

Improving agricultural productivity in Papua New Guinea

Strategic and policy considerations

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EXECUTIVE SUMMARY

If smallholder farming households in Papua New Guinea achieve higher crop productivity levels, progress will be made along several dimensions of the development vision for PNG – increasing GDP for the agricultural sector and the overall economy; driving growth, diversification, and transformation of local rural economies; improving food consumption; and reducing poverty. In this paper, we examine recent data on yields for the most important crops grown in PNG, assess what yields might be achieved based on productivity data from areas of Indonesia with similar growing conditions, and sketch where policy reforms could provide incentives and access to technologies to achieve higher crop yields by all farmers across PNG.

While yield gaps – the difference between the crop yields farmers commonly obtain and what they might realize with optimal crop management and the use of high-yielding varieties – could not be estimated for the main cash crops, rough estimates could be made for the main staple food crops. These vary by crop. The yield gap for sweet potato is the smallest – actual farmer yields are between one-quarter to one-third less than attainable yields for the crop. Yield gaps for taro, Chinese taro, cassava, and yam are between 40 and 60 percent of what might be attained. Banana shows the largest yield gap at only about a quarter of the productivity levels that might be achieved under intensive cultivation. Strong agricultural research efforts coupled with effective agricultural extension systems are critical if farmers are to maximize the returns that they obtain from their crop production and reduce these yield gaps. Moreover, the challenges that farmers face in their crop production today are not necessarily the same challenges that they will face in the future. Climate change will introduce new production challenges, whether through changes in rainfall and temperature patterns or through increased incidence of pests and diseases that are better able to flourish under the changed climatic conditions. Moreover, increased trade in both cash crops and food crops heightens risks from introduced pests and diseases that so far have not affected farming in PNG. To enable farmers in PNG to adapt and surmount to these new challenges similarly will require continuous research and effective communication to farmers of the improved techniques and technologies that will enable them to manage them sustainably and profitably.

However, equally as important, if not more so, is strengthening agricultural markets across the country so that these markets both efficiently supply farmers with improved agricultural inputs to increase their productivity levels and provide sufficient price incentives to farmers to grow specific crops at higher levels of productivity. The performance of the markets into which farmers sell their crops is as important as their access to technologies and techniques to achieving higher agricultural productivity overall. The comparative case study of current crop productivity levels in Indonesia and Papua New Guinea shows that it is uniquely the crops with strong market demand in Indonesia for which productivity levels there are significantly higher than in PNG. In addition to fostering increased commercial crop production through agricultural interventions and strengthening agricultural institutions, such as extension, government must work to raise market demand for crops by improving the efficiency of crop value chains. These efforts include developing techniques and opportunities for food processing and preservation and enhancing domestic markets through improving physical marketplaces, strengthening transportation infrastructure, and ensuring reliable, low-cost communication to enable profitable marketing activities.

To raise crop productivity, specific efforts by crop type will be needed. For broad-based development with significant poverty reduction, staple food crops, particularly the traditional root and tuber crops, should be the crops that receive most support and investment from the public agriculture sector. However, most roots and tubers are difficult to store, are not extensively processed, and are subject to

spoilage in transport. Building increased incentives for commercial production of the traditional staple crops grown in PNG will require research on how best the crops might be processed so that they can be readily marketed or stored and still find a significant consumer market, whether domestic or overseas.

However, PNG's cash crops should not be neglected. Here too some targeting is needed. Particularly those for which smallholders are the main producers – cocoa, coffee, and coconut – deserve more effective attention from government and its partners. The apparent stagnation in production and productivity levels of these cash crops suggests that government is not as supportive of their development as it might be. More effective research, extension, and trade facilitation is required. In contrast, for oil palm, now PNG's largest cash crop, government should primarily facilitate the operations of the firms involved, while ensuring that those firms sustainably manage the resources of PNG that they are using and that beneficial economic spillover opportunities from the oil palm plantations to surrounding communities are maximized.

Keywords: agricultural productivity, smallholder agriculture, Papua New Guinea

INTRODUCTION

In 2018, the agriculture sector was estimated to have contributed about 17 percent of the total gross domestic product (GDP) of Papua New Guinea (PNG) (World Bank 2021). This is a substantial drop from the sector providing one-third of total economic output 50 years ago. In contrast, the services sector in 2018 contributed 42 percent of total GDP and the industrial sector, including petroleum and mineral production, 37 percent. The secondary importance of agriculture to the national economy is also reflected in the share of exports made up by agricultural commodities – statistics from the Bank of Papua New Guinea show that agricultural commodities made up just over 10 percent of all exports by value over the three-year period, 2017 to 2019, while hydrocarbons made up 44 percent and minerals 36 percent (BPNG 2021).¹

Nonetheless, the livelihoods of many individuals of working age in PNG are centered on agriculture, with much of the farming being done by smallholder farming households, relying on family labor principally to grow their own food. Estimates of the share of the workers in PNG employed in each economic sector reflect the central role of agriculture for most PNG households. The International Labour Organization estimated in 2019 that 56 percent of those employed who are of working-age (15 to 64 years) in PNG worked in agriculture, whereas 31 percent worked in the service sector and 13 percent in the industrial sector (World Bank 2021). Given the share of GDP that is attributed to each sector, the relative labor productivity of those engaged in farming is significantly lower than that of those engaged in the service sector and especially the industrial sector. **The low level of labor productivity in agriculture in PNG reflects the development challenges facing the sector and the barriers in PNG to significant economic growth overall emerging from agriculture.**

The food systems of PNG historically have been based on self-sufficient production of roots and tubers, in particular, with most farming activities being for own consumption within the farming household. A mid-2018 rural household survey in communities in Madang, East Sepik, and Sandaun (West Sepik) provinces, found that three-quarters of the food the households reported consuming in the previous week by value came from the households' own production (Schmidt et al. 2019). However, this pattern is not universal across all rural communities of the country. For households in South Bougainville district, the other area in which the 2018 survey was conducted, only 47 percent of the food that survey households consumed was reported to come from their own production. Commercial production of cocoa, as well as artisanal mining, is common in South Bougainville, so households there rely on the market for more of their food than is the case in the other survey areas. Moreover, across all of the four survey areas, it was found that rural households that engaged in some form of non-farm enterprise, in addition to their farming, were able to increase their consumption levels and improve the quality of their diets by expanding the diversity of the foods they consumed through purchases in local markets using the income obtained from those enterprises (Schmidt, Mueller, and Rosenbach 2020). However, even in those rural areas where purchased foods are a more common part of the household food basket, the foods obtained in the market will often be locally produced. Outside of district centers, the diversity of

¹ The share of all exports by value made up by agricultural commodities is somewhat higher than the share of exports made up by marine (4 percent) and forest (3 percent) products, the other export commodity categories, in addition to hydrocarbons and minerals, tracked by the Bank of PNG

Imports of agriculture-based products, primarily food, accounted for 14 percent of the value of all imports into PNG for the same period.

processed foods available in local shops is quite restricted (Benson et al. 2020). Local agricultural production is central to rural food systems in most parts of PNG, whether for own consumption within the producing household or through local markets that facilitate the exchange of foodstuffs between neighboring households and communities.

Based on per capita GNP, PNG is characterized as being a lower-middle income country. However, given that the most significant contributions to economic output come from petroleum and minerals and not from agriculture, outside of oil palm, **the agricultural sector in PNG is better characterized as low income with quite limited development.** What might be the agricultural production possibilities for PNG farmers if its agricultural sector were developed to the same extent as its petroleum and mineral sectors? Such development would involve significant transformations in agricultural land use, production techniques and technologies employed, and in the penetration and scope of agricultural markets across the country.

Higher productivity levels for many of the crops produced in PNG could expand agricultural GDP, improve the quality of diets, and, if coupled with improved performance in local markets across the country, increase household incomes. The relatively low crop yields realized by farmers in PNG and the declining importance of agriculture in the national economy represent important opportunity costs for those who farm or might farm and for the economy overall. A central objective in efforts to further develop the agricultural sector must be to enable PNG's farmers to realize crop yields that are much closer to what they might achieve with the use of improved crop germplasm, sustainable soil fertility management techniques, effective control of crop pests and diseases, and timely crop management operations. Doing so is not only in the best interests of the farmers, but will strengthen local economies across PNG. The increased wealth realized by farmers that increase their crop productivity will have spillover effects within their communities. Productive farmers will demand more of the labor-intensive and generally nonmarketable (outside of the local area) goods and services that their neighbors produce. This consumption linkage diffuses many of the economic gains from the more productive farming of these households to other rural households, deepening local markets, accelerating local economic activities, and improving access to food for economically active households in these communities.

In this paper, we examine the most recent data available on yields for the most important crops grown in PNG, assess what yields might be achieved based on productivity data from areas of Indonesia with similar growing conditions, and sketch out where policy reforms at national level could provide incentives and access to the technologies needed to achieve significantly higher crop yields by all farmers across PNG. However, before considering the data on crop productivity levels in PNG, we first consider from a conceptual standpoint why higher crop yields are important to achieve for the development of the agricultural sector and the national economy of PNG.

HIGHER CROP YIELDS – WHY AND HOW?

Why focus on improving crop productivity?

What motivates our focus on crop productivity in PNG is that growth within the agricultural sector fundamentally reflects increases in the amount of agricultural output produced, of which crops make up the majority, and in the market value of that output. Increased output in the agricultural sector, just as in the industrial and services sectors, in simplest terms contributes to overall economic growth at national level. Economic growth – that is, increases in the output of the economy – better enables the govern-

ment of PNG to make progress in pursuit of its goal of maximizing social welfare for its citizens. Increased output can be used to finance additional production, foster new enterprises in agriculture and in other sectors, and to make the investments that will provide jobs offering higher returns to more workers. For individuals engaged in agricultural production, higher farm production generally will raise the cash income and material resources that they can draw upon to meet the basic needs of their households and, with increases in their production levels over time, improve the welfare of their households and expand opportunities for their children to realize more readily their social, creative, and economic potential. These high-level objectives motivate interest in establishing policies and programs that will sustainably raise agricultural productivity levels in Papua New Guinea.

As noted, on a GDP basis, the structure of the economy of PNG is heavily skewed towards petroleum and mineral production, with considerable potential for additional expansion in these sub-sectors. However, petroleum and mineral production is capital intensive with limited direct spillovers to enhance production in other economic sectors. Consequently, the broader impact of petroleum and mineral production on the welfare of PNG's citizens will be dependent to quite a large degree on how revenues from petroleum and mineral exports are used to foster growth in other areas of the economy. **Given the significance of agriculture in the livelihoods of a majority of PNG households, how government invests its resources to increase agricultural production and commercial activity in the broader agri-food system of PNG will be critical to sustainable poverty reduction and improvements in the welfare levels** of the many agricultural households across the country. Increased investment in agriculture has repeatedly been shown globally to be superior in reducing poverty levels to investments that are directed to other economic sectors (Irz et al. 2001; Diao et al. 2007).

Beyond strengthening livelihoods for households engaged in some farming, increased productivity in the agricultural sector also plays an important role in fostering broad economic growth and lays the foundation for a structural transformation of national economies through substantial movement of labor and capital out of agriculture and into industries and services and, ultimately, a smaller share of GDP being made up by agricultural production. Johnston and Mellor (1961) provided among the first systematic assessments of how a vibrant and productive agricultural sector contributes to overall economic growth and to accelerating economic transformation. Agricultural growth makes five contributions to such processes:

- Providing increased food supplies – as the population continues to grow and as an economy expands and incomes increase, demand for food rises. With greater quantities of food produced, more agricultural output will be brought into the market for sale. With more reliable commercial supplies of food, markets will become more central than traditional subsistence production to household food security. As confidence in markets builds, more households will choose to pursue non-farm livelihoods. To meet their food needs, these households will rely on purchases of foods produced by the increasingly productive farmers remaining in the agricultural sector.
- Expanding agricultural exports – While, given its petroleum and mineral resources, agricultural exports are less pertinent to PNG than to other developing countries, increasing exports of agricultural products is an important means to increase incomes of households and firms and to boost foreign exchange earnings that will enable government to finance and step up its development efforts.

- Enhancing labor markets – Increased and more efficient agricultural production will enable labor currently used for farming to work in expanding sub-sectors in the industrial and services sectors without adversely affecting agricultural production levels.
- Generating capital for greater investment - The capital needed for development in the industrial and services sectors can be generated through increased agricultural production. While petroleum or mineral export revenues will be the main source of development financing for PNG, the agricultural sector can also contribute. The capital requirements for agricultural development generally are less than those required for development in the non-agricultural sectors, allowing some agriculture-derived surpluses to be diverted to finance expansion in the other sectors. However, such taxation of farming can go too far, resulting in agricultural stagnation or decline (Schiff & Valdés 1992). Caution is merited.
- Fostering service and market diversification - The increased rural incomes obtained through more productive agriculture expand demand for the output of the growing services and, especially, industrial sectors, expanding markets for those outputs.

These contributions of increased agricultural production operate at the economy-wide and economic sector levels. However, increased farm productivity can be a central driver in the growth, diversification, and transformation of local rural economies, bringing about sharp drops in local poverty levels (Haggblade, Hazell, and Reardon 2007; Mellor 2014, 2017). The principal mechanism for such rural economic growth involves enabling the more commercially oriented smallholder farming households in a community to significantly increase their productivity through increased use of modern farming inputs and practices over an increasing share of local arable land. As the income of these now more productive farm households grows, their consumption of locally produced goods and services will increase. These goods and services are those that are labor-intensive, require limited capital in their production, and typically are not marketed outside of the local community—construction, building repair, and associated services; transport and associated services; education, health, and other social services; furniture and handicraft-making; food and beverage processing; and the like.

As the economic linkages between the more productive farmers and their neighbors who produce those goods and services deepen, experience from elsewhere shows that the returns that the neighboring households obtain from those nonfarm activities will increasingly surpass those that they can obtain from continuing their low-productivity, generally subsistence-focused farming, propelling some specialization in local rural employment patterns (Mellor and Malik 2017). With sustained returns and continued investment—including judicious public investment in market support services, transportation infrastructure, communication services, electricity, and the like—many of the households producing goods and services for the local market will expand their activities to serve wider markets, further increasing their income. Many will transition from being poor, subsistence-oriented households that engage in some farming to become households specialized in livelihoods outside of farming and no longer be poor. But, critically, at the core of this mechanism for rural economic development is higher crop productivity through the use of improved agricultural technologies and effective crop management, together with strengthened markets to provide continued reliable incentives for commercial agricultural production by these now more productive farmers.

A final significant contribution that increased agricultural productivity can make to economic development and to sustainably improving the welfare of all Papua New Guineans is through mitigating the impact of climate change. Higher crop productivity will reduce land cover change, particularly of carbon-rich forests and wetlands. With higher yields enabling demand for crops to be met from existing

cropland, forests and wetlands will not need to be cleared and brought into production. This will result in reduced greenhouse gas emissions and continued incorporation of carbon dioxide from the atmosphere into the forest and wetland biomass through carbon sequestration (Campbell et al. 2014). Farmers also can better manage their soils to increase the organic matter in them, resulting in greater productivity, increased carbon sequestration in the soil, and reduced greenhouse gas emissions (Lal 2004). Energy needs can also be met through farming dedicated energy crops that could replace fossil fuels in a more sustainable manner that would reduce the contribution of energy use to global warming (FAO 2013). The more efficient use made of natural resources that is inherent to raising crop productivity levels will reduce the adverse impact that a growing agricultural sector in PNG would otherwise have on global warming processes.

Raising crop yields – policy priorities

The previous sub-section provides a condensed answer to the question of why higher crop yields should be an important agricultural and economic development objective for stakeholders in PNG's agricultural sector and for PNG's leaders. But how can crop yields be raised?

In considering what might be done to assist farmers to raise their productivity levels, it has been repeatedly shown that farmers in traditional farming systems, far from being ignorant and passive, quite effectively and logically choose the production techniques they use to maximize the benefits they obtain from their efforts and to reduce the costs they might incur given available technologies, the production risks they face, and the incentives to which they respond as to what to produce and at what level of production (Schultz 1964). **Economic research from around the world has demonstrated that traditional farming systems generally are efficient in economic terms – farmers allocate their available labor, land, and other factors of production up to a level at which the returns to doing so are equal to the value of output they obtain from the use of each factor in their farming.** Productivity levels generally are low in traditional agriculture not because the farmers are bad at farming. Rather, productivity is low because the only production technologies that farmers can profitably use given the conditions under which they farm generate low yields. That traditional smallholder farmers can be characterized as efficient is conditional on their resource constraints, the incentives motivating their production, and the trade-offs that they must weigh in their production decisions, including how best to manage adverse production risks and how to balance their efforts in farming with the labor they dedicate to non-farm productive pursuits or to reproductive tasks within the household (Ellis 1993).

The hypothesis of Schultz that smallholder farmers employing traditional agricultural technologies are “efficient but poor” within the technological, market, and contextual constraints in which they farm suggests several policy initiatives that governments might lead to enable farmers to utilize higher productivity farming technologies profitably. If these checks on production levels can be lifted, both individual farmers and the agricultural sector of the economy as a whole can be considerably more productive. The implications of this for both broad economic growth and for poverty reduction, particularly in rural communities, are significant.

Among the areas where government action and investments could result in smallholder farmers realizing increased productivity are (Schultz 1981; Ellis 1993):

- **Invest in research to develop higher productivity technologies** or those that enable farmers to avoid crop losses to pests and disease. These improved technologies must be adapted for local agro-ecological conditions. Technologies developed elsewhere can be

adapted for PNG conditions by NARI scientists and their partners. However, it should be expected that farmers will face significant barriers to adoption of many of these technologies as innovations within their existing farming systems, since the improved technologies will likely be more costly to adopt than the traditional technologies they currently use. But if the new technologies perform well under PNG conditions, parallel investments in market systems will be required so that there is a sufficient demand for the increased crop production the new technologies generate. If this is done and if farmers are able to learn about and readily access them, relatively rapid adoption of the technologies into traditional farming systems should be expected.

- Critical to increasing productivity through adoption of improved agricultural technologies is to expand the incentives for farmer to increase their production. Where crop production now is primarily for own use by the producing households, the development of competitive agricultural market systems will require investments in physical market infrastructure, reliable transportation networks, good communication services, and financial services. For exportable commodities, government should also foster development of trade infrastructure and put in place the added regulatory frameworks required to expand trade flows.

