especially in the highlands, are common. Rising sea levels is another major threat to Papua New Guinea and is expected to get more severe in future. The situation is aggravated by increasing climate change impacts. The rise in maximum and minimum temperatures is expected to be significantly faster than the average temperature, intensifying risks to human health and ecosystems. There is a potential for higher incidences of pests and diseases in a warm climate. The rainfall projections are less certain, although hazards such as landslides, flash floods and coastal flooding are expected to escalate, with damage to both population and the economy projected to double by 2030 (see KSQ 4). **The incidences of high climate variability and persistent risk to natural hazards and climate change lead to a fragile agricultural production system and cause severe disruptions to value chain supporting infrastructure and resources. This high vulnerability also prevents investment flow and, thus, restricts the overall agrivalue chain development in the country**.

Dominance of customary land tenure system: In Papua New Guinea, approximately 97 percent of land is under customary land tenure system, i.e., owned by its traditional familial owners. The scenario has multiple implications that restricts overall agrivalue chain development in the country. First, due to lack of security of title, there is a minimal capital investment on communally owned or customary lands. **Food production largely relies on labour from family, village or clan members, using very simple tools such as bush knives, spades and knapsacks. In view of several environmental and socioeconomic challenges in growing crops, land and labour productivity remains low, leading to the dominance of subsistence farming with low-quality produce** (Agricultures Network, 2014). Second, under the customary land tenure system, though the specific elements and rules of the system vary from place to place, it also poses a constraint over potential foreign investments in the agricultural sector, due to the cumbersome process involved in accessing land (Business Advantage PNG, 2020). Third, land tenure is one of the key structural constraints in limiting the access to credit by value chain actors (ADB, 2019). Last, but not least, most indigenous community conflicts have their genesis in land ownership. Since land remains the most crucial resource for subsistence and survival in rural Papua New Guinea (the majority of the country), disputes over territory quickly turn into confrontations and violence, with limited presence of police or authority outside cities (Kuku, 2021).

In 2005, the first phase of the **National Land Development Programme (NLDP)** was initiated to improve the administration of customary land, including dispute resolution. However, a majority of the recommendations had not been implemented by 2018, as per the review by

NARI, despite funding allocations to numerous associated government and non-government entities. The poor performance of the NLDP was partially attributed to institutional reluctance to push these vital reforms. In addition, the progress was hindered by the objections from interest groups, which led to the closure of a Customary Land Development Office in 2017 that was opened only a year ago. There is a hesitation among many customary land owners to release their land in fear of exploitation and taxation, indicating the challenges inherent in balancing the interests of different stakeholders. Recently, in December 2019, the Prime Minister announced fund allocation on yearly basis for subsequent five years to the second phase of NLDP, with consideration to keeping a balance among the interests of different stakeholders. However, the arrival of the COVID-19 virus likely stalled its progress. Thus, though this initiative should signal some hope, the results are yet to be realized (Oxford Business Group, 2020).

Weak farmers' cooperatives: There are about 6 000 registered cooperatives in Papua New Guinea, with more than 90 percent of them in the agriculture, livestock and fishery sectors (International Co-operative Alliance, 2020). However, it is difficult to measure the performance of the country's cooperative sector given the absence of any comprehensive national-level statistics in the country. The problem is worsened by the fact that none of the cooperative societies submit their annual returns to the Registrar of Cooperatives. As per an analysis of coffee cooperatives in the country, most of the sample cooperatives were small in size with low productivity, which does not ensure competitiveness and income to the members (Altman *et al.,* 2020). The limited success of cooperatives is evident in the multiple challenges faced by smallholder farmers in profitably maintaining the backward and forward linkages across the value chains. There is an absence of a firm relationship between smallholder farmers with input suppliers, transporters, wholesalers and consumers. Farmers often face rejections or receive low prices for their produce, while marketing to wholesalers, as the produce does not match required quality standards or if there are issues of oversupply of the same produce. In other words, the farmers have little or no bargaining power on the pricing front, yet they continue to absorb the costs and risks associated with production, marketing and transportation (Agricultures Network, 2014).

For instance, **some of the identified constraints faced by smallholder farmers** in the sweet potato value chain include increased infestation of pest and diseases closely associated with lack of access and/or unavailability of clean planting material and lack of awareness regarding the same to an extent. **This leads to low yields with high post-harvest losses that pose a challenge to produce large quantities of marketable roots of sound quality to fetch a good price**. Smallholder farmers engaged in commercial production and marketing of sweet potato are also found to have lack of understanding of the cost–benefit ratio of their operations. A majority of these producers often travel long distances from production areas in highlands to urban markets in Lae and Port Moresby, leading to high marketing costs inclusive of logistics and labour, generating low or negative rates of return for them. In other instances, where middlemen are involved, the farmers complaint of low prices offered to them, with middlemen often making excuses of high (>50 percent) post-harvest losses (Okrupa *et al.,* 2019). Similar constraints were identified in case of the Irish potato value chain as well. Poor access to certified seeds is a major challenge in addressing the issue of seed-borne diseases and other potato viral diseases. Poor sanitation in both the field and seed storage houses and a lack of awareness on appropriate phytosanitary measures generate far-reaching implications on the entire production system, while leading to low yields and high levels of post-harvest losses (Okrupa *et al.,* 2019).