The aim of such efforts should be the development of market systems in which farmers can be certain they will find buyers who will pay them a profitable price for the crops they bring for sale, even as at the same time consumers, at the other end of the value chain, can be certain they will find the food and other products they require in the market at a price they can afford. The traders, as the intermediaries between the suppliers of the produce and those demanding it, similarly should be able to derive a reasonable return for the necessary services they provide to enable the markets to operate effectively.

With the objective of significantly and sustainably increasing crop productivity levels across PNG, **an equally important facet of the development of effective agricultural markets is the development of reliable input markets.** While it is the prices offered in output markets that provide smallholder farmers with the incentives to increase their production of marketable crops, to achieve higher production on the same land area or with current labor supplies will require that farmers have access to the modern inputs – improved planting materials, fertilizer, agro-chemicals, and any farm machinery – that will enable them to achieve higher productivity levels. These farm inputs are most sustainably provided through the market.

- Invest in both general education and effective agricultural extension services.
 - Building human capital is a foundational component of human development, including for economic development. A well-trained (and healthy) workforce is needed so that more complex production processes can be used, including in agriculture; more effective services can be offered to increase the overall output of the economy of PNG; and all workers can better respond to and benefit from new economic opportunities and incentives. Increasing numbers of well-educated citizens expand the human capital stock of PNG and, thereby, its economic potential.
 - To improve their agricultural productivity with improved technologies, farmers will need to engage in a process of learning and experimentation over several cropping seasons. Access to the technologies, whether through the market or through government programs, will allow them to experiment. However, information on how to make effective use of the new technologies is an important additional component in efforts to foster farmer uptake of the new techniques so that all adopters realize significantly higher

yields. This information can be offered by government, nongovernmental organizations, or private firms and flow to smallholder farming households using any effective means, whether in person or, more remotely, using new communication technologies.

While not all smallholder farming households in a community will be able to profitably adopt new technologies to raise their farm productivity or to significantly increase their participation in agricultural markets, those with sufficient land, labor, knowledge, and other productive assets should be able to do so. If we accept the hypotheses of Schultz, most smallholder farmers in PNG are as productive as they can be given the constraints under which they farm. But several of those constraints can be lifted by government and its partners to sustainably increase crop productivity levels. By improving markets and changing the structure of incentives that governs the agricultural production decisions of smallholders, by improving their access to improved farm technologies, and by improving their abilities to effectively use the technologies through improving their skills and decision-making abilities, much higher levels of crop output per unit of land or unit of labor used can be attained and sustained.

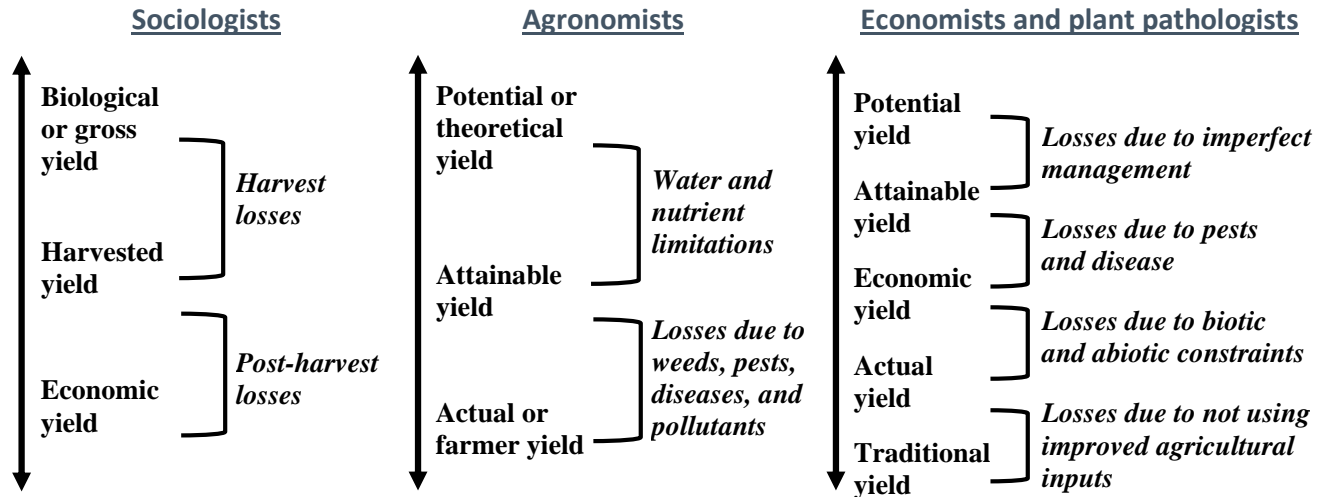
Measuring crop productivity

Crop yields

Crop productivity is a measure of crop output per unit of input used in producing the crop. In this paper, we primarily measure crop productivity as the amount of crop harvested per unit of land farmed in a cropping season – that is, crop yields measured in kilograms or metric tons per hectare. This is the most common measure of productivity used, because the data required to compute such yields is relatively well understood, even if collecting the data may not be easy.

Challenges in computing such yields include determining what is the amount harvested, what is the land area under production, and what time period constitutes a cropping season. Though the definition seems simple, in many circumstances none of these components of the yield measure may be easy to determine as both the amount of crop harvested and measures of the land area farmed are prone to error and bias and their measurement can be time consuming. In computing yields, Fermont and Benson (2011) highlight the range of different measures of the amount harvested that might be used as the numerator in any crop yield computation, depending on the type of analysis being conducted (Figure 1).

Figure 1. Crop yield concepts used by sociologists, agronomists, and economists and plant pathologists



Source: Adapted from Fermont and Benson (2011).

For this paper, the yield concepts in Figure 1 that are most relevant are those used by economists and plant pathologists. Of the five yield levels noted, most of the crop productivity measures reported in this paper are those that reflect “actual” yields. However, for most subsistence-oriented farmers in PNG, these also will be “traditional” yields, as most do not use modern agricultural inputs on their staple food crops. However, the objective to which this paper seeks to contribute is to raise crop productivity levels in PNG so that they are much closer to the “economic” yields that can be obtained given available farming technologies and prices for both farm inputs and crop outputs. Ideally, as agricultural markets continue to improve in the country and access to adapted high-yielding agricultural technologies improves, the economic yields that farmers obtain will move closer to “attainable” yield levels, even if they will not attain those yields, given the cost trade-offs farmers must manage in their crop production.²

However, the yield concepts of sociologists that are presented in Figure 1 are also important in considering crop yields in PNG, particularly for the main staple food crops. Most of these are roots or tubers that have a high moisture content when harvested. In most parts of the country, due to limited dry periods, once harvested, it is difficult to dry or otherwise preserve these crops for long-term storage. Consequently, postharvest losses can be high for the dominant staple crops in PNG so that the difference between the “harvested” and the “economic” yields, as sociologists use the terms, will be significant.

Among the challenges in measuring the land area dedicated to a crop to compute yields are:

² “Potential” and “attainable” yields will be of most interest to agricultural researchers as they work to develop crop varieties and other technologies that best control both the biotic and abiotic stresses on a crop that reduce output. However, farmers are unlikely to be able to profitably attain such experimental yield levels. Given diminishing returns in outputs to increased use of inputs, trade-offs among production objectives, and variable input to output price ratios, highest financial returns are obtained at lower productivity levels – the economic yield level.

- How a measurement of the land area is determined. Various technical approaches can be used to compute plot areas ranging from traditional chain and compass land survey methods to the use of Global Positioning System (GPS) devices in the field to remote analysis of aerial photographs or, increasingly, satellite imagery. Field methods are expensive given the trained staff required, while the costs of obtaining recent remote imagery and accurately analyzing it pose a high barrier. A common alternative is to rely on farmer estimates of the size of their plots, because obtaining such estimates can be done as part of a survey of farm households and does not necessarily involve data collectors going to the actual farm plot, reducing costs. However, smallholder farmers often do not have a good understanding of the size of standard land area units, such as hectares or acres, and most have never had their land measured by anyone with such expertise. Recent rigorous analyses demonstrate that such farmer-reported estimates are not accurate and often are biased (e.g., Carletto, Gourlay, and Winters 2015). Making use of estimates from farmers of their cropped area to compute yields to guide policy and to design programs is not recommended. Nevertheless, continued use of such self-reports of land area remains common in computing crop yields, likely including for many of the crop yield values reported in this paper.
- Heterogeneous crop performance is high in smallholder farming and can be seen at plot level, within a community, and between regions. Average yield levels computed from small samples of farmers are likely to not be as representative of yields for all farmer as we would wish.
- Intercropping or mixed species cropping is a technique smallholder farmers use to spread risks, diversify their production, and increase total output of individual fields, including in PNG (Bourke and Allen 2009, 107). The final impact of intercropping on individual crop yields is a result of complex interactions of many factors that include relative time of planting, plant density, rainfall, soil fertility, and the optimal timing among the intercrops of the farmer's crop management activities, among others. Estimating yields of individual crops on a farm plot into which two or more crops are grown at the same time presents difficulties for any crop yield estimation method, with significant overestimates or underestimates common for the individual crops in intercropped plots (Fermont and Benson 2011).

The final important challenge in computing crop yields, particularly relevant to PNG, is the definition of a cropping season or other time period over which crop production is computed. In farming systems which show significant seasonality in cropping patterns every year, this problem typically does not arise since annual crops dominate in those farming systems. However, in PNG, due to the relatively even distribution of rainfall in large parts of the country, farmers may plant and harvest crops throughout the year. Many important crops are perennials or require more than a year of growth before harvest, including cassava and banana. Other crops have extended harvest periods, including cassava, sweet potato, banana, and coffee (Fermont and Benson 2011; Kilic et al. 2021). This uncertainty about the period of time over which production takes place complicates the estimation of both total production and productivity levels for such crops.

Other measures of productivity

Crop yield – the physical amount of crop harvested per unit of land farmed in a cropping season – is not necessarily the most useful measure of crop productivity to use to assess the economic performance of the agriculture sector at farm level. For example, in assessing productivity at the entire farm or broader

levels of aggregation in which multiple crops are involved, land-based measures of productivity will generally use the market value of output produced, rather than the physical quantity, enabling the inclusion in the productivity measure information from all crops that a farmer might produce, even those for which the harvests have very different physical characteristics. However, in this paper, our interest is crop-specific, so we will use physical quantity-based measures of yield.

Yields are not the only measure of crop productivity, however, because land is only one factor in agricultural production. Labor and capital are also critical factors.³ Productivity measures can be computed over a specific time period for these other factors using either the physical amount or the value of output from a plot, farm, or broader agricultural area as the numerator and for the denominator a measure of the input of labor (person-days; total labor costs) or some partial or complete measure of capital employed (e.g., value of purchased inputs, value or number of farm machines or other tools, value of capital improvements to plot or farm, etc.). However, the challenges to collecting complete and reasonably accurate data on the use of labor or the value of capital invested in production in smallholder farming systems are daunting. Moreover, in smallholder farming systems, most of the labor is supplied by members of the farming household, which is unpaid, often difficult to measure given its heterogeneity (children, adults, or elderly; male or female; trained or untrained), and usually ignored by the household members in estimating production costs for the crops they produce. Consequently, measures of productivity based on these other factors are not commonly produced by statisticians for monitoring crop productivity trends or farm and farming system performance. Researchers are more likely to calculate them for analytical purposes.

These factor-specific productivity measures are partial productivity measures. A measure of total factor productivity can also be computed. Such a measure for a farm, farming system, or agricultural sector can be computed by calculating the market value of all farm outputs for the unit of interest as the numerator and the market value of all factors – land, labor, and capital – used to produce that output as the denominator. While we will not consider total factor productivity in this paper, for studies of economic growth, both broad and agriculture-specific, and for studies of economic structural transformation, changes in the measure over time or over space provides important insights into these economic development processes (e.g., Benin 2016; McMillan, Rodrik, and Sepúlveda 2017).

CURRENT CROP YIELD LEVELS IN PAPUA NEW GUINEA

The overall aim of this paper is to consider how higher agricultural productivity levels for many of the crops produced in PNG could be increased to foster significant growth in the agricultural sector of the economy and to improve the welfare of the many households across the country that rely at least in part on farming to meet their basic needs. We focus on a set of six basic staple food crops – sweet potato, banana, taro (*Colocasia esculenta* and related species), Chinese taro (*Xanthosoma sagittifolium*), cassava, and yam (*Dioscorea* species) – and the principal cash crops produced in PNG – cocoa, coffee, palm oil, and coconut / copra. We also discuss the productivity of sago obtained from naturally oc-

³ Land, labor, and capital are the classic factors of production in the economics literature. But over recent decades entrepreneurship has increasingly been seen as an additional equally important factor (e.g., Naudé 2008). However, standard measures of entrepreneurship in smallholder agriculture remain to be developed. In consequence, we are unaware of any productivity measures for developing country agricultural systems based on entrepreneurship inputs.

curing perennial stands of sago palm. Sago is more a managed source of staple food, rather than cultivated. The most recent statistics on agricultural production from across the country for these eleven crops are summarized in Table 1 to provide a situation analysis on crop productivity.⁴ More detailed information by crop is presented in Appendix 1, including maps of where the crops are significant components of local farming and food systems across PNG.

Yield gaps – the gap between the yields farmers commonly obtain and what they might obtain with optimal crop management and the use of high-yielding crop varieties – could not be estimated for the main cash crops, except coffee, due to no data on attainable yields for those cash crops in PNG being found. However, for the main staple food crops, yield gaps could be roughly estimated from the statistics presented in Table 1. Yield gaps vary by crop. The yield gap for sweet potato is the smallest – actual farmer yields are between one-quarter to one-third less than the attainable yields for the crop. Yield gaps for taro, Chinese taro, cassava, and yam are similar with actual yields obtained by farmers being between 40 and 60 percent of what they might attain with improved planting materials and excellent crop management practices. The data on actual versus attainable yields for banana shows the largest yield gap – PNG banana growers are obtaining only about a quarter of the productivity levels they might achieve with more intensive cultivation of the crop.

The only cash crop for which yield gaps could be computed from the available productivity data for PNG is for coffee. Coffee producers are generally harvesting about half of what they might harvest if they used improved coffee production practices.

Given the challenges that farmers in PNG, particularly smallholder farming households, face in seeking to obtaining good information on how best to produce these crops under local conditions and to obtain improved inputs to do so, that there are significant yield gaps for these major crops is not surprising. Some of the information constraints that farmers face can be addressed through adaptive agricultural research coupled with sound systems for supplying farmers with advice on how best to manage their crops to maximize the returns that they obtain from their crop production.

However, equally as important is strengthening agricultural markets across the country so that these markets both supply farmers with improved agricultural inputs at prices which allow them to earn a reasonably financial return on the use of those inputs and to provide sufficient price incentives to farmers to grow specific crops at higher levels of productivity. Without strong markets, crop productivity will remain low because, as was highlighted in the previous section of this paper, the only production technologies that farmers can profitably use given both the agro-ecological and market conditions under which they currently farm generate low yields. With access to improved technologies and crop production techniques and appropriate market incentives in place, PNG farmers can achieve yield levels higher than what they now realize and much closer to the ‘attainable’ yields noted in Table 1.

⁴ Most of the crop data used is also over a decade old. While it is still useful for the purpose of the analysis here, readers should recognize that current production and productivity levels for the crops examined and where they are grown in PNG may differ somewhat from what is presented. Stronger data systems and greater applied analytical capacity within the agricultural sector in PNG are areas of rising urgency for identifying realistic and achievable strategies for increasing the productivity of PNG’s farmers and developing the agricultural sector.

Table 1: Productivity levels of major staple food and cash crops in Papua New Guinea, actual and attainable on farm with optimal management, most recent estimates, mt/ha

Crop	Elevation or other production conditions	Actual	Attainable
Staple food crops			
Sweet potato	lowlands (<1,200 masl):	13 ¹	15 to 20 ²
	highlands (1,200 to 1,800 masl):	15 ¹	20 to 30 ²
Banana	lowlands:	12 ¹	--
	highlands:	9 ¹	--
	on-farm with good husbandry:	--	38 to 50 ³
Taro	lowlands:	6 to 8 ¹	--
	highlands:	10 ¹	--
	on-farm with good husbandry:	--	15 ¹
Chinese taro	lowlands:	14 ¹	--
	highlands:	11 ¹	--
	on-farm with good husbandry:	--	25 ¹
Cassava	lowlands:	22 ¹	--
	highlands:	16 ¹	--
	on-farm with good husbandry:	--	45 ¹
Yam	lowlands: lesser yam:	15 ¹	--
	greater yam:	13 ¹	--
	highlands: greater yam:	11 ¹	--
	on-farm with good husbandry:	--	lesser yam: 40 ¹ greater yam: 30 ¹
Sago	average, per trunk:	180 kg ¹	500 kg ¹
Major cash crops			
Cocoa	smallholder:	0.2-0.4 ⁴	--
	plantation:	0.4-0.6 ⁴	--
Coffee Arabica	smallholder:	0.75-1.25 ⁴	--
	plantation:	1.00-2.40 ⁴	--
	on-farm with good husbandry:	--	1.25-2.50 ³
Robusta	average:	0.90 ⁴	--
	on-farm with good husbandry:	--	1.90 ³
Oil palm (fresh fruit bunches)	smallholder:	6.0 to 14.5 ⁴	--
	plantation:	19.0 to 21.5 ⁴	--
Coconut (in form of copra)	smallholder:	0.40-0.70 ⁴	--
	plantation:	0.70-1.00 ⁴	--

Sources: 1: Bourke et al. (2009); 2: Allen and Bourke (2009); 3 Acland (1971); 4 Allen, Bourke, and McGregor (2009).

Note: -- = "not available"; masl = "Meters above sea level"

Yam – Lesser yam = *Dioscorea esculenta*; 'mami' or 'taitu'. Greater yam = *Dioscorea alata*; 'yam tru'.

However, we should not minimize the challenges involved in improving the markets for the main staple foods produced in PNG. **The principal staple crops of PNG are roots and tubers.** While the crops are well adapted for the agro-ecological conditions in which they are produced and often have long harvest periods that contribute to a consistent supply of food for the producing household and for neighboring households and communities, **these staples are difficult to store after harvest for any extended periods of time.** Their high perishability also makes them difficult to transport and market without incurring significant losses to wastage. The principal exception to this rule is yam, which can be

stored for quite long periods without spoilage or other losses. The other staple crops require extensive processing and drying or cold storage to avoid significant losses after harvest.