Post-harvest and marketing constraints for smallholder farmers are mainly attributable to **inadequate infrastructure and poor access to markets**. For instance, based on the value-chain analysis of three high-value commercial crops in Papua New Guinea (sweet potato, Irish potato and bulb onion), the unavailability or lack of access to a steady market was found to be a major impediment affecting farmers' drive to produce volumes and generate equitable revenues to offset production and marketing costs. With already high post-harvest losses along lengthy supply chains, farmers sell their produce for low prices for fear of incurring further post-harvest losses. Poor conditions of roads along the highland highways, absence of a dedicated transport system and cold-chain and storage facilities are integral to the problem of post-harvest losses and poor quality (Okrupa *et al.*, 2019). In addition, information asymmetries (such as related to market price and demand) due to poor communication infrastructure among the value chain actors, viz., producer, trader, and retailer, cause distrust and result in lack of specialization across all nodes (Kosec *et al.,* 2022).

Another important and cross-cutting issue across the value chain for smallholder farmers in the areas of production, post-harvest and agribusiness is **poor access and/or the lack of an effective extension system and advisory services**. The lack of farmer training and engagement mainly regarding how to effectively manage pest and diseases was identified as the second-most major production constraint in case of bulb onions. Further, as per the common findings under all the three value chains, farmers lack basic knowledge and skills in post-harvest handling practices like an appropriate harvesting technique and the timing to harvest, drying, sorting and grading, packaging and transportation. Meeting formal market requirements in terms of quality and extended shelf-life is the key challenge faced by commercial farmers and middlemen. Most semi-commercial to commercial farmers lack capacity to operate their farms as enterprises, because it is a challenge for them to comprehend the economics of costs and profits, and thereby to make sound decisions to improve farm productivity and profitability (Okrupa *et al.,* 2019).

Gender disparities: According to an IFPRI study (Carrillo *et al.*, 2022), women are strongly involved in vegetables and the poultry value chains and generally feel that this allows them to be more independent and empowered. However, at the same time, they are still expected to maintain the household (e.g., cooking, cleaning, childcare, gardening, etc.), which substantially extends their workday. Further, in Papua New Guinea, while women have ample responsibilities in managing and utilizing non-land assets, they have relatively limited agency, as social norms influence the ownership and control of these assets. Given this, though women are already active in most of the livestock value chain activities, they lack rights to decision making over investments in and income from production and marketing. Taking another case of fresh vegetables value chain, while women are the primary producers and sellers, they are almost absent from the midstream activities of the value chain. Given this, they face significant challenges and safety risks with transportation and price negotiation and have less authority over the use of income generated from fresh vegetables. Further, **since fresh vegetable value chains have specialized packaging and**

processing needs, it could be a potential area for greater women's employment. Also, it is key that women have better access to price information, decent market infrastructure and an enabling environment to negotiate formally, efficiently and safely to contract other service providers to transport, package and store the produce. Previous research suggests that where women are economically empowered and employed in lucrative nodes (activities) of value chains, households have higher incomes and are less likely to be poor (Kosec *et al.,* 2022).

Inadequate access to financial services and lack of investments by value chain actors: In Papua New Guinea, access to finance is a challenge for smallholder farmers (male and female), small traders and processors in developing viable operations and agribusinesses that can benefit fully from value chains. Lack of financial support across domestic (food) value chains holds back investment in technology and innovations by various actors along the chain.

The majority of the population in the country lack access to finance as banks remain reluctant to lend. Banks maintain low exposure to agriculture and semi-subsistence farming, with borrowers largely tending to be urban-based, despite about 80 percent of the population being dependent on agriculture. The loans are usually extended only to large and medium-sized, formal sector companies, while it remains a challenge for smaller firms to access credit. Regulatory barriers and high costs have further restricted the growth of the banking sector. Besides structural constraints, limited knowledge and exposure to financial services, as well as geographical distance from these services, are other major contributors in limiting financial access for value chain actors, especially in rural areas. Lack of access to finance severely impedes the growth of the private sector (ADB, 2019). The percentage of consolidated loans and advances from commercial banks to the agricultural sector remained less than three percent over the period 2011–2017 (ADB, 2019).

Moreover, as discussed in KSQ 1, the public sector's contribution to agriculture is only 2 percent of the overall budget and this translates into limited public support and finance for farmers, agroprocessors and other actors in the food systems.