It is common in many subsistence-oriented economies globally to dry staple crops in the open air using solar radiation during the regular dry seasons. **However, few areas of PNG have dry seasons of sufficient length with sufficient sunshine to adequately dry the harvested roots and tubers.** These staples could be dried using heat, primarily using firewood as the source. However, the adverse environmental ramifications of doing so are considerable. With significantly expanded rural electrification, both drying and cold storage of these staple crops become possible. However, whether doing so will be cost-effective is unlikely.

In consequence, these staple crops are primarily marketed in unprocessed forms either locally or, where there is reasonably good transportation infrastructure to connect producing areas to PNG's main cities, in the wider domestic market. The tradability of PNG's principal food crops poses a challenge for intensive commercialization to raise producer incomes. It is difficult to see where demand-side incentives for PNG's main staple crops will come from outside of local areas, given that they are difficult to transport if not processed into more storable forms. **There are likely only to be niche export markets, at most, for PNG's principal staple foods.** Building increased incentives for commercial production of the traditional staple crops grown in PNG is a significant agricultural development challenge.

STAPLE AND CASH CROP YIELDS IN INDONESIA – A COMPARATIVE ANALYSIS

The broader aim of this paper is to identify what sort of policy reforms and public investments could be made, particularly at national level, to provide improved incentives and better access to the technologies needed to achieve significantly higher crop yields by all farmers across PNG. Virtually all staple crop production and much of the cash crop production in PNG is carried out using traditional production methods and technologies. This in part reflects the relatively limited development of PNG's agricultural sector.

Indonesia is a middle-income country with a growing economy that is the largest in Southeast Asia and is among the 20 largest globally. Neighboring PNG to the west and sharing half of the island of New Guinea, the main islands in the eastern half of the Indonesian archipelago have the same agro-ecological conditions as are found in PNG. From a biophysical perspective, agricultural production possibilities in PNG should be relatively similar to those in eastern Indonesia.

However, from an economic perspective, much of the agricultural production in Indonesia is done within the context of a strongly commercially-oriented farming sector. **While smallholder agricultural systems remain a significant part of farming systems in Indonesia, in contrast to PNG, the incentives many Indonesian smallholders respond to in choosing what and how much to produce are more driven by considerations of the market-based income they might derive from their farming than by the subsistence consumption needs of their household.** Smallholders in Indonesia also are able to better access modern farm inputs, primarily through the market, and information on how best to employ those inputs to raise their crop productivity levels than is the case for farm households in PNG. Indonesian smallholder farmers have access to larger and deeper markets than those into which smallholders in PNG might sell their crops. Theoretically, based on the stronger agricultural market systems in which they are emmeshed, we would expect that smallholders in Indonesia attain on average higher crop yields than do smallholders in PNG.

To determine whether the crop productivity patterns in Indonesia relative to PNG are higher due potentially to the economically more developed and greater commercial orientation of agriculture in Indonesia, we compare in **Table 2** average productivity levels reported in Indonesia and PNG for the food and cash crops considered in this paper for which data is available. Where possible in the data, we focus on productivity levels in the eastern provinces of Indonesia that agro-ecologically are most comparable to PNG – the islands of Kalimantan and Sulawesi, the Maluku Islands, and the provinces of Indonesia (Papua and West Papua) on New Guinea itself (**Figure 2**).

Figure 2: Provinces of Indonesia



Source: https://commons.wikimedia.org/wiki/File:Indonesia_provinces_english.png. Copyright remains with the author(s). This map is licensed for use under a Creative Commons Attribution 4.0 International License (CC BY 4.0). To view this license, visit <https://creativecommons.org/licenses/by/4.0>.

The crop yields reported in **Table 2** for PNG are the actual farmer yield estimates presented in **Table 1**, which are discussed in more detail in Appendix 1. For banana, cassava, cocoa, and coffee yields in Indonesia, as these crops have sufficiently detailed data, we further disaggregate productivity levels across the 15 provinces of the eastern part of the country for the period 2015 to 2017. We also further disaggregate productivity estimates for these crops by three groups of provinces in eastern Indonesia—average yields for the two Indonesian provinces in western New Guinea, which likely best reflect the conditions under which crops are produced in PNG just to the east of those two provinces; average yields for the six provinces on Sulawesi island, which has significant areas of highland; and those for the five provinces on Kalimantan and the two provinces in the Maluku Islands, which generally have lowland and coastal agro-ecologies. For oil palm and coconut (copra), sub-national production data for Indonesia are not readily available. For these crops, only average national yields are presented. No recent national or sub-national productivity estimates for taro, Chinese taro, and yam in Indonesia were found, despite extensive online searching.

Table 2: Productivity levels of selected food and cash crops in Indonesia and Papua New Guinea, most recent estimates, mt/ha

Crop	Papua New Guinea	Indonesia	Eastern Indonesia	Papua	Kalimantan and Maluku	Sulawesi
				(Indonesia New Guinea – mainly lowland production)	(lowland production)	(some highland production)
Sweet potato	lowlands: 13 highlands: 15	17.1	13.2	13.1	13.9	13.0
Cassava	lowlands: 22 highlands: 16	24.0	21.8	12.1	22.5	22.1
Banana	lowlands: 12 highlands: 9	55.4	42.1	38.2	36.5	50.1
Cocoa	smallholder: 0.2-0.4 plan- tation: 0.4- 0.6	0.36	0.37	0.24	0.28	0.39
Coffee, Arabica	smallholder: 0.75-1.25 plantation: 1.00-2.40	0.55	0.38	<i>limited produc- tion</i>	<i>no production</i>	0.42
Copra (coconut)						
smallholders	0.40-0.70	1.1	<i>na</i>	<i>na</i>	<i>na</i>	<i>na</i>
plantations	0.70-1.00	2.8	<i>na</i>	<i>na</i>	<i>na</i>	<i>na</i>
Oil palm						
smallholders	6.0-14.5	15.3	<i>na</i>	<i>na</i>	<i>na</i>	<i>na</i>
		potential: 44.6				
plantations	19.0-21.5	19.5	<i>na</i>	<i>na</i>	<i>na</i>	<i>na</i>
		potential: 48.8				

Source: PNG yields – Bourke et al. (2009); Indonesia banana, cassava, cocoa, and coffee – KPRI (2021); Indonesia oil palm – GYGA (2021); Indonesia copra – Alouw & Wulandari (2020).

No recent national or subnational yield estimates for Indonesia for taro (*Colocasia* spp.), Chinese taro (*Xanthosoma* spp.), and yam (*Dioscorea* spp.) could be found through standard online searching. Sago productivity estimates were not sought.

Note: na = “not available”.

Our comparison of crop yields from Indonesia with those from PNG do not provide consistent results across the crops examined. Sweet potato and cassava show comparable productivity levels in Indonesia with those recorded for PNG, particularly for the eastern provinces of Indonesia. It is unclear the degree to which production of these two staples is commercialized in Indonesia. However, given the technical challenges in processing sweet potato and cassava for long-term storage, likely the crops in Indonesia are principally sold in fresh form, similar to how they are marketed in PNG, or grown for own consumption by the producing household. **As a consequence of their restricted commercial potential, as is the case for these crops in PNG, low levels of investments in crop breeding or in crop value chains are likely seen for sweet potato and cassava in Indonesia.** Given this neglect in both

countries in developing varieties of sweet potato and cassava with higher productivity potential or in developing deeper marketing systems that offer farmers good incentives to raise their levels of productivity of the two food crops, we find similar productivity levels for the crops in the two countries.⁵

In contrast, for banana, the third food crop listed in Table 2, productivity levels are far higher in Indonesia than in PNG. While Indonesia is among the top ten banana producing countries globally, little of the production is exported. With over half of all Indonesians living in urban areas – over 150 million urban dwellers, there is a large domestic market for banana. The high productivity levels for banana in Indonesia almost certainly reflect research investments to develop banana varieties with higher productivity potential and to identify optimal agronomic practices for banana production. These investments make sense in the context of significant and growing demand for banana in Indonesia's cities. As a result, much of the banana produced in Indonesia is under intensive, specialize farming systems, in contrast to PNG where much of the banana is produced out of plots in which banana is one of several intercrops. The low productivity levels for banana in PNG reflect the low commercial potential for the crop. The country does not have the large domestic market for banana seen in Indonesia, with less than one in five of PNG's citizens living in urban areas. In consequence, most banana production in PNG remains for own consumption or for local trade. Efforts to raise banana production and productivity levels in PNG would likely require close attention to developing export markets for PNG's bananas.

For the cash crops examined, we also find that productivity levels in Indonesia are not consistently higher than in PNG. **Cocoa yields estimated for Indonesia are at the lower end of yield ranges for the crop in PNG.** Indonesia's cocoa sector, which is centered on the island of Sulawesi and is dominated by smallholder production, is at least ten times larger in terms of total annual production than that of PNG – Indonesia is the third largest producer of cocoa globally. Given the size of the sector, we might assume that there is more effective outreach to producers with improved planting materials and advice on optimal cocoa production techniques in Indonesia than in PNG. However, productivity levels shown in **Table 2** do not support such an assumption. **Analyses of constraints facing the cocoa sector in Indonesia highlight many of the same challenges facing cocoa producers in PNG – sub-optimal crop management, old trees that should be replaced, limited access to credit for cocoa farmers, and volatile prices for both cocoa beans and inputs, among others (Fahmid et al. 2018).**

A similar pattern is seen with Arabica coffee. Like cocoa, coffee also is a smallholder crop in Indonesia – 90 percent of production comes from smallholders. **Indonesia is the fourth largest coffee producer globally. However, despite the size of the sector, the yield levels obtained by Indonesian coffee farmers are not necessarily any higher than those of coffee producers in PNG.** The constraints noted above as being faced by smallholder cocoa producers in both Indonesia and PNG are also many of the same constraints that coffee producers in both countries face. **Indonesia has not solved the challenge posed by low coffee yield levels constraining growth of the sector any more than PNG has.**

⁵ Although we have no comparative data on taro, Chinese taro, and yam, we have found no evidence to indicate that yield levels for the three would differ between PNG and Indonesia. Moreover, in explaining why we see on-farm yield levels in PNG for the three crop being considerably lower than what is potentially attainable (**Figure 5**, **Figure 6**, and **Figure 8**), the arguments for why yields of sweet potato and cassava in Indonesia are low related to restricted market potential also apply to these other three staple crops. Moreover, that it is difficult to obtain information on their production or productivity levels in either PNG or Indonesia is in part due to the crops being viewed as purely for subsistence, with any commercial potential they have being primarily restricted to local markets and not for wider domestic markets or for international trade. Agricultural researchers similarly give them much less attention than more commercial crops, further exacerbating data gaps on the productivity of these crops.

However, productivity estimates in **Table 2** show that this pattern is not replicated for the other two cash crops examined, coconut and oil palm. Both show higher productivity in Indonesia. The Food and Agriculture Organization of the United Nations (FAO) reports that Indonesia is the leading producer of coconut globally. **While PNG is among the top ten global producers, FAO coconut production estimates for PNG for 2019 are less than 10 percent those of Indonesia** (FAO 2021). While both Indonesia and PNG are among the largest exporters of copra globally, demand also is high in the Indonesian domestic market for a wide range of coconut-based food products (Alouw & Wulandari 2020). A far larger share of the coconut produced in Indonesia is consumed either directly or after commercial processing than is the case in PNG. The size of the domestic market in Indonesia supports considerable specialized processing of the crop into a range of food products. Because of this greater commercial potential, coconut producers in Indonesia, most of whom are smallholders, demand more productive varieties of coconut and the information that will allow them to produce the crop most profitably. **The higher productivity levels reported for copra in Indonesia reflect, at least in part, effective response to these demands of Indonesian coconut farmers on the part of agricultural researchers and extension service providers, whether public agencies or private firms within the coconut sector.**

The Indonesia case shows that PNG coconut producers can be considerably more productive. However, to replicate the outcomes of patterns of investment in Indonesia in the coconut sector in PNG will be much more challenging, simply because the domestic market for coconut products in PNG is much smaller and unlikely to provide the returns on public and private investments to improve productivity that is apparent in Indonesia. **However, that coconut in PNG (as in Indonesia) is a smallholder crop is an important consideration in prioritizing which crops should see higher investments to improve their productivity.** The direct welfare and poverty reduction benefits for coconut producing households of targeted investments to raise coconut productivity levels would certainly be much higher than they would be for investments in crops that are less commonly produced by smallholders.

Oil palm is much less widely grown by smallholders. **Table 2** shows that oil palm producers in PNG, both smallholders and plantations, are keeping pace with the productivity levels of Indonesian producers. This should not be so surprising given that oil palm plantations in both countries are vertically integrated and often part of multinational corporations. These features facilitate any innovations in production of oil palm to be quite quickly disseminated and scaled up. Moreover, smallholder outgrowers work closely with the plantations, so have good access to improved planting materials, other inputs, and advice. However, we see in **Table 2** that there is considerable scope for further productivity improvement for oil palm. Based on crop modeling which assumes optimal management of improved planting materials that are perfectly adapted for local growing conditions and have the highest production potential, researchers estimate that productivity levels for oil palm in Indonesia could more than double current levels. While those levels are unlikely to be realized by most farmers, the estimates demonstrate that there is room for more efficient and more profitable production of oil palm in Indonesia. There are no biophysical barriers to similar productivity yields being realized by oil palm producers in PNG.

Consequently, we can expect that there is considerable potential for growth in output from the oil palm sector in PNG simply through greater oil palm productivity. Raising productivity in the sector will increase the amount of physical product produced and, as most oil palm in PNG is exported, expand agricultural export revenues, and increase both agricultural and the overall GDP of PNG's economy. Indirectly, this economic growth should provide significant benefits to the welfare of poor households across PNG. However, in determining whether public investments, in particular, should go to increasing oil palm productivity, the structure of the oil palm sector in PNG should factor in such decisions. The

organization of oil palm production in PNG, like petroleum and mineral production, is in enclaves with rather limited linkages to the broader economy in the provinces in which those oil palm plantations and their associated smallholder outgrower schemes are located. In consequence, **the direct benefits of increasing productivity of oil palm are likely to be significantly less than would be equivalent improvements in the relative productivity levels of other crops, particularly staple food crops, but also cocoa, coffee, and coconut, since smallholders mainly produce them.** This has implications for the poverty reduction objectives that guide government's decision making as to how public resources should be invested. More so than for the other crops considered, if public investments are made to enhance oil palm productivity, policy makers will need to identify how the benefits from those investments will flow through the economy to result in improved welfare for PNG households who are not involved in oil palm production.

This comparative case study of food and cash crop productivity levels in PNG and Indonesia, although somewhat constrained by limits on the data available, demonstrates some of the enabling conditions that need to be in place to raise crop productivity levels in a country. **Demand for the crop is the most important driver of sustainably increasing crop productivity. In this, the differences between Indonesia and PNG are stark – Indonesia has a domestic market of over 275 million persons, while that of PNG is under 9 million.**⁶ A general pattern is apparent of Indonesian farmer's responding to higher (particularly domestic) market demand with greater production achieved in part through higher productivity. In both countries, however, we find that several of the main staple crops have not been commercialized and have only quite local value chains or only supply the crop to relatively thin domestic markets in perishable form. Consequently, there is no indication that sweet potato or cassava producers in Indonesia have any greater incentive to improve their productivity than do producers in PNG. Likely the same conditions constrain improving productivity for taro, Chinese taro, and yam producers, as well, as these staple foods also are characterized by limited market demand. **Both banana and coconut are good examples of crops with good markets in Indonesia, but relatively small ones in PNG, resulting in sharply contrasting productivity levels in the two countries.**

While growing market demand is the principal driver, investing in agricultural research and putting in place effective agricultural extension services also make important contributions to increased productivity. It is evident that for both banana and coconut in Indonesia and for oil palm in both countries, doing so has resulted in quite high average productivity levels. The somewhat stagnant cocoa and coffee sectors in both Indonesia and PNG suggest that more effective research and extension efforts on those crops may enable producers to increase their productivity and realize higher incomes.

Policy reforms are also important to raising productivity of specific crops. That productivity levels of the traditional roots and tubers staple crops in both countries remains much lower than what might be realized with better planting materials and crop management and effective market demand for greater production quantities in part reflects policy decisions that prioritized investments in other crops. However, **that the traditional staples have generally been neglected in PNG, as well as Indonesia, works against development visions in both countries to realize sharp reductions in poverty.** Increased productivity of these staples with parallel development of markets and diversification in the value chains for each will stabilize production and prices. The benefits of reliable production levels and

⁶ A possibly more useful detailed comparison would be between the two provinces of Indonesia on New Guinea, Papua and West Papua, which have a total population of about 5.5 million people, and PNG. However, doing so would require overcoming additional gaps in the data to what was faced with the comparison with Indonesia as a whole.

stable and, ideally, lower prices for staples will result in improved consumption levels for poor households, for which staples are the major component of their consumption basket. If the development vision for PNG, as well as for Indonesia, goes beyond economic development alone to consider higher level development objectives like poverty reduction, increased attention to the productivity of staple crops should receive greater policy attention.

Our discussion now considers the strengths and gaps in the policies and strategies of PNG that have a bearing on raising crop productivity levels, both within and outside of the agricultural sector.

CRITICAL REVIEW OF POLICIES AND STRATEGIES OF PAPUA NEW GUINEA WITH A BEARING ON CROP PRODUCTIVITY

The policies and strategies of the government of PNG that might contribute to raising agricultural productivity levels were reviewed based on the discussion in section 2 on why improvements in agricultural productivity levels are important for economic development and how such improvements might be achieved. The policy architecture around improved agricultural productivity as a development objective in PNG is anchored to the development vision for the country and to both 20-year and 5-year development plans. These three documents are examined from the perspective of what priority they give or, if updated, might potentially give to improving productivity levels in the agricultural sector as part of the pathways to achieving the development vision they lay out for PNG. Thereafter, we turn to examine agricultural sector policies and strategies, before concluding our discussion by examining non-agricultural policies and strategies that could play a role in enabling farmers across PNG to adopt higher productivity methods in their farming by providing them with both the knowledge and the incentives they will require to do so.

More detailed synopses on some of the policies or strategies reviewed, particularly the major ones, are presented in Appendix 2 to this paper. In those synopses is additional discussion to what is presented in this section on how the content of each might contribute to improving agricultural productivity levels in PNG.

Master development frameworks – what role for improved agricultural productivity

Three documents make up the current master development framework for PNG – the Papua New Guinea Vision 2050 (NPC 2009), which lays out the development goals for the country to 2050, the 20-year Papua New Guinea Development Strategic Plan 2010-2030 (PNGDSP) (DNPM 2010); and the current 5-year Medium Term Development Plan III (MTDP III) (DNPM 2018). The two plans are at the apex of development planning within government, providing a cross-sectoral assessment of what government needs to invest in, undertake, or facilitate to achieve the development vision laid out in the Vision 2050 document.