While commercial banks focus more on urban-based transactions, microfinance firms have an increasing role in the rural economy. They even cater to urban-based small enterprises that lack access to formal financial services. However, these institutions have largely been used for savings, since deposits exceed loans (ADB, 2019). Some small-scale initiatives also exist in the country. For example, the Fresh Produce Development Agency (FPDA), which has been working to support smallholders by liaising with the Bank South Pacific's (BSP's) Branchless Banking section to introduce rural banking services by ensuring that farmers have bank accounts and can manage their income (FPDA, n.d.).

Inadequate enabling business environment: The agricultural industries in Papua New Guinea have great potential, but it is a great challenge for the private sector (including SMEs) to come in, due to various reasons. First, there is a lack of information in every subsector, which means the feasibility studies take more time and resources than elsewhere. Second, there is no easy access to public or private funding and concessional finance is almost non-existent. Third, there is a lack of infrastructure, roads, energy and water, which requires an additional investment to create an agroprocessing facility, for example. Fourth, it is difficult to transport any product through the water route, as it incurs some of the highest charges in the world for port management facilities, which dilutes the value and the opportunity. Last, but not the least, one of the major constraints that a company faces is over land titles. There is always a fear of probable land disputes over any issue, which could bring the complete process to a halt (James, 2019) (see dominance of land tenure).

These factors have several implications on developing an agribusiness in Papua New Guinea, including the high cost of operations, which calls for substantial gross margins to compensate; be self-sufficient in generating reliable information and for maintaining infrastructure, especially in case of energy; the need to develop strong relationships with retailers and understand their needs, for domestic production and to have a careful risk management plan, especially with regard to land issues (James, 2019). To quote a relevant example, based on the poultry value-chain analysis, due to unreliable power supply, small-scale poultry processors, who invested in processing equipment to produce packaged meat for supermarkets incur significant risk, while farmers are reluctant to invest in increasing poultry production capacity given their inability to reliably process, flash freeze and store processed poultry. The situation led semi-commercial farming entities to scale back available production quantity, which has several cost implications while mounting inefficiencies (Kosec *et al.,* 2022).

Potential impacts

Lack of well developed and integrated agrivalue chains (and therefore problems such as poor coordination within the value chain, traditional agricultural practices that may suffer from a lack of innovation, transportation issues and limited agroprocessing), poor access to finance and quality inputs, and limited focused efforts in the country result in low productivity and quality of produce with high levels of post-harvest losses, which restricts potential returns from the agricultural sector. It is a lost opportunity for small producers and other food systems actors to access and profit from high-value domestic markets and create productive employment opportunities for youth and women in the agroprocessing subsector. The current scenario, therefore, perpetuates the cycle of rural poverty (40 percent) and unsustainable agrobased livelihoods in the country. It also contributes to worsening the country's dependency on food imports, and its food and nutrition insecurity.

Proposed systemic levers

1. **Promoting and strengthening farmers' cooperatives/organizations**

Strengthening farmers' cooperatives/organizations can go a long way to creating an enabling platform for numerous smallholder farmers in Papua New Guinea and foster their economic inclusion. By providing economies of scale, producers' organizations can help create effective backward and forward linkages leading to strengthened value chains. These linkages will help mitigate the challenges faced by small-scale producers associated with access to quality inputs and markets, benefits of extension services, aggregation, post-harvest handling, transportation, processing and marketing. This will also lead to improved agricultural practices, better production and productivity, low post-harvest losses and greater economic benefits to farmers with higher bargaining power in input and output markets. Further, it is important that these organizations/cooperatives are gender inclusive.

2. **Creating an enabling environment for value chain actors**

The aim here would be to enhance value chain development by improving access to rural finance and appropriate financial products by engaging financial service providers, and enabling banks and microfinance institutions to address the financial needs of the actors in the value chain, while also upgrading the required infrastructure, such as cold-chain transport system, electricity, digitalization and rural roads. Better infrastructure and road connections would improve market access, which is crucial to increasing the availability and distribution of quality inputs and locally produced food to become more competitive against imports.

Key Sustainability Question 4: Why is the agrifood system in Papua New Guinea increasingly vulnerable to natural hazards and climate change impacts?

Papua New Guinea is one of the countries that are at maximum risk to climate change and natural disasters (World Bank Group, 2021). The implications are multidimensional with colossal damage caused to human lives and resources. The discussion under this KSQ reflects upon the relevant indicators, the major drivers and the impacts associated with the country's food systems becoming increasingly vulnerable to natural hazards and climate change impacts.

Papua New Guinea is at high risk of exposure and vulnerability to natural hazards, with a ranking of 10 out of 171 countries in 2016 (World Bank, 2018). Most prominently, it faces high risks of floods, droughts, landslides, earthquakes and sea level rise. The reason is its geography, geology, topography, climate and tectonic setting (Global Logistics Cluster–WFP, 2011).

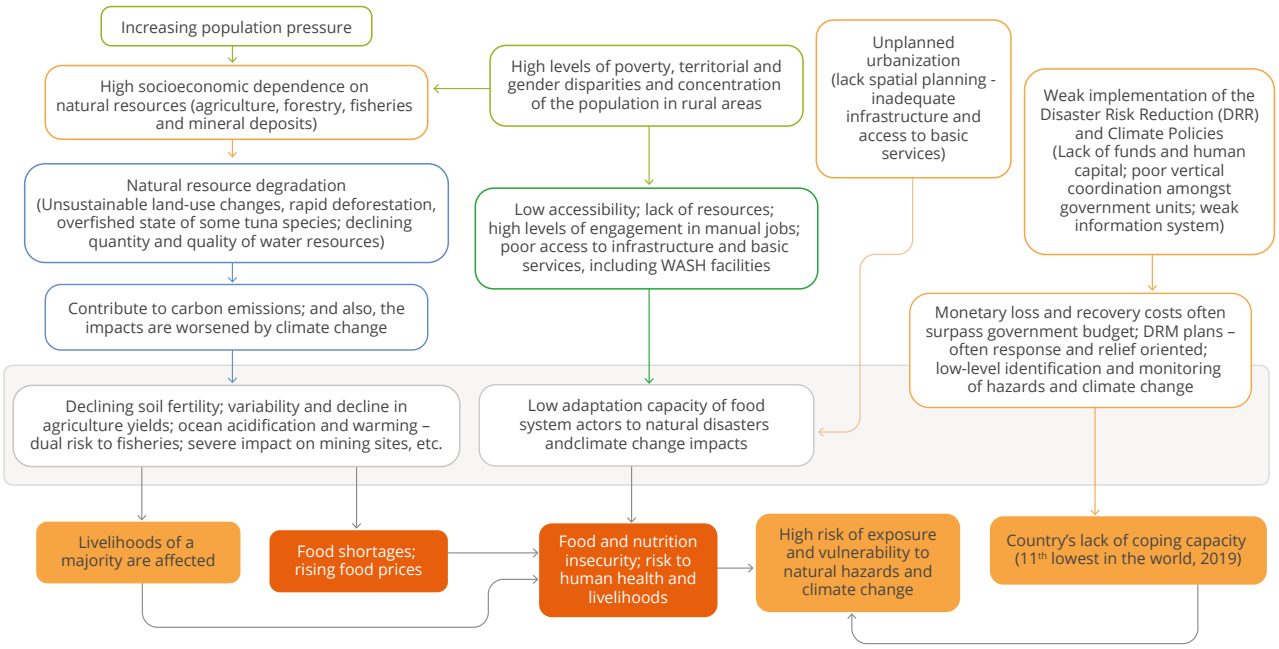
About 18 percent of the country's total land area is regularly flooded or permanently inundated, with highlands that have a long history of severe flooding. During monsoons, most of the parts in the country experience flooding. The main drought affected regions include the Southwestern plains, Central Province plains, the Cape Vogel area, Markham Valley, Bulolo Valley, the Maprik–Angoram area, and areas in the Eastern Highlands and Madang Provinces. This reflects the high levels of climate variability within the country. On one hand, Papua New Guinea is considered to be among the wettest countries in the world with an annual rainfall exceeding 2 500 mm in many areas, especially in the highlands (CCK Portal, 2021); while on the other hand, some parts of the country experience a drier climate. For instance, in Port Moresby, the annual precipitation is usually lower than other parts of the country and frequently fluctuates between 700 mm and 1 400 mm. This variation is further influenced by the El Niño Southern Oscillation, with El Niño events to be typically related with below average rainfall and drought (World Bank Group, 2021). Where landslide hazards are concerned, Papua New Guinea has the most severe profile in the world given its steep mountain ranges, high annual rainfall and high seismicity. Recurrent damage to infrastructure, upland forests and habitats are common features. Further, the country is vulnerable to substantial seismic activity given its location along the Pacific Ring of Fire. The country experienced about 10 earthquakes of equal to or more than a magnitude of 7.0 within the four-year period from 2014 to 2018 (World Bank Group, 2021). Earthquakes have been the major cause of landslides across the country, along with tsunamis that have affected its islands and coastal regions. Occasionally, major earthquakes result in loss of life and significant damage to infrastructure. Rising sea level is another major threat, which is expected to get more severe in future. The impacts are visible in Katarets Island and Motlocks where much land is underwater (World Bank, 2018).