Published in 2009, the vision seeks that by 2050 PNG be a “Smart, Wise, Fair, Healthy and Happy Society”. From a strategic standpoint, **the key economic development challenge identified in Vision 2050 is to move the economy from being dominated by the mining and energy sectors, which typically operate in enclaves with somewhat limited employment opportunities, to an economy in which there has been a significant expansion in the economic contributions of more broad-**

based sectors including agriculture, as well as forestry, fisheries, tourism, and manufacturing. Vision 2050 is supported by seven development pillars, two of which are particularly relevant to raising agricultural productivity: (i) human capital development; and (ii) wealth creation through building a strong, dynamic, competitive, and productive economy. However, no detail is provided in the document on the role that a growing agricultural sector might play in achieving this development vision or on how to foster increased growth in the sector through improved productivity. The vision document states that how this is to be done will be detailed in forthcoming sectoral policies and strategies, particularly a National Agricultural Development Plan. This agricultural sector plan is discussed in the next sub-section of this paper.

More detailed all-of-government guidance for achieving the goals set in the 2050 Vision was formulated in the PNGDSP and in a sequence of 5-year Medium Term Development Plans, of which MTDP III is the current one. PNGDSP provides cross-sectoral integrated development planning and includes more detail on agricultural sector priorities than do either the Vision 2050 document or the MTDP III. **A set of 20-year production targets for cash crops relative to current levels are established in PNGDSP.** Staple food production is to be increased to fully meet demand from domestic markets and downstream industries. **These increases in agricultural production are to be achieved through both increasing the productivity of PNG's farmers by 60 percent and by expanding the area of land farmed by 180 percent.** An overriding aim of PNGDSP is to convert most subsistence producing farm households into small and medium agricultural enterprises. The plan also highlights the need to establish the research basis for higher productivity across PNG's economy, including agriculture. Equally important, the PNGDSP devotes considerable attention to rural development efforts critical to providing farmers with the skills and incentives they require to raise their productivity and, thereby, the income and consumption levels of their households.

The MTDP III has less content on agricultural development than does the PNGDSP. However, the principal course correction for the economic development of PNG laid out in the five-year plan is an increased focus on investing in renewable sectors of the economy, particularly agriculture, and away from petroleum and mineral exploitation. Three of the eight Key Result Areas of MTDP III, if significant progress is achieved under them, will either directly contribute to improved agricultural productivity or provide an enabling context, the skills, or the incentives to farmers to increase their productivity – (i) inclusive economic growth; (ii) continuing infrastructure development; and (iii) higher quality education and skills development.

However, the financing plan of the MTDP III has no detail on public support to the agricultural sector. Consequently, it is not clear whether we should expect improvement in agricultural productivity during the five-year implementation period of MTDP III. This general critique of a lack of specificity in any strategic approaches to agricultural development in PNG can be applied to the other master development framework documents, too. Although the PNGDSP is the strongest of the three in this regard, even in that plan, what defined steps will be taken to transform agriculture in PNG to contribute to improved welfare and lower poverty are not provided.

Priority given to raising crop productivity in current agricultural sector policies and strategies

We now critically examine agricultural sector policies and strategies that are relevant to increasing agricultural productivity. The National Agriculture Development Plan 2007-2016 (NADP), although now dated, remains the overarching statement of the priorities and strategies of the government of PNG for

the development of the agricultural sector to achieve Vision 2050 (DAL 2007). Its objectives are rural economic development, food security, and improved livelihoods for all. In addition to a 200-page narrative document, a 300-page implementation framework for NADP was developed. There are eight priority areas under the NADP. Three are pertinent to improving farmer productivity – (i) Food and horticultural crops development, which concerns the production, processing, and marketing of traditional staples, fresh vegetables, and domestically-produced wheat and rice, with a focus on fostering commercial food production; (ii) Tree and industrial crops development, with a strong focus on reversing the declining productivity seen in recent years in all cash crops, except oil palm; and (iii) Agriculture research and extension, particularly through substantially improving the access of farm households to relevant agricultural extension services. However, the implementation framework budget privileges cash crops, with the industrial crops priority area receiving just over half of the proposed ten-year budget, while food crops receive 12 percent and agricultural research and extension activities receive 22 percent. These relative budget allocations call into question how broadly the benefits of NADP implementation might have been spread – cash crop producing farm households are likely to have received the most direct benefits from implementation of NADP.

The Agriculture Medium Term Development Plan 2020-2022 (AMTDP) is the current plan for the agriculture sector (DAL 2020). It aligns with the MTDP III, setting a target for the sector of increasing overall production by 30 percent. Organized around eleven sectoral growth drivers, several of these are pertinent to improving productivity at farm level. The discussion on the driver on food security, quality, and nutrition highlights the importance of increased domestic food production, as well as downstream processing and preservation, while the driver on quality provision of agricultural services is centered on how those services will increase agricultural productivity. Less directly, the drivers on agricultural trade and investment, on agricultural marketing, and on downstream processing are critical to providing enhanced incentives to farmers to raise their agricultural production, in part through greater productivity. The agricultural land mobilization driver is to bring into production land that can be farmed in a sustainable manner but which is not now being used for agriculture, raising crop output overall. **Notably, AMTDP presents a broad set of specific measurable targets to achieve by 2022.** Most have to do with improving cash crop exports, reducing food imports, or undertaking policy or administrative reforms in the sector. **There are only a few targets related to improving the productivity or increasing production levels of staple foods and most of these targets will be difficult to measure.**

The NADP and AMTDP are the agriculture sector-wide development plans of the government of PNG. However, we also reviewed sub-sectoral strategies within agriculture, if they existed – agricultural research, agricultural extension, and agricultural marketing and trade. While here we discuss all three, only for agricultural research has much strategic thinking found its way into policy documents. **No priorities for facilitating increased supply of extension services and for expanding marketing and trade have yet been established for the agricultural sector in PNG.**

For agricultural research, **NARI has a mandate to conduct research on all aspects of agricultural development in PNG**, with particular attention to meeting the information and technology needs of smallholder farmers and rural communities. The overall strategic objective for NARI under its Strategy and Results Framework (SRF) for the period 2011 to 2020 is the “enhanced productivity, efficiency, stability, and sustainability of the smallholder agriculture sector ... [through] ... enhanced food and nutritional security, increased cash income generation, increased gainful rural employment, and a sustainable resource base (NARI 2011, p. vii)”. NARI’s efforts are to contribute to the higher-level impact of improved welfare for rural families and communities.

Four programs are described under the NARI SRF for 2011 to 2020. It is the first on improving the productivity, efficiency, and stability of agricultural systems that is most focused on raising farm productivity levels. **Seven sub-programs under this program address many of the limitations that smallholder farmers face in raising their productivity levels** – access to improved planting materials; strengthened market systems; effective management of weather and climate-related shocks; sustainable soil fertility management; effective and sustainable control of pests and diseases; farm mechanization where it can be used efficiently; and profitably integrating crop, livestock, and aquaculture production. Recalling the conceptual discussion in section 2 on why improved agricultural productivity matters and how it might be achieved, these agricultural systems sub-programs are well justified and provide a useful guide to how NARI should strategically allocate both its human and financial resources. However, **priority setting across different crops will still be required.**

The second program on creating an enabling environment for smallholders to increase both their production and productivity levels is equally well thought out and necessary. The sub-programs here include building marketing opportunities from the outputs of smallholders through infrastructure development, domestic market and international trade policy reform, and strengthened market information systems; policy reforms to foster increased investment in agriculture production and agriculture-based enterprises; appropriate and predictable government regulation of both production and marketing; and land reform. If implemented, these sub-programs will result in farmers being more willing to increase their production to supply markets, increasing household income in doing so.

This now outdated SRF for 2011 to 2020 for NARI is conceptually strong. The strategic priorities laid out in it are well justified. These are as important for agricultural development in PNG ten years after the SRF was written as they were in 2011. Whether much progress has been achieved in attaining the objectives of the SRF programs will to a large degree have been dependent on whether NARI was able to amass sufficient qualified and dedicated staff and material and financial resources to implement the strategic programs effectively – that is, whether the fourth program under the SRF on NARI institutional management and development was successfully implemented. Unfortunately, success under this fourth program has been patchy, at best. That this is the case has been a continuing challenge for both NARI specifically and for the public agricultural sector in PNG more broadly.

With the end of the period of application of the 2011-2020 NARI SRF, a new SRF is now under preparation for the period 2021 to 2030 (NARI 2021). While still in draft form, this document was shared for review. Its content is built from the earlier SRF and retains the same objective of “enhanced productivity, efficiency, stability, and sustainability of the smallholder agriculture sector”. However, some major changes are made to its content. Setting aside a focus on increased productivity to foster growth in the agricultural sector, **the 2021 to 2030 NARI SRF draft proposes to shift the focus of NARI’s efforts to commercialization of production, to building resilient farming systems in the face of shocks, and to improving nutrition.** An immediate question that arises with this movement away from NARI’s traditional priority of sustainably improving agricultural productivity is whether NARI has the capacity and expertise and is best placed among public institutions in PNG to address the three new priorities laid out in the draft SRF. The expertise needed to improve market systems and specific agricultural value chains or to improve the nutritional status of the population of PNG are quite different from the classic areas of expertise in plant breeding, agronomy, plant pathology, soil science, agricultural production economics, and so on that enabled NARI to develop and adapt new more productive and sustainable agricultural production technologies. **Can NARI effectively take on these new priorities which have somewhat higher-level objectives than what NARI scientists are trained to address?**

However, it should be noted that the outcome matrix for the draft of the new NARI SRF does not neglect improving agricultural productivity as a central measure of the performance of the Institute. Increases in agricultural GDP attributed to smallholder food production, increases in factor productivity and resource use efficiency, and increased productivity per unit of limiting resource in specific farming systems are all listed as indicators of success for the SRF. However, **there remains a conceptual gap between actions to address the three priorities under the draft SRF and actions to achieve these production and productivity-focused outcomes.**

On agricultural extension, neither the Department of Agriculture and Livestock (DAL) nor the overall government of PNG have developed any sub-sectoral strategies. **Most efforts to increase the productivity levels of smallholder farmers across PNG will be hampered without effective means to ensure that farmers are able to access context-adapted information** on how they might be more productive and efficient and realize greater profits in their farming. **This is the role of agricultural extension agencies.** Although there have been calls for a comprehensive agricultural extension policy or strategy for PNG for several decades, such a document has not yet been formulated. The description by Sitapai (2012) of how agricultural extension services were provided in PNG ten years ago remains largely accurate. The provision of such services is done by all three tiers of government – national, provincial, and local level governments – as well as by crop-specific commodity boards, most of which are parastatal, so reliant, in part, on government funding.⁷ **While extension services focused on horticultural crop and fruit production are provided by the Fresh Produce Development Agency, there is no dedicated agency focused on staple crops.** Most of the other extension service providers focus on increasing the production of cash crops.

While there is no agricultural extension policy document, both NADP and AMTDP have detailed sections laying out a rationale for increased investment in more effective extension services. NADP devotes a full chapter to agricultural extension and research efforts and what must be done to improve the delivery of the services they might offer farmers. In a critique of agricultural extension efforts nationally, NADP highlights poor coordination between the agencies with agricultural extension responsibilities; poor linkages between levels of government; limited public budget allocations; human capacity and management deficiencies; and the low priority given to agricultural extension relative to other development priorities of the various level of government. **To address these deficiencies, NADP calls for the formulation of a formal National Agricultural Research and Extension System (NARES)** that will “provide timely and equitable access by farm households to relevant, quality agricultural extension, education and information services (p. 61)”.

AMTDP also bemoans the poor state of agricultural extension service provision in PNG, highlighting that public-sector agricultural extension had been in decline. Responsibility for most extension services was devolved from the national Department of Agriculture and Livestock to the provinces and districts. **In many provinces, extension is virtually non-existent due to lack of funding and capacity issues.** However, little detail is provided in AMTDP for strengthening the provision to farmers of agricultural extension services, beyond cash crop-specific efforts. In discussion in AMTDP of the Digital Agri-

⁷ The Organic Law on Provincial Government and Local-Level Government 1995, which was a reform of the earlier law of 1977 on the decentralization of government administration and public service provision, stipulated that the provision of agricultural extension services would primarily be the responsibility of provincial governments.

culture growth driver for the agricultural sector, the provision of extension services through digital Information and Communication Technologies (ICT) platforms is noted as an early area of investment under this driver. An E-agriculture Strategy has since been developed and is discussed in Appendix 2.

Effective agricultural extension service provision will be necessary if rapid and sustained increases in the productivity of smallholder farmers across PNG are to be realized. However, strategies for ensuring that farmers have access to all of the information and improved technologies that they require to profitably realize increased levels of productivity have yet to be developed. **How agricultural extension services will be provided is an important gap in efforts seeking to increase productivity levels to expand PNG's agriculture sector.**

On agricultural marketing and trade, in section 2 it was repeatedly noted that increased commercialization of agricultural production will be necessary to provide incentives to smallholder farmers to expand their production beyond levels that solely met the subsistence needs of their households. This **increased agricultural production for the market – whether domestic markets for food crops or overseas for cash crops – is fundamental to sustained expansion of the agricultural sector** within PNG's economy. Reliable demand is necessary for strengthening food markets nationally, and for establishing the economic conditions under which workers in PNG can increasingly work outside of agriculture, assured that the subsistence needs of their household can be met through more vibrant local markets in which they can reliably obtain all of the food their household requires at reasonably predictable prices. Moreover, increased production for the market is an effective approach to poverty reduction, benefiting producer households with increased income and benefiting consumer households through generally lower and more predictable prices through the greater supply of staples and other foods available in the markets they patronize.

Despite the importance of agricultural commercialization for agricultural sector growth, for poverty reduction, and for stimulating economic structural transformation processes, **no strategies have yet been developed to change the production orientation of PNG's smallholder farming sector away from primarily meeting subsistence needs to additionally producing commercial surpluses of their food crops.** Of course, development of the various cash crop sub-sectors over many decades have implicitly involved integrating smallholders producing these export crops into the value chains for each. However, broader strategies that encompass food crops have not been developed.

Nonetheless, recent agricultural sector or sub-sector policy statements increasingly have highlighted the need for dedicated public investments to provide smallholders with incentives to increasingly produce a fuller range of crops for the market. **In addition to continuing a focus on cash crops for export markets, domestic market considerations feature as new elements in the priorities of the agricultural sector in PNG in both NADP and AMTDP.**

A program under the food and horticultural crops development priority of NADP is on market development and promotion. This includes a set of public investments in marketing infrastructure, market information systems, and agro-industrial development involving smallholder outgrowers. Despite this attention to food crop marketing in the text of the NADP, traditional cash crops were budgeted to receive several times more public investment for marketing than were food crops in the NADP implementation plan.

AMTDP echoes NADP in paying somewhat increased attention to domestic marketing, justifying doing so particularly in terms of import substitution – producing domestically rice, meat, and fresh produce that is now imported. Of the eleven sectoral growth drivers around which the plan is organized, the seventh on agricultural trade and investment focuses on developing external agricultural markets,

while the eighth on agricultural marketing does the same for domestic markets. However, **while most of the traditional cash crops have specific development programs under AMTDP, there is no AMTDP program on domestic marketing, particularly for staple food crops.**

The June 2021 draft of the new NARI SRF for 2021 to 2030 has as the first of three priorities laid out in the strategy efforts to enhance agricultural markets, value chains, and trade. This policy statement is **the most developed on domestic marketing of any of the agricultural sector policies and strategies reviewed for this paper.** While the content of this priority covers domestic, regional, and international markets, much of the justification for the inclusion of this market-centered priority in the NARI strategy is focused on addressing weaknesses in domestic market systems. It is argued that doing so will contribute to accelerating a transition from traditional subsistence and semi-commercial production systems to an agribusiness-oriented model of farming which provides increased employment and income earning opportunities (NARI 2021, p. 16).

Overall, it appears that there is increasing policy attention to improving the domestic marketing of food crops. However, the priorities that have been proposed for doing so generally are not informed by a close understanding of why increased food crop commercialization will make important contributions to achieving the medium- and longer-term development ambitions of PNG. So far, much of the policy content on domestic agricultural marketing seems to draw from that which has been in place for some time to support export trade in agricultural produce. While lessons can be learned from PNG's experience with agricultural trade over past decades to strengthen domestic agricultural market systems, it is likely that new approaches will be required for attaining some of the domestic marketing objectives laid out in NADP and AMTDP. **The draft NARI strategy provides something of a template to build upon in enhancing domestic agricultural market systems across PNG.**

Motivating improved agricultural productivity through non-agricultural policies and strategies

We end our discussion of the policy and strategy frameworks by examining non-agricultural policy documents that conceptually should play a role in enabling farmers across PNG to adopt higher productivity farming methods by providing them with both the knowledge and the incentives they will require to do so. Those examined are heterogeneous as to which agencies championed their formulation.

Papua New Guinea National Food Security Policy, 2018-2027 (draft) – We first examine the draft National Food Security Policy. DAL (2017) led the formulation of the policy. Its sub-title is “Growing agriculture for food security, good nutrition and health”. As such, it could be treated as an agricultural sector policy.⁸ However, doing this would reflect an incomplete and incorrect understanding of the determinants of food security, whether at household or at national level. Food security is a cross-cutting issue. It is short-sighted to view food insecurity as solely an agricultural productivity problem. **Assuming that agricultural production alone will improve the access of food insecure households in PNG to the food they require is misplaced.** Both improving the employment choices of workers in PNG and strengthening the markets upon which particularly the growing numbers of non-agricultural households

⁸ Observers of agricultural policy making in PNG suggest that due to the significant policy independence and private sector leadership in the cash crop sub-sectors of PNG, the principal policy functions of the Department of Agriculture and Livestock are primarily restricted to food and food security issues (McKillop, Bourke, and Kambori 2009). This may account for why DAL was given responsibility for the formulation of the National Food Security Policy, rather than a cross-sectoral coordination agency of government.

rely for their food are critical food security challenges facing the country. Food security policies and the institutions in PNG that implement them should be guided by an understanding of how to ensure food security in the country that extends beyond agricultural approaches alone.