The situation is aggravated by increasing climate change impacts. Papua New Guinea has been recognized as vulnerable to climate change impacts, with a ranking of 156 out of 182 countries in the 2019 ND–GAIN Index.[8] Measured in terms of the difference between average temperature in 1900–1917 and 2000–2017, warming over Papua New Guinea's landmass has been approximately 0.8–0.9°C. The rise in maximum and minimum temperatures is expected to be significantly faster than the average temperature, intensifying risks to human health and ecosystems. The rainfall projections are less certain, however, and hazards such as landslides, flash floods and coastal flooding

[8] "The ND-GAIN Index ranks 182 countries using a score that calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. The more vulnerable a country is the lower their score" (University of Notre Dame, 2019).

are expected to escalate, with damage to both population and the economy projected to double by 2030 (World Bank Group, 2021). The model simulations point to a greater recurrence of El Niño weather trends, likely to trigger more severe and prolonged drought and flood incidents. The impacts of climate-change-driven weather events and sea-level change are already evident in coastal areas and islands (World Bank, 2018). **Figure 14** represents a systemic view of different drivers and elements of the food system leading to the high vulnerability of Papua New Guinea to natural hazards and climate change, followed by the discussion.

Figure 14. Drivers and impacts of natural disasters and climate change on Papua New Guinea's food systems



Source: Authors own elaboration, 2022.

Key Drivers

High socioeconomic dependence on natural resources: In Papua New Guinea, the natural environment and ecosystems provide a crucial basis to its key economic sectors. The country's coastal and marine resources, farming lands, wide-ranging dense forests and immense freshwater reserves and their related ecosystem services are fundamental to the livelihoods of millions, whose livelihoods are based on agriculture, forestry, fisheries and tourism (World Bank, 2018). Furthermore, mineral deposits like copper, gold and oil comprise nearly two-thirds of the country's export revenues. However, an increasing pressure on natural resources, given high socioeconomic dependence, coupled with increasing population, intensifies the country's vulnerability to extreme climatic events. In addition, the phenomena of climate change and climate variability are likely to aggravate these impacts and contribute to depletion of resources that are crucial to livelihoods, as well as to food and nutrition security of most of the country's population (UNDP, 2022).

Agriculture combined with forestry and fishery is one of the major sectors of the country's economy. Papua New Guinea is a major global producer of coffee, cocoa, coconut (copra) and oil palm, supporting millions of rural residents. Other important agricultural activities supporting cash incomes include betel nut, betel pepper, firewood, tobacco and Irish potato, besides several food crops. Forest products are a significant source of both exports and household income. The country is ranked second in the world for the export of tropical logs (World Bank, 2018). However, the sector has experienced major challenges in terms of rapid deforestation due to illegal and unsustainable logging, facilitated by poor governance (World Bank Group, 2021). Unsustainable land-use changes in recent years and forest degradation have reduced soil quality and fertility, affecting agricultural yields and leading to greenhouse gas (GHG) emissions. From 2000 to 2021, Papua New Guinea lost about 3.8 percent of its tree cover, equivalent to 1.21 Gt of CO_2 emissions (Global Forest Watch, 2022). In case of the fisheries industry, it is an important source of the country's export earnings and equally significant to its local markets and subsistence economy. Tuna forms the largest share of the country's fisheries. The tuna catch from Papua New Guinea's waters comprises about 20–30 percent of the regional catch and about 10–15 percent of the global catch. But the industry is under threat as some of the tuna species, such as yellowfin and bigeye, have been overfished (National Fisheries Authority, 2023; United Nations, 2022).

The situation has been worsened by climate change impacts on natural resources. About 70 percent of the households in Papua New Guinea remain dependent on subsistence agriculture by UNDP (2022) estimates, making these communities highly vulnerable to climatic hazards. As mentioned in its Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), the country's population is specifically reliant on sweet potato production, with 63 percent of calories in rural areas being derived from this source. Though the area suffers from sheer lack of high-quality research, different studies have suggested that the yields of sweet potato may decline by about 10 percent by 2050 due to changing climatic conditions. In fact, all the crops assessed, including cassava, rice, maize, sugarcane and taro, showed negative trends in yields of similar magnitude. Rising minimum temperatures during the night is considered to be a specifically important driver of these losses. In addition, production losses are already being experienced in coastal areas due to saline infiltration of soils and groundwater as an effect of the rising sea level, and throughout the country due to events of floods and droughts (World Bank Group, 2021). The arrival/non-arrival and intensity of annual monsoon cycles have a significant effect on local livelihoods, especially in the regions where rainfall is marginal but critical to cropping. The highland areas are primarily sensitive to variable agricultural yields due to climate change. Climate-driven food shortages during recent years in the highlands left several thousands in need of food aid while pushing up prices of some staple crops, intensifying the vulnerability of poor households (World Bank, 2018). Another area of concern includes the potential for higher incidences of pests and diseases in a warm climate (World Bank Group, 2021).

Floods cause erosion and heavy sedimentation in coastal plains that impact agricultural productivity and downstream settlements. If projections are realized, future flooding events may adversely affect about 30 percent of the country's population. There have been incidences when flooding rendered access to mining sites impossible, with severe impact on mining revenues (World Bank, 2018).