To the credit of the stakeholders involved in drafting it, in the Policy's foreword it is stated that food security will be achieved "through a range of measures across all the key sectors, such as agriculture, fisheries, trade, health, education, transport infrastructure, and water, sanitation, and hygiene services." That the Policy for PNG focuses strongly on the role agriculture might play to achieve a food secure country is not surprising given that much of the population of PNG relies upon agricultural livelihoods. However, the Policy is conceptually grounded in the definition of food security advanced by the 1996 World Food Summit Plan of Action – "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996). It also utilizes the four dimensions of food security – availability, access, stability, and utilization – to make it clear that food production alone does not equal food security. Rather, food security entails reliable access to food and its proper use to meet dietary needs.

The Policy does not assert that PNG is structurally food insecure at national level. However, with high levels of undernutrition being seen in children across PNG, it is evident that some dimensions of food security currently are insufficiently addressed. Moreover, shocks to food systems can render many households food insecure, even if only temporarily. Consequently, the principal strategies advanced in the Policy to ensure that the country as a whole and that individual households are able to maintain food security are focused on improving both food availability and access within PNG.

Productivity is rightly an important element of these efforts. The first of the five strategies laid out in the Food Security Policy is closely aligned to the earlier conceptual discussion in this paper on why increased productivity matters and how it might be achieved. This strategy seeks to achieve productivity growth for the main food staples, horticulture, small livestock, and fish farming and to increase efficiencies along food value chains. A list of eleven sub-elements to the strategy is laid out. These summarize to a large degree many of the objectives of the agricultural sector policies and strategies already reviewed. However, **there is a notable expansion in the scope of these efforts to pay more attention to the quality of the food produced, to address seasonality in food production so that food is available at all times, and to the integration of production, distribution and marketing, and consumption in developing efficient food value chains.** These priorities are sound and, if effective action is taken to achieve them, will result in smallholders across PNG achieving higher crop productivity levels.

As a supplement to the draft National Food Security Policy, a draft Action Plan for the period 2018 to 2022 was also formulated. This further refines the sub-elements under the five strategic areas of the Policy. That on agricultural productivity growth has six intermediate outcomes in the Action Plan – increased investment in agricultural research and development; strengthened agricultural extension services; increased productivity and production, building efficient and inclusive nutrition-sensitive food value chains; transportation, storage, processing, and marketing infrastructural development; and increasing the number of food-focused enterprises. The intermediate outcomes are further detailed by identifying key outputs for each – for increased productivity and production, the key outputs are strengthening farmer organization, increasing farmer access to productivity-enhancing inputs and technologies, and providing financing to smallholders.

National Nutrition Strategy 2016-2026 – Our interest in the National Nutrition Strategy (DoH et al. 2016) lies in dietary adequacy being one of the underlying determinants of good nutritional status

(UNICEF 1990). Increased food availability through increased productivity and production will result in households in PNG having better access to the food they require, whether they grow it themselves or purchase it. Moreover, increased production of a diversity of foods for consumption by all households across PNG can effectively address several forms of micronutrient malnutrition. Given the importance of an adequate and high-quality diet to improved nutrition, increased food crop productivity can make useful contributions to improving the nutritional status of many citizens of PNG, particularly young children, adolescent girls, and women of childbearing age. In the situation analysis on nutrition in PNG presented in the Policy, attention is drawn to food insecurity being among the reasons that nutritional indicators in communities across the country are worse than anyone would wish them to be. **Access to nutritious food for many is hampered by insufficient market supplies resulting in higher food prices, so that households forego more expensive nutrient-rich foods for carbohydrate dense staples.**

However, the National Nutrition Policy does not devote much attention to food-based approaches for dealing with many nutritional problems that are faced in PNG, so does not highlight any need for increased food crop production and productivity. It is only under Policy Objective 3, on addressing under-nutrition across the life cycle, and Objective 4, on reducing micronutrient deficiencies, in which food-based approaches are mentioned and the Department of Agriculture and Livestock is given a role under the Nutrition Policy. In the strategies laid out to attain both of these objectives are included efforts to diversify diets through adequate production of diverse foods, including local foods rich in micronutrients, small livestock, and aquaculture. However, the value of increased food productivity can readily be seen as a component of the strategies to address nutrition challenges in PNG laid out in the Nutrition Policy.

National Education Plan 2020-2029 – To effectively master improved agricultural technologies in order to profitably and sustainably make use of them at high levels of productivity will require that users of those technologies have attained a reasonably high level of education or have received specialized instruction in agricultural production. **Our interest in examining the National Education Plan for PNG is to assess how conducive its implementation might be for enabling students to then go on to be highly productive farmers. However, the Education Plan is silent on this.** While the vision statement for the Department of Education is to prepare “literate, skilled and healthy citizens, each educated and trained to their fullest potential, to contribute to the economic and social development of the nation (DoE 2020, p. 1)”, the Plan itself does not focus on the content of the education its students receive. The focus is much more on ensuring that all Papua New Guineans have access to education services by putting in place throughout the country the necessary human resources, physical infrastructure, and operational financing.

Details on the content of the curriculum offered and how it might be modified or adjusted to better meet local needs, particularly in farming communities, is not considered in any detail in the Plan. However, the Plan notes that efforts will be made to provide alternative “Education pathways”, through which greater opportunities will be made available for students to gain strong trade skills outside of the general education program through vocational education and training at secondary level. Such an approach might be used to strengthen and build specialized farming abilities and knowledge in students. The Plan’s focus area on “Quality learning” also provides an opening for increased incorporation of agricultural topics into the general education curriculum.

Papua New Guinea Small and Medium Enterprise Policy 2016 – Small and medium enterprises (SME), which typically operate at household level outside of the formal economy and require relatively low amounts of capital to establish and run, can be important drivers of economic growth and job crea-

tion. Given the potential that SMEs have for accelerating economic growth and economic transformation processes, the Small and Medium Enterprise Policy 2016 was developed to prioritize public actions and investments that would enable the SME sector in PNG to realize this potential and be an important contributor to the growth of PNG's economy (DTCI 2016). The policy seeks by 2030 to see nationwide about a ten-fold increase in the number of SMEs, in the number of jobs created within SMEs, and in the share of PNG's annual economic production generated by SMEs.

The SME Policy includes economic sector-specific priorities for SME development, including for agriculture. However, it is not evident that the agricultural sector priorities for SMEs offer anything new to propel the formation of agri-businesses. In several ways, the agricultural priorities noted are misguided and are offered in list form without any rationale or detail. The priorities for SME development in the agricultural sector stated in the Policy include expanding agricultural value-addition activities; making efforts to increase commercialization of staples, including cassava and sweet potato; fostering domestic feed and dairy industries to reduce imports of these agricultural products; and providing subsidies for imported machinery and fertilizers. Moreover, later in the policy there is a section devoted to establishing a wide-ranging agricultural commodity price support program. How such an expensive program will benefit SME operators or serve to socially benefit all citizens of PNG is not made clear in the text of the Policy.

Overall, the 2016 SME Policy offers no clear vision of how government might support farming or other rural households establish enterprises within their households, particularly if focused on agri-processing or marketing. Increasing agricultural productivity is not examined in the SME Policy at all, even though greater agricultural output would allow for more agricultural SMEs to be established and for more employment in them. The 2016 SME Policy lacks strategic guidance for economic development in PNG, whether in agriculture or elsewhere. Revisions would make it more effective.

National Trade Policy 2017-2032 – This first trade policy for PNG has the vision of guiding “PNG towards an internationally competitive export-driven economy that is built on and aided by an expanding and efficient domestic market (DTCI 2017, p. 36)”. The role of the policy is to provide a framework for negotiating foreign trade agreements and to establish mechanisms for identifying and supporting economic sectors with a comparative advantage for trade to access overseas markets demanding their outputs. In addition to laying out broad economic development priorities, such as trade-conducive policies and regulations and significantly greater investment in trade-related infrastructure and services, the Policy also provide sector-specific priorities.

The priorities for agriculture in the Trade Policy have little to do with raising productivity. Rather, the measures suggested include establishing Special Economic Zones for agri-manufacturing, providing support to domestic livestock feed and poultry industries for import substitution purposes, and regulating agricultural imports to prevent the undercutting of domestic production through unfair agricultural trade practices. To support agricultural exports, the Policy prioritizes establishing and enforcing national standards for the production and processing of agricultural products to maintain their quality and safety along the supply chain to delivery in export markets. Echoing the SME Policy, the Trade Policy also calls for introducing commodity price stabilization funds to protect farmers against price downturns. However, no argument is offered for why this should be a Trade Policy priority.

Nonetheless, if demand for PNG's agricultural products in export markets is expanded, producers will respond to this added incentive to substantially increase their production. Much more so than with the SME Policy, **the Trade Policy makes a clear case for how improved trade in agricultural products should bring forth increases in production from PNG's farmers and provide incentives for them to raise their productivity levels.**

Papua New Guinea Biosecurity Policy, 2021-2031 (draft) – Biosecurity seeks to prevent the introduction of new agricultural pests and diseases into PNG and to manage endemic pests and diseases, particularly ensuring that PNG does not become a source for those pests and diseases spreading to its trade partners. As such, **effective biosecurity is critical to protecting the livelihoods of agricultural households across PNG and for ensuring that PNG’s farmers can sell their output in export markets.** With effective biosecurity, buyers in export markets can be assured that agricultural produce from PNG will pose no risk to their domestic farming systems due to the strict biosafety controls imposed on the produce before it is exported from PNG. Adequate biosecurity safeguards will support agricultural production and enhance access of farmers in PNG to export markets to generate increased economic growth, employment, and incomes. The draft Biosecurity Policy is aligned with these objectives. Developed under the leadership of the Department of Agriculture and Livestock, the objective of the Policy is to “to create a framework to protect agriculture, environment and livelihoods, and to boost domestic and international trade, through the provision of modern biosecurity services (DAL 2021, p. 11)”.

The draft Biosecurity Policy is complementary to the National Trade Policy. Similar to that Policy, the Biosecurity Policy is unlikely to directly boost agricultural productivity, although it is an important instrument for controlling pests and diseases that may potentially have catastrophic effects on the productivity of PNG’s farmers. Rather, by safeguarding export market access for agricultural products from PNG, the Policy will protect and improve trade levels in agricultural products and, thereby, should result in increased farm production and provide incentives for farmers to raise their productivity levels.

National Strategy for Responsible Sustainable Development for Papua New Guinea (StaRS) – StaRS commits the government of PNG to following a new paradigm in formulating its development priorities and strategies that focuses on sustainability. All new strategies across government are to be sustainable across three dimensions – economic growth, ecological sustainability, and social equity – and to be implemented in a manner that does not compromise the world’s biodiversity or puts the future of PNG’s children at risk (DNPM 2015, p. 32).

With regards to the agricultural sector and productivity in the sector, the StaRS strategy calls for increased use of farming technologies and methods that are based on agroecological principles. Similarly, it calls for (i) reforming any agricultural subsidies so that the economic development objectives that the subsidies support are ecologically sustainable and socially fair, and (ii) for the institution of payment for ecosystem services schemes that may involve the use of agricultural techniques. However, the strategy is quite high-level in its orientation, being a paradigm to guide both national and sectoral development priorities. Nonetheless, it provides an important set of principles against which the design of any strategies or programs to promote increased farm productivity in PNG would need to be evaluated. If any of those designs are found to be wanting against what is stipulated under the StaRS development paradigm, this would indicate that further design work is needed on those strategies or programs.

Assessment of policy framework for increased agricultural productivity in Papua New Guinea

Overall, the current policy framework in Papua New Guinea pays limited attention to increased agricultural productivity as an important sectoral and economic development goal for the country. The importance of increased productivity to the growth of the agricultural sector overall and, indirectly, to rural economic development, as discussed in section 2, appears for the most part to be ignored in formulating agricultural sector policies, priorities, and strategies. However, any policies or strategies that seek

improved incomes for farm households and increased consumption and reduced poverty for both producers and consumers of agricultural produce are unlikely to attain their objectives without raised productivity. Perhaps the silence on the need to raise productivity in PNG's current policy framework is because this component of agricultural and rural economic development is so foundational that it was felt that it did not need to be mentioned in various policies and strategies reviewed. Only the NARI Strategy and Results Frameworks clearly recognized the basic need for substantially improved productivity across all agricultural sub-sectors – not cash crops alone – if PNG is to reach its ambitions for agricultural development and rural and national economic growth. Most of the other policy documents either are silent on improving agricultural productivity or focus only on productivity levels for cash crops.

Missteps will be made and waste of public resources will occur if the objective of realizing higher farm production per unit of input – for staple foods, other food crops, cash crops, and livestock – is not consistently incorporated into agricultural development policy in PNG. However, in doing so, a broad perspective should be adopted on how increased productivity fuels economic development and improved household welfare. Increasing productivity does involve research by crop breeders, agronomists, plant pathologist, and livestock specialists to solve technical agricultural production challenges and ensuring that the solutions that these scientists discover are adapted for use by PNG's farmers and disseminated to them. However, increased output through the use of these improved technologies and innovations on its own will not result in the economic development or reduced poverty desired. There are several areas outside of agriculture where complementary public investments will be needed for improved agricultural productivity to contribute to higher development objectives. These include investments in market support infrastructure, including in market facilities, transportation, storage, and ICT; in technical education in agriculture; in trade-facilitating infrastructure and regulations, and in ensuring the sustainable use of the agriculture resources of PNG. Consequently, in achieving a vision of an agriculture sector in PNG with much higher levels of productivity, priorities must be set and actions must be taken that go well beyond the public agriculture sector alone. Higher agricultural productivity will contribute to much broader development achievements than in the agriculture sector alone. But to do so, a range of complementary actions must be taken at the same time outside of agriculture.

PRIORITIZED ACTIONS TO ENHANCE AGRICULTURAL PRODUCTIVITY IN PAPUA NEW GUINEA

If smallholder farming households in PNG, in particular, achieved higher productivity levels for many of the crops they produce, several components of the development vision for PNG could be realized. The increased production that results would expand agricultural GDP and have spillover effects to improve the performance of PNG's economy overall. Particularly if productivity improved for a wide range of food crops, the quality of diets of both the producing households and those to whom they supply the food crops would improve, potentially leading to reductions in different forms of malnutrition. Higher crop productivity, if coupled with improved performance in local markets across the country, provides an important path to increased household incomes for producers and higher food consumption levels at lower cost and, hence, improved welfare for consuming households. Moreover, with increased supplies of food in local rural markets and in urban centers, many who now work in agriculture in PNG could confidently seek more remunerative livelihoods outside of agriculture, assured that they will be able to meet the food needs of their household from reliable markets, rather than through own production. Finally, higher productivity will help mitigate climate change processes in PNG by reducing the need for more carbon-rich forests and wetlands to be cleared for agricultural production. Increased agricultural

productivity will make important contributions to a sustainable transformation in the structure of the economy of PNG, to improved welfare for many of PNG's citizens, and to lower poverty.

In this paper, we examined the most recent data available on yields for the most important crops grown in PNG, assessed what yields might be achieved based on productivity data from areas of Indonesia with similar growing conditions, and sketched out **where policy reforms at national level could provide incentives and access to the technologies needed to achieve significantly higher crop yields by all farmers across PNG**. It is clear that central to any agricultural sector development strategies for PNG must be continuing efforts and investments to raise crop productivity levels through **enabling farmers** to make use of improved crop germplasm, sustainable soil fertility management techniques, and effective means of control of crop pests and diseases and to undertake timely and thorough crop management operations. **These will require continued, possibly increased, attention in any agricultural sector policies or strategies to how efforts must be organized and resources allocated to increase agricultural production and productivity levels**. Increased productivity is a fundamental measure of agricultural development, even if not the only consideration that should govern the content of such policy documents. In consequence, **continuing support to agricultural research and a significant restructuring of how agricultural advisory services and improved farm inputs are provided to farmers will be needed over the medium to long-term to see sustained improvements in crop productivity**.

Moreover, the challenges that farmers face in their crop production today are not necessarily the same challenges that they will face in the future. Consequently, the agricultural research and advisory services across PNG must be alert and proactive to changing or emerging production challenges. Climate change will introduce new production challenges, whether through changes in rainfall and temperature patterns or through increased incidence of pests and diseases that are better able to flourish under the changed climatic conditions (Crimp & Howden 2018). Moreover, if the desired increase in agricultural commercialization highlighted as a priority in this paper is achieved, the increased trade in both cash crops and food crops will heightens risks from introduced pests and diseases that so far have not affected farming in PNG. To enable farmers in PNG to adapt and surmount to these new challenges similarly will require continuous research and effective communication to farmers of the improved techniques and technologies that will enable them to sustainably and profitably manage them. The adoption and effective implementation of the draft Biosecurity Policy is similarly critical to managing new and changing risks to agricultural production in PNG.

However, raising productivity levels is not solely an agricultural sector development challenge. Farm households make their cropping decisions – both on what crops to produce and how intensively to do so – in light of their livelihood needs and the likely effectiveness of each crop they might consider to helping meet those needs. For many crops, their effectiveness in this regard is linked to the profits the household might realize from the crop produced at different levels of intensity. Farm households will raise their productivity levels if they are reasonably certain that they will realize higher benefits relative to the costs that they will incur to do so.

Consequently, the performance of the markets into which smallholder farmers sell their crops is as important as their access to higher productivity technologies and techniques to achieving higher agricultural productivity overall. **In any efforts to raise agricultural productivity in PNG, strengthening of domestic markets, in particular, as well as trade in agricultural products will be as necessary as any agricultural sector actions**. We will not see higher crop productivity if farm households do not expect to see any additional benefits from raising their productivity levels. **Government policies and**

strategies should foster increased commercial crop production through agricultural interventions, through building increased demand for crop outputs by developing food processing opportunities and preservation techniques suitable for commercial and cottage industries, and through domestic market development that involves improving physical marketplaces, strengthening and maintaining transportation infrastructure, and ensuring reliable, low-cost communication and dissemination of information to enable profitable marketing activities. In developing policies and strategies and designing programs to increase agricultural productivity in PNG, the scope of these efforts must go well beyond the agricultural sector alone.

In developing strategies to raise crop productivity in PNG, specific efforts by crop type will be needed. In the relevant policies and strategies now in place that might contribute to improved crop productivity, it is the cash crops that receive most attention and the greatest share of the budgets developed in any investment plans. Staple food crops, particularly the traditional root and tuber crops, are almost entirely ignored in these strategies and plans. If broad-based development with significant poverty reduction is at the center of the development vision for PNG, then these traditional staples should be the crop type that receives the most support and investment from the public agriculture sector. The benefits of reliable production levels and stable and, ideally, lower prices for these staples will result in improved consumption levels for poor households, for which staples are the major component of their consumption basket. With greater supplies of their staple foods in local markets at lower cost, households will be able to use household resources, whether labor, cash, or capital, previously used for producing or otherwise obtaining food and use it to meet other basic needs, to invest in non-farm enterprises, or to seek wage employment. Broad based economic development in PNG requires attention to increased production of staple foods consumed by poor households.

However, **successfully raising productivity and improving staple food production**, particularly of the traditional staples, **will not be an easy task**. Inherent to the logic of prioritizing such staples in development plans is significantly increased commercialization of these crops. However, these staples are not readily tradable. Most roots and tubers are difficult to store, are not readily processed into stable products, and are subject to spoilage in transport. Building increased incentives for commercial production of the traditional staple crops grown in PNG will require research on how best the crops might be processed so that they can be readily marketed or stored and still find a significant consumer market. However, the case study of Indonesia crop productivity shows that it can be done for some crops – banana and coconut there – even as Indonesia so far has done no better than PNG in developing strong domestic markets for the other traditional staples – sweet potato, cassava, taro, Chinese taro, and yam.

That staple crops are singled out in this paper for attention to raise their productivity does not mean that **PNG's cash crops should be neglected**. However, here too some targeting is in order.

- Production of cocoa, coffee, and coconut all require attention and investment from government, if not at the expense of staple food crops. Smallholders are responsible for much of the production of these crops. Providing those farming households with technologies, information, and incentives that will result in increases in their productivity of these crops are activities that government can facilitate. In the areas where these cash crops are produced, important poverty reduction and rural economic development goals can be achieved with such government support. The recent apparent stagnation in these cash crop sub-sectors suggests that government is not as supportive in raising productivity levels as it might be. **More effective research and extension efforts and trade facilitation for these crops is required.**

- In contrast, increasing the productivity of PNG's currently most successful cash crop, oil palm, is likely best supported simply by getting out of the way and allowing the firms involved in organizing its production and trade conduct their operations. However, government has a regulatory duty to ensure that the firms operating oil palm plantations in PNG sustainably manage the resources they are using and that any economic spillover opportunities from the plantations to surrounding communities result in lasting economic growth and human development.

Finally, earlier in this section it was noted that stronger and more focused efforts are needed in agricultural research, in agricultural extension, and in strengthening domestic markets and linkages between them. These agricultural development priorities must be continually addressed for many years to come. However, a more secondary issue within the agricultural sector we should highlight lies in strengthening planning in the agricultural sector. In this paper, we were unable to buttress our recommendations as to what must be done to raise crop productivity levels with as detailed or as current data or other evidence as we would wish to have had. In consequence, some of the recommendations made reflect patterns seen in how agricultural development through increased productivity has proceeded in other developing countries. While insights developed in this way will still be valid, it will become increasingly important as PNG's agricultural sector continues to develop to strengthen data systems within the sector and to form a cohort of strong strategic agricultural analysts, whether within government, at universities, or in the private sector. Improved statistics will be of immense value for identifying realistic and achievable strategies for increasing the productivity of PNG's farmers and developing the agricultural sector.

APPENDICES

Appendix 1: Current yield levels of major staple and cash crops in Papua New Guinea

In this appendix, we review the most recent statistics on agricultural production from across the country to provide a situation analysis on crop productivity. We focus on a set of six basic staple food crops – sweet potato, banana, taro (*Colocasia esculenta* and related species), Chinese taro (*Xanthosoma sagittifolium*), cassava, and yam (*Dioscorea* species) – and the principal cash crops produced in PNG – cocoa, coffee, palm oil, and coconut / copra. We also discuss the productivity of sago obtained from naturally occurring perennial stands of sago palm. Sago is more a managed source of staple food, rather than cultivated.

In addition to the challenges highlighted in section 2 on computing measures of crop yield for farming systems that are dominated by roots and tubers, production and area data for these most economically important crops grown in PNG are limited and quite scattered, of variable quality, and often quite localized, rather than national in scope. There are very few nationally representative data sources on crop yields for PNG. While the Food and Agriculture Organization of the United Nations (FAO) publishes annual data on national crop production, area, and yields in their online statistical website, FAO-Stat (FAO 2021), the FAOStat records for PNG highlight that for most years the crop production data is imputed. The best compilation of production data is found in the edited book from 2009, *Food and Agriculture in Papua New Guinea*, in which a rigorous attempt at compiling such data was made by the chapter authors (Bourke and Harwood 2009). But the data in this book are now at least a dozen years old. In our investigations, we relied extensively on this source. Much of the crop-specific productivity data below is drawn from it.

Moreover, all of the maps presented here on the spatial distribution of the staple and cash crops are drawn from analysis of the Mapping Agricultural Systems of Papua New Guinea (MASP) Project database (LMG-ANU 2000). The MASP database was published in 2000, so some years before even the Bourke and Harwood (2009) edited volume was published. While for most of the crops considered, there likely has only been limited changes over the past two decades in where they are found, this may not be the case for sweet potato and oil palm, in particular. In using the maps, it also is important to recognize how the spatial distributions of each crop were defined to create them – certainly all of the staple foods are grown as minor crops over a much wider area of PNG than that shown in the maps. This likely is the case for coconut as well.

Staple food crops

In this section of Appendix 1, we focus on six staple food crops – sweet potato, banana, taro (*Colocasia esculenta* and related species), Chinese taro (*Xanthosoma sagittifolium*), cassava, and yam (*Dioscorea* species) – plus sago. While agricultural systems throughout PNG are extremely diverse with several other minor staples and many vegetables, fruits, and nuts produced, outside of cash cropping areas, it is the major staples that dominate both the land allocated and the labor farming household devote to crop production. Consequently, we do not consider productivity levels for the many dozens of other minor food crops that are grown by smallholder farmers. Moreover, for many of these secondary crops, data on productivity levels do not exist.

Sweet potato

Sweet potato (*Ipomoea batatas*) is the most important staple food crop grown in PNG, providing by weight almost two-thirds of the staple food crops produced (Allen and Bourke 2009).⁹ While it dominates staple food consumption in highland communities, it also is among the principal staple foods in many lowland areas (**Figure 3**). Overall, it is grown across a wide range of agro-ecologies at elevations ranging from sea level to 2,700 meters above sea level (masl).

The duration of its growth cycle is between 3 and 5 months in the lowlands, but, due to lower temperatures at higher elevations, between 5 and 8 months at 1,600 masl and between 8 and 12 months at 2,300 masl (Allen and Bourke 2009). These different growth patterns allow for considerable flexibility in how sweet potato is incorporated with a mix of other staples into local food systems to assure a continual supply of carbohydrates through the year. Higher yields of sweet potato are obtained in the highlands due to the longer growth cycle for the crop there. **While sweet potato typically is not dried or processed for long-term storage, its extended harvest period allows it to be an important source of calories in local diets for significant periods of the year.** However, sweet potato production is adversely affected by flooding, so is best grown on well-drained soils. Extended periods of heavy rainfall during the growing period can significantly reduce production (Allen, Bourke, and McGregor 2009).

Sweet potato originated in the Americas. It was introduced into PNG about 300 years ago and subsequently replaced taro as the principal staple in most highland communities, while in lowland PNG, sweet potato, together with cassava and Chinese taro (which both also originated in the Americas), were added to the mix of staples in local food systems. Their introduction reduced the share of staple consumption made up by taro, yam, banana, and sago, albeit more slowly and to a lesser extent than in the highlands (Bourke 2009). Sweet potato is the most widely grown of any staple crop, being grown by almost all rural households. It is an important staple in the food systems of about 65 percent of the rural population of PNG (Allen and Bourke 2009). Bourke et al. (2009) suggest that its importance in local food systems continues to increase. Sweet potato is produced without the use of any purchased inputs, with planting materials sourced from within the local community.

While there are no estimates of the amount of sweet potato that is marketed domestically in local or regional markets, studies of food marketing in PNG typically list sweet potato among the principal crops that are sold. Allen, Bourke, and McGregor (2009) examine the financial returns to commercial production for a range of crops produced in PNG. Their results show that sweet potato is among the crops providing the greatest returns to labor – somewhat lower returns to labor than Irish potato or oil palm, but higher than the traditional cash crops of cocoa, coffee, and coconut, and much higher than the return to rice production.

⁹ Among the staple crops considered in this paper, sweet potato is unique in that a significant share of production in the highlands is fed to domestic pigs. Bourke et al. (2009) estimate the pigs consume about one-quarter of total sweet potato production in PNG. The other staples examined are generally not used as livestock feed because they require processing before they can be safely used as feed. Consequently, production estimates for sweet potato are not directly related to dietary consumption levels in the same manner as are the other staples (Bourke et al. 2009).

Figure 3: Sweet potato productivity and production areas of Papua New Guinea

Actual yields:

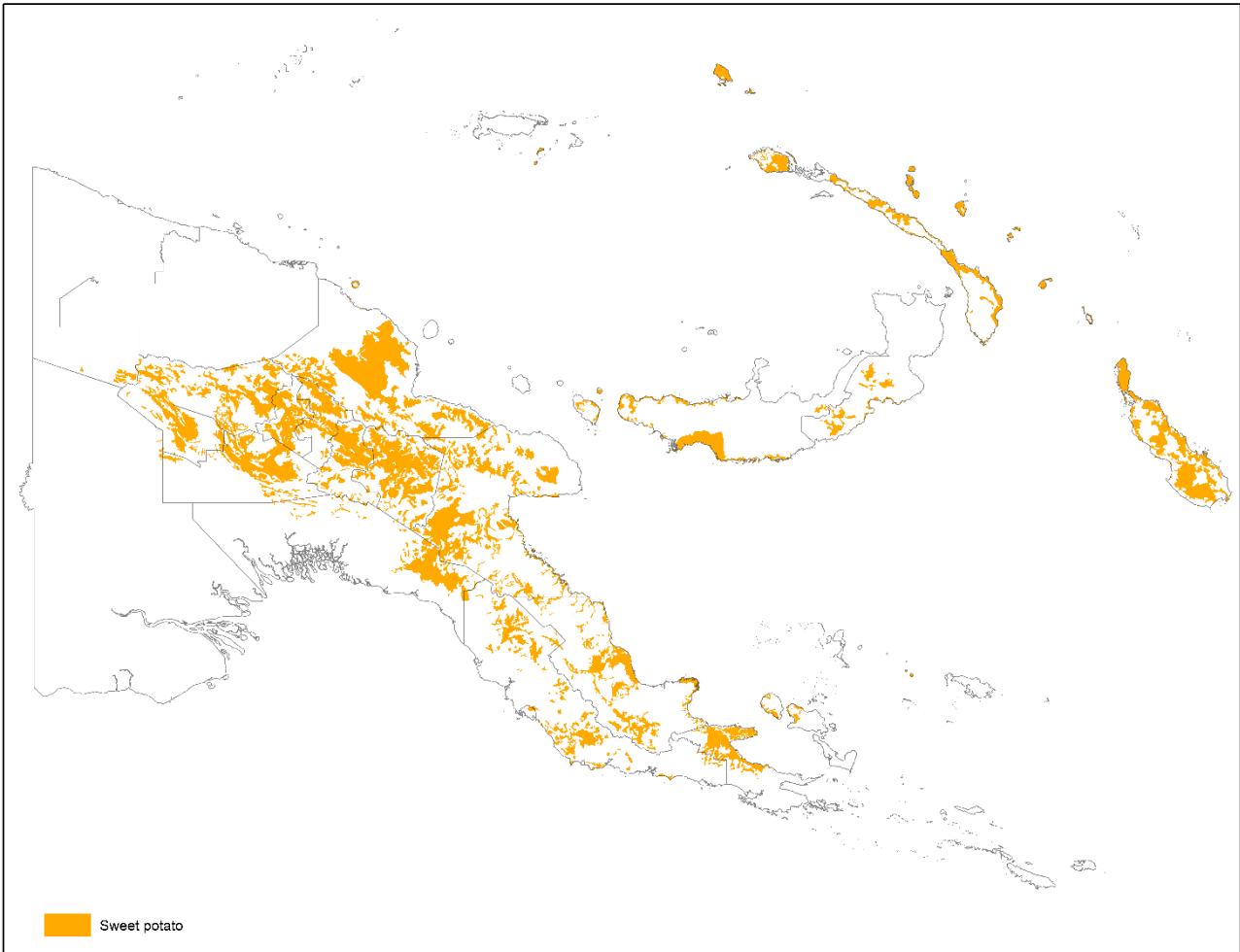
Lowlands (<1,200 masl):	13 mt/ha ¹
Highlands (1,200 to 1,800 masl):	15 mt/ha ¹

Attainable (experimental) yields:

Lowlands (<1,200 masl):	15 to 20 mt/ha ²
Highlands (1,200 to 1,800 masl):	20 to 30 mt/ha ²

Attainable yields on farm with good husbandry:	38 mt/ha ³
Yields (marketable) from agronomic trials on pathogen-tested varieties at Aiyura, Eastern Highlands:	23 to 38 mt/ha ⁴

- Sources:
 1. Bourke et al. (2009)
 2. Allen and Bourke (2009)
 3. Acland (1971)
 4. data from R. Ovah, NARI



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which sweet potato is estimated to cover more than one-third of area planted to staple crops.

However, obtaining estimates of total production and average productivity levels for sweet potato in PNG that are both accurate and precise is difficult. These challenges reflect the underground nature of the main edible portion of the crop, the potential that some tubers may not be harvested, the extended

harvest season of sweet potato, and the degree to which post-harvest losses are considered in computation of production. Bourke et al. (2009) provide a sweet potato production estimate of 2.87 million mt in 2000 which they extrapolate to an estimate of sweet potato production in 2006 of 3.39 million mt.¹⁰

Banana

Banana (*Musa* spp.) is grown throughout PNG and by most rural households at elevations ranging from sea level to 2,150 masl. It is more likely to be consumed in PNG cooked as a staple food rather than as an uncooked sweet, ripened fruit. Given its growth pattern with extended harvesting period, banana has been shown to be commonly found as part of the staple crop mix in areas of PNG with seasonal rainfall patterns (Allen and Bourke 2009). However, banana is not restricted to those agro-ecologies, being also common in areas with little seasonality in annual rainfall patterns (**Figure 4**). Banana is an important staple in the food systems of about 9 percent of the rural population of PNG, but is an important part of the diets, if not a central staple, for a further 32 percent (Bourke and Allen 2009).

Archeological records show that banana has been consumed in PNG for several thousand years starting soon after agricultural systems began to develop on New Guinea (Bourke 2009). Indigenous banana varieties were domesticated as part of the development of agriculture on the island. However, from the colonial period onwards, new banana varieties from elsewhere with higher productive potential or other characteristics attractive to PNG farmers have been introduced into local food systems. Banana is produced without the use of any purchased inputs, with planting materials sourced from within the local community.

About 10 percent of all calories consumed by the population of PNG are estimated to be sourced from banana (Bourke et al. 2009). This share of total calories is much less than that provided by sweet potato, but is more than that provided by the other staple crops examined here – taro, Chinese taro, cassava, and yam, as well as sago.

Bourke et al. (2009) provide a banana production estimate of 230,000 mt in 2000, which they extrapolate to estimate production in 2006 of 276,000 mt.¹¹ More recent production figures for banana in PNG based on plot level observation could not be found in preparing this paper. Obtaining consistent production figures for banana is difficult due to its somewhat perennial character, the multi-year nature of its production cycle, the nature of the fruit in that the edible portion of a banana bunch makes up a relatively small share of its mass, and the possibility of significant post-harvest losses.

¹⁰ In contrast, FAO estimated total sweet potato production in 2019 in PNG to be just under 750,000 mt with an average yield level of 5.1 mt/ha. However, the FAO production estimates are noted to be imputed and not based on actual crop measurements in the reporting year. The Bourke et al. (2009) estimates are likely closer to current sweet potato production levels than is the FAO estimate, if somewhat less than actual production, given population growth since 2000 and 2006.

¹¹ The FAO estimated total banana production in 2019 in PNG to be 1.41 million mt planted on 81,000 ha with an average yield level of 17.3 mt/ha. However, the FAO estimates are imputed and do not reflect recent crop measurements. Consequently, they first should be triangulated with other recent banana production data before being used to guide any policy decisions or in the design of agricultural programs.

Figure 4: Banana productivity and production areas of Papua New Guinea

Actual bunch yields:

Lowlands (<1,200 masl): 12 mt/ha ¹

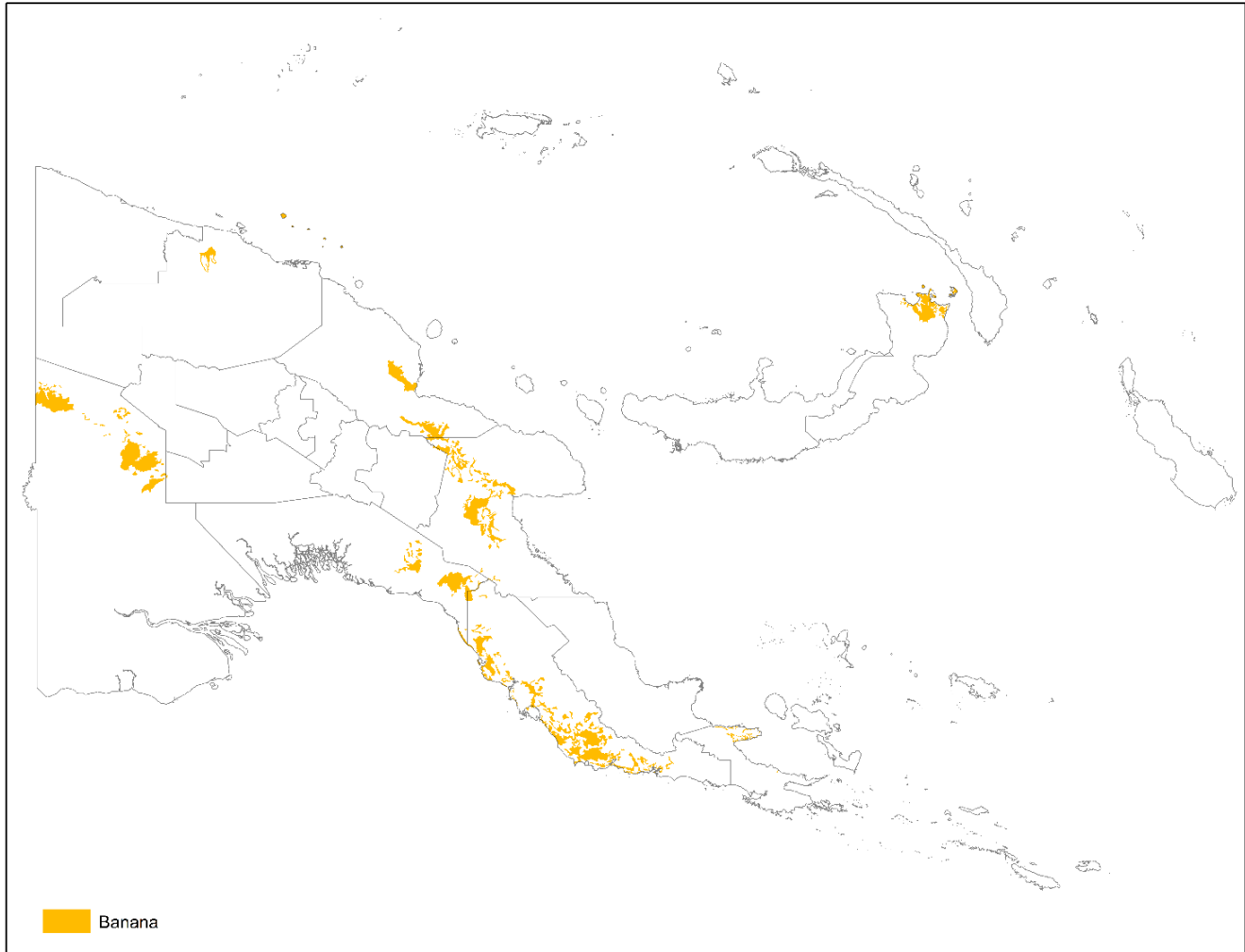
Highlands (1,200 to 1,800 masl): 9 mt/ha ¹

Attainable yields on farm with good husbandry: 38 to 50 mt/ha ²

Sources:

1. Bourke et al. (2009)

2 Acland (1971)



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which banana is estimated to cover more than one-third of area planted to staple crops.