Ocean acidification and warming represent a dual risk to Pacific coral reefs. As per projections, ocean conditions around Papua New Guinea are in a transition state and by 2030, will remain only

marginally suitable for corals, together with an increase in frequency of coral bleaching events due to ocean warming. This unfavourable stance on coral reefs is likely to have adverse effects on the health of coastal fisheries. Another study suggested a probable decline in Skipjack tuna catch by 30 percent by the end of the century under a high emission scenario (World Bank Group, 2021). There is a need for further research to better understand the impact of climate change on ocean fisheries, but it is essentially a potential threat to the country's largest protein source. The estimated average per capita fish consumption in Papua New Guinea is 18.2–24.9/kg/year (World Bank Group, 2021). Furthermore, coral reefs are not only crucial to the country's economic growth through fisheries and tourism, they also protect coastlines from storms and land loss. About 50–70 000 coastal inhabitants rely on coral reefs for their livelihood, food and shelter (World Bank, 2018).

A comparatively understated influence of climate change includes its impact on human health and labour productivity. For instance, coastal and river floods are also likely to deplete water quality, outspreading salt contamination and water-borne diseases. Globally, as per an estimate, labour productivity has already dropped by 10 percent during peak months and a decline of up to 20 percent is expected by 2050, under highest emission pathways. Further investigation is required in the country's context (World Bank Group, 2021).

High rates of poverty, inequality and concentration of population in rural areas: In case of climate-related hazards, the extent of impact and the coping strategy of the populace is highly based on their socioeconomic status, access to resources, sociocultural norms, poverty, as well as gender (World Bank Group, 2021). As discussed in KSQ 1, there are high levels of territorial and gender inequities in Papua New Guinea. About 80 percent of the population is concentrated in rural areas, with poor access to infrastructure and basic services. Poverty rates are about 40 percent as per available estimates, with the populace engaged in agriculture likely to be poorer than other sectors.

Low accessibility to rural areas due to the country's difficult geography and poor connectivity infrastructure is one of the major contributing factors to high disaster risk, given the high cost of providing logistics support. Lack of healthcare facilities, especially in rural areas, which are crucial to deal with the aftermath of natural disasters, is also of grave concern (UNDRR, 2019). With many rural communities living in flood and landslide risk zones, exposure to natural hazards is substantial and likely to escalate. The projected climate change impacts are expected to disproportionately affect the poorest sections in the country. For instance, productivity losses due to heat stress are maximum in case of heavy manual labour jobs that are also the lowest paid. It is a challenge for poor communities and farmers to afford local water storage, irrigation infrastructure and technologies for adaptation (World Bank Group, 2021). Not only the rural poor, but the urban poor are equally vulnerable to climate change impacts. Climate-driven food shortages in 2015 and 2016 had left over 0.3 million people in need of food aid and led to a sharp rise in prices of some staple food in urban areas, putting considerable pressure on the poorest and the most vulnerable (World Bank, 2018). The situation is worse for women, given the very high level of gender-based differences in the country. Women are highly concentrated in rural areas, victims of sociocultural norms, vulnerable to personal safety risks and lack access to resources and economic opportunities (see KSQ 1). These factors greatly undermine their adaptation capacity to climate change in comparison to men.

Unplanned urbanization: The share of Papua New Guinea's urban population is very low at present (about 13 percent), but growing at an increasing rate of about 2.6 percent in 2020

from 1.0 percent in 2000 (World Bank, Country Profile). The population in Port Moresby, for instance, is expected to exceed the one-million mark before 2050. This is mainly due to the out-migration trend to urban regions in search of better employment opportunities. However, this is largely an unplanned urbanization dominated by informal settlements, comprising about half of Port Moresby's dwellings. These areas often lack basic infrastructure and because of low enforcement of spatial planning, are increasingly vulnerable to floods, earthquakes, urban fires and diseases in the absence of adequate WASH facilities. Further, with the rapid rate of oil and gas development, there is also an increase in vulnerable infrastructure. For instance, the recently established PNG–LNG liquefied natural gas pipeline running through the Southern Highlands, is not resistant to disasters. Earthquakes and landslides, for instance, can cause large-scale disruption, endangering the environment and biodiversity due to the high potential of gas and oil leakages (UNDRR, 2019; World Bank Group, 2021).

Weak implementation of the Disaster Risk Reduction (DRR) and Climate Policy: It is to be noted that **over the years, the Government of Papua New Guinea has exhibited its commitment to adaptation and mitigation of climate change hazards through various measures at the national level as well as on international platforms**. Papua New Guinea signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and became a party in 1993 after its ratification. The country ratified the Paris Climate Agreement in 2016 during the Seventy-second UN General Assembly and submitted its Intended Nationally Determined Contribution (NDC) to UNFCCC in 2016 and its Enhanced Nationally Determined Contribution in 2020. In 2014, it also published its Second National Communication (NC2), recognizing sea level rise, landslides, agriculture, food security, and threats to public health as the greatest climate change impacts to the country. Further, Papua New Guinea is a member of the Small Island Developing States (SIDS) and affiliates itself with the Alliance of the Small Island Developing States (AOSIS) within the UNFCCC. The country is also one of the leading members of the Coalition of Rainforest Nations among 52 member countries (CCDA, 2020; World Bank Group, 2021).