Taro

Taro is grown across most of PNG at elevations ranging from sea level to 2,400 masl. In our discussion here, we include *Colocasia esculenta*, the main type of taro grown, but also other types of taro, except for Chinese taro (*Xanthosoma sagittifolium*), which is discussed separately. About 4 percent of all calories consumed by the population of PNG are estimated to be sourced from taro. Bourke et al. (2009)

provide a national taro production estimate of 230,000 mt for 2000, which they extrapolate to estimate production in 2006 of 275,000 mt.¹²

Figure 5: Taro productivity and production areas of Papua New Guinea

Actual yields:

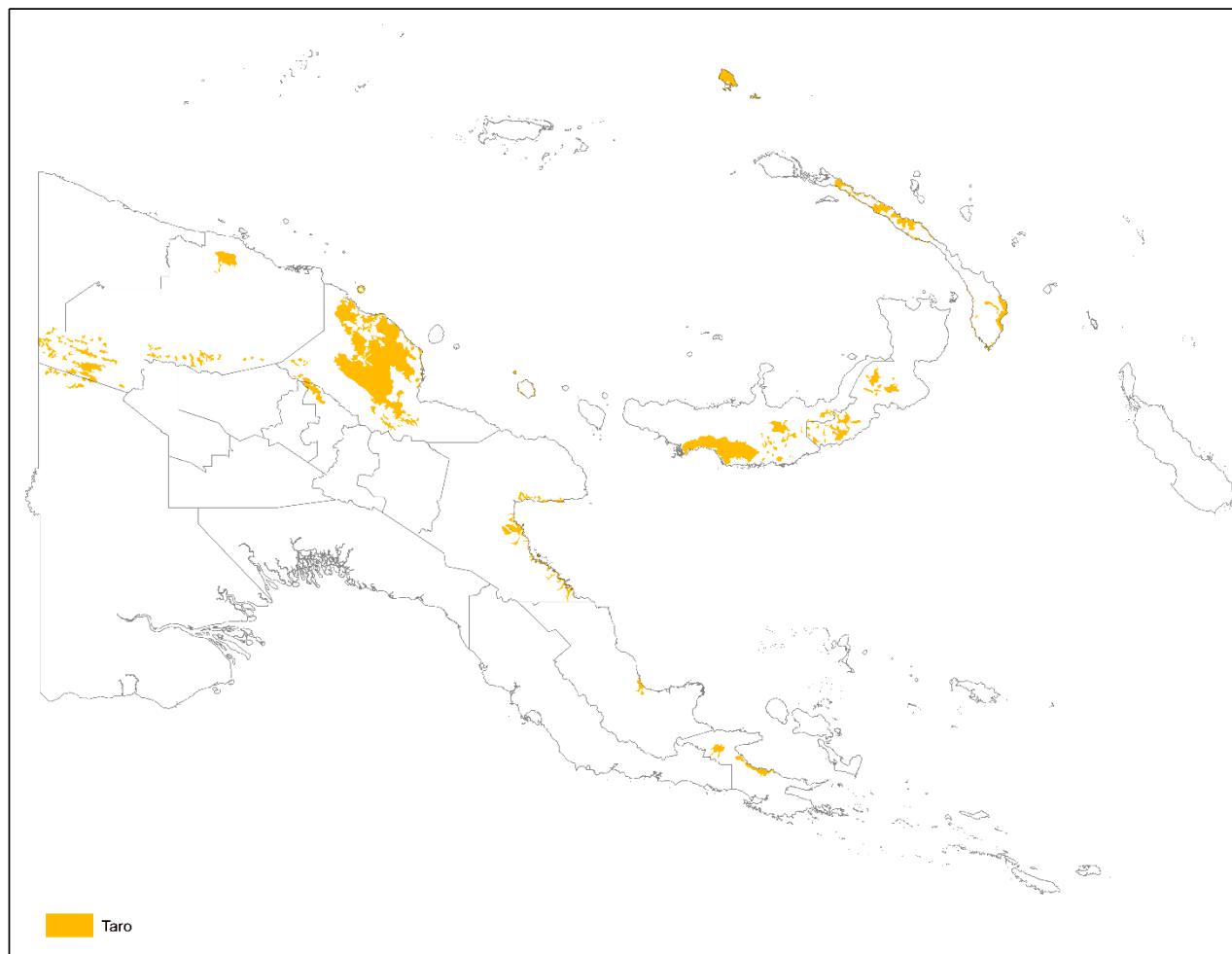
Lowlands (<1,200 masl):	6 to 8 mt/ha ¹
Highlands (1,200 to 1,800 masl):	10 mt/ha ¹
Yield range across PNG:	5 to 10 mt/ha ²

Attainable (experimental) yields:

Yields from breeding trials on-station:	Lowland stations:	7.4 to 15.7 mt/ha ³
	Highland stations:	3.7 to 5.1 mt/ha ³

Sources:

1. Bourke et al. (2009)
2. Onwueme (1999)
3. Singh et al. (2006)



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which taro is estimated to cover more than one-third of area planted to staple crops.

Taro has been consumed in PNG throughout much of the archeological record going back to the consumption of wild taro by hunter-gatherers 28,000 years ago, well before agriculture was developed

¹² FAO estimates of taro production do not distinguish taro from Chinese taro. Their total “taro” production estimate for 2019 for PNG is 272,000 mt planted on 35,000 ha with an average yield level of 7.8 mt/ha. These values are much lower than the totals of Bourke et al. (2009) from ten years earlier. The FAO estimates are imputed and do not reflect recent crop measurements, so should be validated before use in planning.

about 10,000 years ago. Taro was among the first indigenous plants domesticated for agricultural production in PNG (Bourke 2009). Before the arrival of sweet potato about 300 years ago, taro was the most important staple crop for highland communities. Taro also is an important staple in the lowlands (**Figure 5**). However, an epidemic in the 1940s of taro blight, which primarily occurs in lowland agro-ecologies, led to a replacement of taro's prominence in food systems in the Autonomous Region of Bougainville by sweet potato, particularly, but also by cassava (Bourke and Betitis 2003). Sweet potato remains the dominant staple in Bougainville today, with taro now being a secondary food in local diets. This anecdote demonstrates that food systems in PNG can be quite dynamic, particularly when farmers have access to new staples or varieties of existing staples that are better adapted than the traditional staple food varieties for local conditions and the production challenges farmers face.

Taro is grown in most rural communities, but is the most important food for only 6 percent of rural households (Bourke and Allen 2009). Despite being secondary to sweet potato in most rural food systems today, it is an important part of the mix of staple foods grown. Taro is produced without the use of any purchased inputs, with planting materials sourced from within the local community. Its growth cycle varies with elevation, requiring 6 to 9 months in the lowlands, but more than a year in the highlands (Bourke et al. 2009). Of the cultivated staples, taro is the most tolerant of waterlogged conditions, so is often a dominant staple in farming systems with soils susceptible to flooding. Taro production is adversely affected by drought. There remain a few small areas in PNG where taro is still produced using traditional irrigation systems (Allen and Bourke 2009).

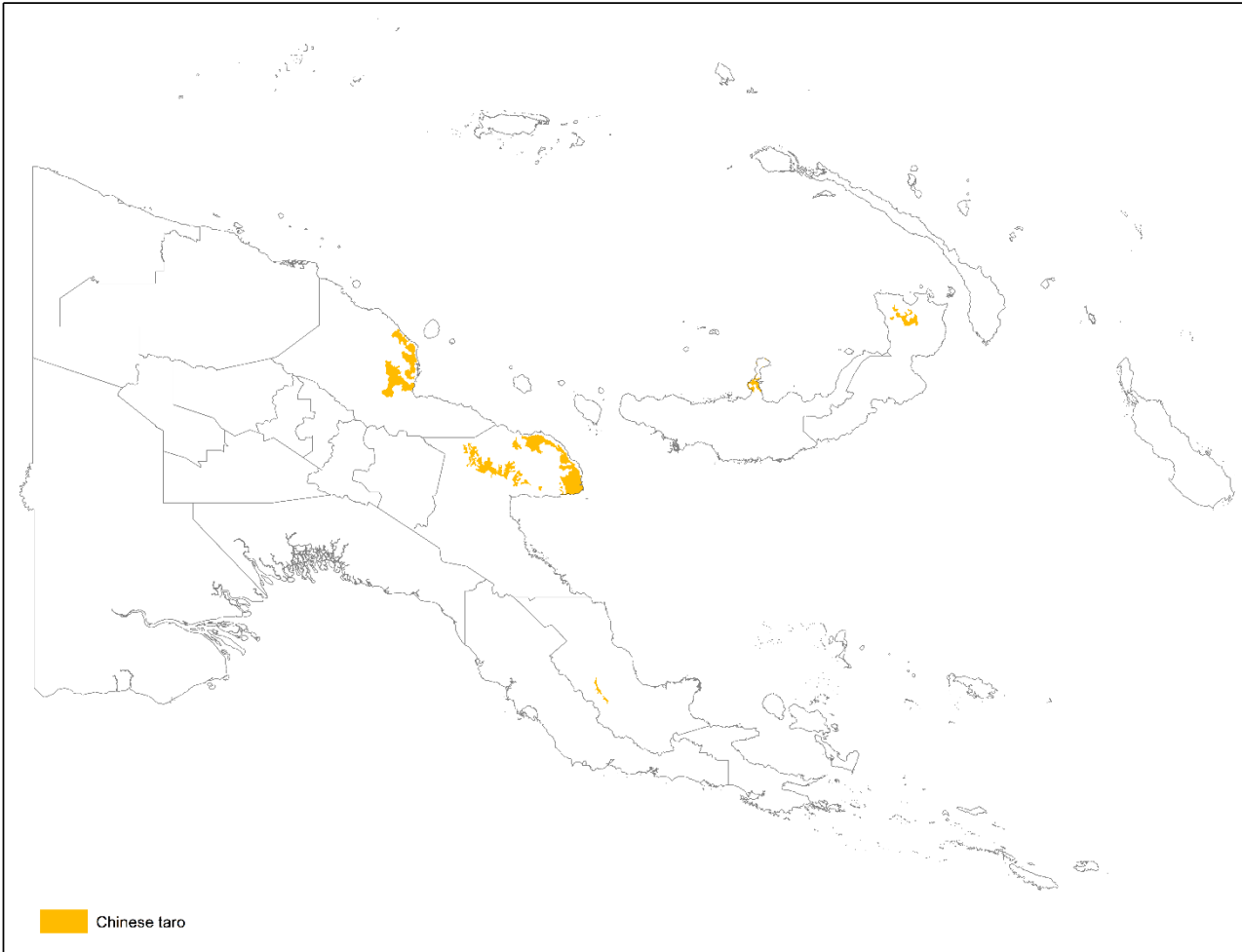
Chinese taro

Chinese *taro* (*Xanthosoma sagittifolium*) is grown in most agro-ecologies of PNG and at elevations ranging from sea level to 2,000 masl, although it is most commonly grown at intermediate elevations between 500 and 1,500 masl (**Figure 6**). The crop is grown by more than half of rural households in PNG. While it is a key staple for only 3 percent of the population, it is an important food for another 19 percent (Bourke and Allen 2009). About 4 percent of all calories consumed by the population of PNG are estimated to be sourced from Chinese taro. Bourke et al. (2009) provide a national Chinese taro production estimate of 225,000 mt for 2000, which they extrapolate to estimate production in 2006 of 265,000 mt.

While taro (*Colocasia esculenta*) and Chinese taro have similar morphologies and production profiles in PNG, they are quite different botanically. While taro is a crop indigenous to PNG, Chinese taro, like sweet potato and cassava, originated in the Americas. Sweet potato was introduced to PNG about 300 years ago, but Chinese taro and cassava were introduced later in the 1800s (Bourke and Allen 2009). The crop then was increasingly adopted by farmers, particularly in lowland farming system, resulting in some displacement in the relative shares of total staple production accounted for by the older indigenous staples. Bourke et al. (2009) report that it now is the most commonly grown staple crop in agricultural systems in Morobe and Madang provinces and across New Britain, but can be found in most lowland farming areas. Comparative analysis by the same authors of production data collected in 1960 and from around 2000 indicate that the share of total staple production in PNG made up by Chinese taro increased over the first several decades of this period, while that for taro decreased somewhat. Its spread slowed in the 1980s and 1990s due to the crop being affected in many locales by disease, particularly a fungal root disease.

Figure 6: Chinese taro productivity and production areas of Papua New Guinea

Actual yields:		
Lowlands (<1,200 masl):	14 mt/ha ¹	
Highlands (1,200 to 1,800 masl):	11 mt/ha ¹	
Attainable (experimental) yields:	25 mt/ha ¹	Sources:
		1. Bourke et al. (2009)



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which Chinese taro is estimated to cover more than one-third of area planted to staple crops.

Cassava

Cassava (*Manihot esculenta*) is grown in most agro-ecologies of PNG and at elevations ranging from sea level to 1,800 masl, but is most important in lowland agricultural systems. Cassava is a particularly significant staple food for communities in Milne Bay and West New Britain provinces (**Figure 7**). The crop is grown by more than half of rural households in PNG. While it is a key staple for only 1 percent of the population, it is an important food for another 12 percent (Bourke and Allen 2009). About 6 percent of all calories consumed by the population of PNG are estimated to be sourced from cassava. Bourke et al. (2009) estimated cassava production in PNG in 2000 to be 270,000 mt, from which the authors extrapolate production in 2006 to be 320,000 mt.¹³

¹³ FAO estimates that cassava production for 2019 for PNG was 155,000 mt planted on about 16,000 ha with an average yield level of 9.9 mt/ha. These values are significantly lower than those of Bourke et al. (2009) from ten years earlier.

Figure 7: Cassava productivity and production areas of Papua New Guinea

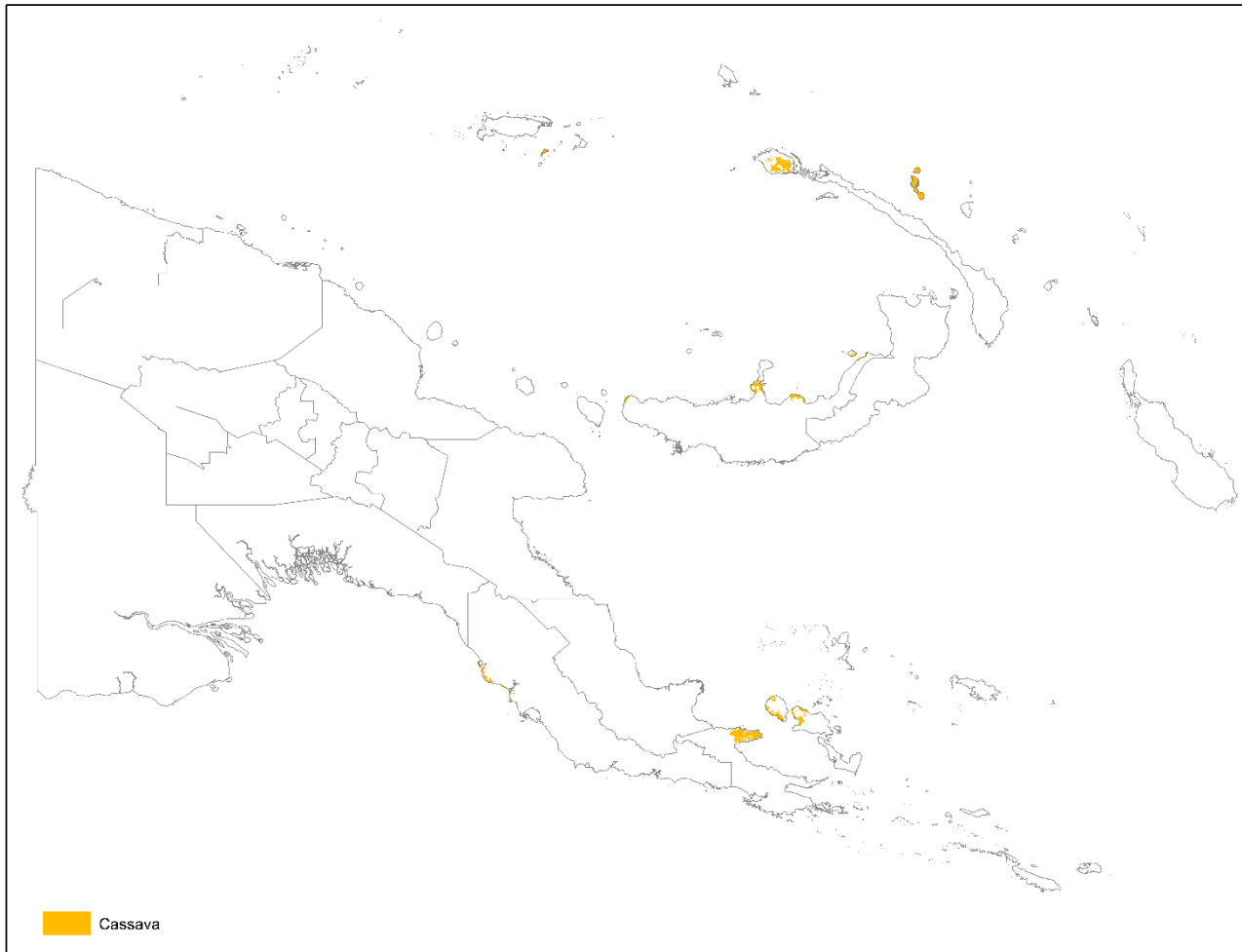
Actual yields:

Lowlands (<1,200 masl): 22 mt/ha ¹
 Highlands (1,200 to 1,800 masl): 16 mt/ha ¹

Attainable (experimental) yields:

45 mt/ha ¹

Sources:
 1. Bourke et al. (2009)



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which cassava is estimated to cover more than one-third of area planted to staple crops.