At a national level, the Climate Change and Development Authority (CCDA) was established under Papua New Guinea's national Climate Change Management Act 2015 (CCMA), primarily to facilitate and develop suitable policies and a regulatory framework to address climate change in the country. The country has also mainstreamed climate change in its development primacies, as reflected in its national long-term plans and strategies, including the PNG Vision 2050, the national Development Strategic Plan (2010–2030) and MTDP III, among others. These strategies intend to facilitate strengthening and diversification of the grounds of Papua New Guinea's economic growth, while taking steps to both increase its climate change resilience strategy and to mitigate emissions. The most recent step in this direction is the development of its SDG 13 Climate Action Roadmap as well as the development of the National REDD[9]+ Strategy (CCDA, 2020).

Several policy frameworks have also been laid down for disaster risk reduction in the country, including the National Disaster Management Act of 1984, which mandated institutionalization of disaster risk management (DRM) at the national and provincial levels; the National Disaster Mitigation Policy, in 2004, to shift the focus from responsive disaster management to proactive readiness and mitigation; the high-level PNG National Framework for Action of 2005, the all-encompassing strategic framework for DRM; the National Disaster Risk Management Plan (2012),

[9] REDD: Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable forest management of forests, and enhancement of forest carbon stocks (CCDA, 2020).

the first comprehensive document to lay out regulatory and legislative framework for DRM for all levels; the National Disaster Risk Reduction and Disaster Risk Management Framework for Action (2005–2015), a strategic framework aligned with the mandates of Hyogo Framework for Action; and the National Disaster Risk Management Framework for 2017–2030, a joint initiative with the NDC and UNDP to ensure the immediate and long-term disaster risk management challenges, aligned with SFDRR.

Despite these positive strides, the high levels of risk to climatic hazards faced by the country are echoed in its ranking (28 out of 191 countries) in the 2019 INFORM Risk Index.[10] In terms of specific risks, the country's low ranking is mainly driven by its lack of coping capacity (eleventh lowest in the world), with comparatively moderate levels of exposure to floods, droughts and cyclones (World Bank Group, 2021). It is argued that governance plays a crucial role in building the country's coping capacity here, with several factors contributing to this role.

A complex set of factors play a role in limiting the application and effectiveness of the measures taken by the government in the area of managing disaster and climate risks. Besides the biophysical environment, infrastructure and several socioeconomic factors, as discussed above, adequate implementation of relevant policies and plans and understanding risks is hindered by scarcity of funds and human capacity, lack of coordination at different levels of government and a weak information system.

DRM in Papua New Guinea has constantly been affected by limited resources and capacity to operate from the national to subnational levels. During 2006–2012, the National Disaster Centre (NDC) worked on a limited annual budget of USD 1.3 million, and previously, even less than USD 0.5 million. At the subnational level, the situation is more critical as most Provincial Disaster Committees are highly indebted. Thus, because of rising impacts of changing climate and disaster events, monetary loss and recovery costs often surpass the government budget. Vertical coordination among government units is an added challenge given the country's unique dispersed geography and, sometimes, even lack of standard coordination mechanisms. Even if a national DRM plan exists, neither is it widely circulated nor supported by a legal framework, thus making the country's DRM mainly response and relief oriented (UNDRR, 2019).

Weak information system is another crucial factor. The present system for data collection and management is tenuous and erratic. The climate information is collected on project-to-project basis. Further, even if there is an existing information on historical hazards, it is difficult to access it and follow trends owing to lack of analytical tools and updated data. The situation is exacerbated by inadequate technical and human capacity, a limiting factor for authorities to conduct risk assessment, monitoring and analysis, especially in the remote islands. This results into low-level identification and monitoring of hazards and climate change, which leaves the country with an inability to assess vulnerability and recognize risk issues (World Bank, 2010; UNDRR, 2019).

Given the limited resources and capacity at national level, stakeholders' contribution has been crucial in dealing with disasters and climate risks in Papua New Guinea. The country has received an immense support from different regional and international level organizations, including Secretariat of the Pacific Community's Applied Geoscience and Technology Division (SPC/SOPAC), Secretariat of the Pacific Regional Environment Programme (SPREP), the Australian Government, UNDP, IOM, FAO, WFP and UNFPA, among others (UNDRR, 2019).

[10] The Inform Risk Index identifies specific risks across a country to support decisions on prevention, preparedness, response and a country's overall risk management (World Bank Group, 2021).

Potential impacts

As discussed, natural catastrophes have been causing large-scale disruptions in food production over the years, threatening human survival in the country. Such impacts are likely to get severe given the increasing intensity of climate change related events. If left unmitigated, these impacts can jeopardize human health and welfare, the country's economic growth and the government's ability to achieve development plans for the next century. Further, the consequences will be disproportionately dire for the weaker and marginalized social sections, including the poor, the elderly, the disabled, women and children (UNDRR, 2019).

Proposed systematic levers

The drivers for increasing vulnerability to natural disasters and climate change in Papua New Guinea are multidimensional and, hence, its levers are too. However, for the purpose of this study, two broad systemic levers have been identified that may potentially bring an overall influence in mitigating the vulnerability of Papua New Guinea to natural hazards.

1. **Strong policy and regulatory framework for efficient and sustainable utilization of natural resources and collaboration with different stakeholders to increase adaptation and mitigation capacity of local communities.**

It is important to manage trade-offs between economic growth and sustainability. High socioeconomic dependence on natural resources have resulted in their over-exploitation, as discussed above. Thus, it is important to have a strong policy and regulatory framework for efficient utilization of natural resources to mitigate the impact of climatic hazards. Supporting communities in diversifying their livelihood portfolio is vital. Further, strengthening local communities with the help of local government units/private sector/NGOs/CSOs is important to build an awareness related to adaptation and mitigation measures and effectively respond to the aftermath of disasters.

2. **Increase national disaster finance and support the creation of a strong national database/ information system for disaster and climate related information.**

Since comprehensive data collection, analysis and management is crucial for informed disaster risk reduction (DRR), initiatives and investment decisions by the public as well as private sectors are imperative to strengthen the capacities of stakeholders at all levels of administration for the functioning of an effective data management system. This overarching lever, therefore, supports increased (public and private) disaster financing that may contribute to strengthening capacity of stakeholders at all levels in the country. More finance will allow the establishment of a strong database system for climate related information; strengthen human resources; and a stronger meteorological department with an early warning system.

Transition to Sustainable Food Systems

The Food Systems Assessment brings to light the fact that the challenges facing sustainable food systems and the levers for systems' transformation encompass many dimensions — agriculture, gender, health, education, climate and environment, mining, across rural and urban areas in Papua New Guinea — and require strong engagement of all actors in the food systems. Poverty, and food and nutrition insecurity suffered by the majority of Papua New Guineans remain key issues for sustainable human development in the country. Active and professional agriculture extension and education on improved agriculture production techniques, storage and processing, as well as information dissemination on nutritious food recipes to rural districts targeting female farmers may be critical to overcome food and nutrition insecurity at the family level.

At the same time, much remains to be done in the area of infrastructure – enabling environment in general – and value chains development in particular, while the customary land tenure system may need to be revisited too. Papua New Guinea is at high risk of floods, droughts, landslides, earthquakes and sea level rise. Coupled with a number of other issues such as rapid urbanization, changing consumer behaviour and rising lifestyle diseases, land degradation, soil fertility loss, destructive logging (deforestation) and indiscriminate fishing, this will continue to spur significant and rising demands on the food and health systems in the country.

The FSA also reveals that inclusive transformation urgently requires increased and sustained empowerment of women and youth at all levels in the country, and the broadening of access to resources, technologies, finance and innovations, such as digitalization and updated information systems, including a food systems database. Investments in basic infrastructure, such as roads, electricity, safe water supplies and water storage are also necessary as are improved access to health services and education.

Finally, good multisectoral governance at the various levels and close collaboration between stakeholders in the food systems (agriculture, health, education ministries, universities, public works, and government departments at provincial and local levels, etc.) are imperative parts of the food systems transformation process.

The findings of this assessment serve as a first step in thinking about the transition necessary for sustainable food systems transformation. Further research will help to better detail the challenges and their impact on food systems sustainability and refine the levers and necessary actions for the desired impact. Institutional innovations could help to ensure that the voices of all stakeholders, especially in the most vulnerable sections of society, are reflected in the activities and plans.

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Acknowledgements

The following people have contributed to this assessment and the writing of this note:
Sergie Bang, Henry Nema, Ted Sitapai **(national experts);** *Birte Komolong* **(National Agriculture Research Institute);** *Heai hook* **(Ministry of Agriculture);** *Delelegne Abera EU* **(Joint Research Centre);** *Laniette Bai, Melinda Benjamin, Mirriam Mondia, Sonnie, Jacinta, Pupune, Paula, Ken Shimizu* **(FAO PNG);** *James Tefft, Meeta Punjabi Mehta, Wadzanai Garwe, Kanika Garg, Béatrice Ngirabacu, Carolina Pino* **(FAO Investment Centre).**
Editing and formatting: *Saon Bhattacharya, Paul Nagle, Polly Butowsky.*

ISBN 978-92-5-138007-9

9 789251 380079

CC7056EN/1/07.23