Cassava originated in the Americas. It was introduced into PNG in the 1800s, about the same time or somewhat earlier than Chinese taro (Bourke and Allen 2009). Farmers in both the north and south lowlands in western PNG view cassava as a traditional indigenous crop, which suggests it may originally have been introduced from eastern Indonesia (Bourke 2009). It then diffused and was adopted by farmers elsewhere in PNG, particularly in lowland farming systems and in the Islands region. Comparative analysis of production data collected in 1960 and from around 2000 indicate that cassava as a share by weight of total staple production in PNG increased from 2 percent to 6 percent (Bourke et al. 2009). New research will be needed to determine if this trend is continuing.

While cassava produces well on good soils with adequate moisture, it quite reliably produces a (smaller) crop even where the nutrient status of soils is poor or when drought may occur. Cassava also has an extended harvest period starting from about 10 months after planting and running for one or two years thereafter. This characteristic makes it a useful addition to food systems in areas with seasonal patterns of food production.

Yam

While several different species of yam (*Dioscorea* spp.) are grown in PNG – Bourke et al. (2009) note that almost all yam consumed comes from *D. esculenta* (lesser yam, mami, taitu) and *D. alata* (greater yam, yam tru). Yam is grown in most agro-ecologies of PNG and at elevations ranging from sea level to 900 masl particularly, but is found up to 1,550 masl for lesser yam and up to 1,900 masl for greater yam. Yam is most important as a staple in lowland agricultural systems situated away from the coast that have seasonal rainfall patterns (**Figure 8**). Yam is a particularly significant staple food for communities in East Sepik, Madang, Milne Bay, and New Ireland provinces as well as for some agricultural systems in Western province. Lesser yam is a primary staple for about 7 percent of the rural population (notably in parts of East Sepik and southern parts of Western provinces) and an important food for another 6 percent. About one-third of the rural population consume lesser yam as part of their diets. Greater yam is not a primary staple in any agricultural systems in PNG, but it is an important food for 4 percent and is consumed by 60 percent of the rural population (Bourke and Allen 2009). About 6 percent of all calories consumed by the population of PNG is estimated to be sourced from yam.

Bourke et al. (2009) estimated total yam production in PNG in 2000 to be 270,000 mt, from which they extrapolate production in 2006 of 322,000 mt.¹⁴ Comparative analysis of production data collected in 1960 and from around 2000 indicate that yam as a share by weight of total staple production in PNG decreased over this period from 9 percent to 6 percent (Bourke et al. 2009), likely being displaced in prominence in some food systems by sweet potato and cassava.

Greater yam is indigenous to PNG, while the center of origin for lesser yam is less clear but likely within the neighboring islands of SE Asia. Lesser yam is superior to greater yam along several dimensions, including fewer problems with diseases, greater tuber yield per plant, and being easier to prepare for cooking (Bourke 2009). While more rural households grow greater yam than grow lesser yam, lesser yam, given its higher productivity, makes up about two-thirds of the total yam harvested in PNG (Bourke et al. 2009). Greater yam matures around 6 or 7 months after planting and lesser yam between 6 and 9 months. While the harvest period for yam is not extended like most other staples, harvested yam is better able than the other common staples of PNG to be stored after harvest with limited losses. Yam is produced without the use of any purchased inputs, with planting materials sourced from within the local community. Unique to yam among the staples, in some areas yam vines are supported by stakes to better expose the plants to sunlight. Experiments have shown that staking improves yam tuber yields (Bourke and Allen 2009).

¹⁴ FAO estimates that total yam production for 2019 for PNG was 380,000 mt planted on about 21,000 ha with an average yield level of 17.7 mt/ha. As with the other FAO production estimates reported, these are imputed and do not reflect recent crop measurements, so should be validated before use for planning purposes.

Figure 8: Yam productivity and production areas of Papua New Guinea

Actual yields:

Lowlands (<1,200 masl):

Greater yam: 13 mt/ha¹

Lesser yam: 15 mt/ha¹

Highlands (1,200 to 1,800 masl):

Greater yam: 11 mt/ha¹

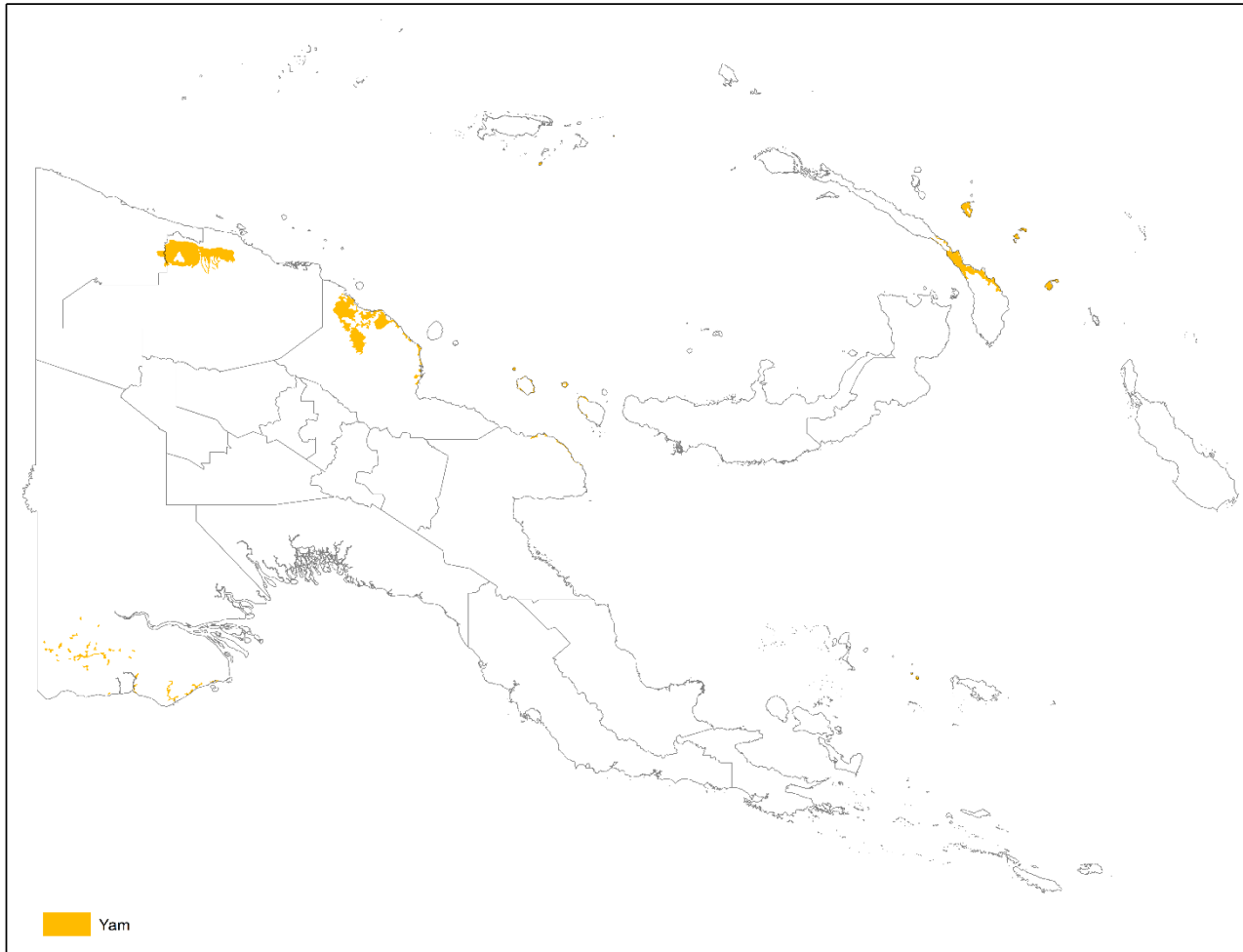
Attainable (experimental) yields:

Greater yam: 30 mt/ha¹

Lesser yam: 40 mt/ha¹

Sources:

1. Bourke et al. (2009)



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which yam is estimated to cover more than one-third of area planted to staple crops.

Sago

Sago, which is produced mainly from the indigenous *Metroxylon sago* palm, is an important staple in several lowland areas of PNG, particularly in western coastal provinces where it is a major source of calories in local diets (**Figure 9**). However, it is not an intensively cultivated crop similar to the other staples considered in this paper. Rather, naturally occurring perennial stands of sago palm are managed by the local community within their natural habitat, rather than cultivated by farmers. To obtain sago, the sago palm is cut down just as it reaches flowering stage after 7 to 15 years of growth. Starch is then extracted from the pith in the trunk of the palm through a process of crushing, kneading, washing, straining, and drying (Pue et al. 2018). Given the nature of production of sago and, although often planted by farmers, that the palms generally are not uniformly distributed across the landscape in which they grow, it is challenging to compute productivity values for sago in a manner comparable to how

sourced from sago. Bourke et al. (2009) estimated total sago starch production in PNG in 2000 to be 83,000 mt, from which they extrapolate production in 2006 of 98,000 mt.¹⁵

When the average per trunk yield value of about 180 kg is combined with information on observed sago palm stand density of about 300 palms per hectare and an annual harvest intensity of between 7 and 42 palms per hectare per year, estimated annual yields on a per hectare basis of dry sago starch are between 1 and 7 mt/ha (Bourke et al. 2009).¹⁶ As processed sago starch has higher calorie content than sweet potato, this level of production is the equivalent of the calories produced by between 4 and 27 mt of sweet potato.

Cash crops

We focus in this sub-section of Appendix 1 on the production and productivity levels of the four principal cash crops of PNG – cocoa, coffee, oil palm, and coconut. The share of the total value of agricultural exports made up by each of these crops is over 10 percent.

Other cash crops could be considered, including tea, rubber, vanilla, betel nut, betel pepper, and tobacco. However, these cash crops are secondary to the production in PNG of cocoa, coffee, palm oil, and coconut/copra. Total production of tea and rubber in PNG is relatively small with the value of exports making up less than one percent of the value of all agricultural exports annually, while vanilla production levels are quite variable, responding to volatile price trends in international markets (Allen, Bourke, and McGregor 2009). For betel nut, betel pepper, and tobacco, obtaining reliable information on their production and productivity levels is a challenge. While these crops are commonly produced across PNG and are quite widely traded domestically, as the crops are not industrially processed or exported, there is virtually no information on yields or on total production (Bourke and Allen 2009).

Cocoa

Cocoa (*Theobroma cacao*) is a lowland crop in PNG grown at elevations up to 800 masl in areas receiving between 1,800 and 5,000 mm of rainfall annually. The most suitable agro-ecologies for cocoa in PNG are those with fertile soils receiving about 3,500 mm rainfall per year (Allen, Bourke, and McGregor 2009). East New Britain province and the Autonomous Region of Bougainville continue to be the most important centers of cocoa production (**Figure 10**). It was first grown in PNG in any significant way on plantations in the 1950s as an alternative for coconut, since copra prices were poor and erratic at the time. However, smallholders quickly adopted the crop. Almost all cocoa in PNG is produced by smallholders. In the mid-1990s it was estimated that 27 percent of the rural population of PNG were members of households that obtained some cash income from cocoa sales. Among the main agricultural exports of PNG, cocoa is second to coffee in terms of the share of rural households that engage in its production.

FAO estimates total annual production of cocoa in PNG in recent years to be about 46,000 mt grown on an area of about 112,000 ha (FAO 2021). Under good management, cocoa yields of up to

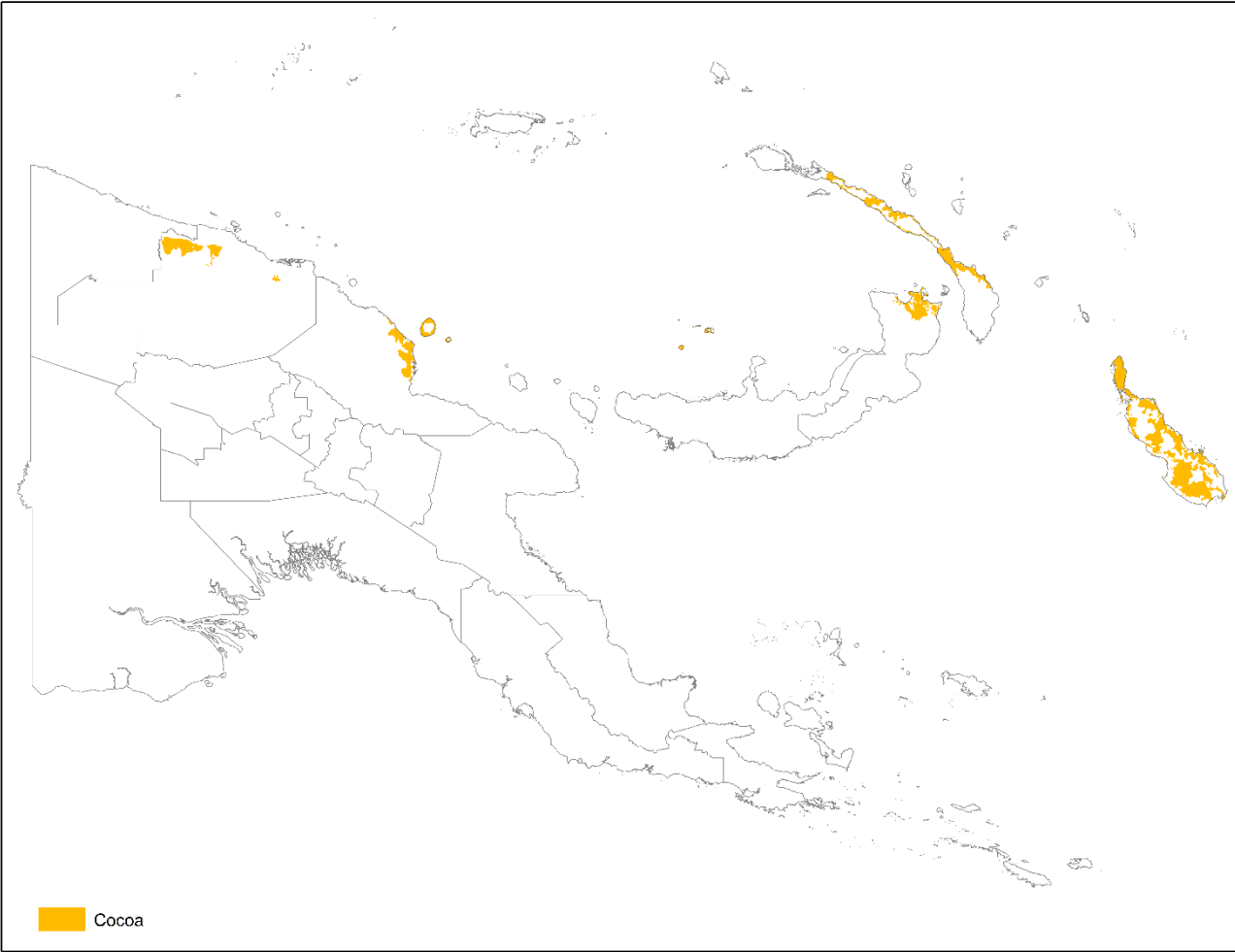
¹⁵ FAO estimates that cassava production for 2019 for PNG was 155,000 mt planted on about 16,000 ha with an average yield level of 9.9 mt/ha. These values are significantly lower than the totals of Bourke et al. (2009) from ten years earlier.

¹⁶ These productivity values for sago are under traditional management. Although no commercial sago plantations operate in PNG, studies suggest that, if intensively managed with a much higher annual harvest intensity, 25 mt of sago starch per hectare could be obtained annually from stands of mature palm (Bourke et al. 2009).

1.50 mt/ha have been achieved. However, smallholder yields are typically around 0.25 mt/ha, while plantations achieve around 0.50 mt/ha. Allen, Bourke, and McGregor (2009) note that smallholders should be able to achieve significantly higher yields from their existing trees with improved pruning, better management of shade around the trees, better control of cocoa pests and diseases, and more thorough harvesting of pods.

Figure 10: Cocoa productivity and production areas of Papua New Guinea

Actual yields: 0.20 to 0.40 mt/ha by smallholders ¹
 0.40 to 0.60 mt/ha on plantations ¹ Sources:
 1. Allen, Bourke, and McGregor (2009).



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which cocoa is commonly seen for sale in local markets.

Almost all cocoa produced in PNG is exported. While cocoa accounted for about 20 percent of the value of PNG’s agricultural exports in the 1990s, official export data for 2017 to 2019 shows that it made up 11 percent of the value of such exports over this more recent period. This drop in the share of the value of agricultural exports made up by cocoa primarily reflects the sharp expansion in oil palm production and exports over the past 20 years, while cocoa has not seen either much growth or decline in total annual production – total annual cocoa exports recorded have varied between 25,000 and 35,000 mt per year since the early 1990s (BPNG 2021). Reconciling the FAO production figures for cocoa with the official export figures will require more research.

Coffee

The two main types of coffee grown globally, Arabica (*Coffea arabica*) and Robusta (*Coffea canephora* var. *robusta*), are both produced in PNG – Arabica mainly in highland agro-ecologies between 700 and 2,050 masl, while Robusta is a lowland crop grown from sea level to 550 masl (**Figure 11**). As Arabica commands much higher prices on global markets, most coffee produced in PNG is Arabica – it was estimated in 2009 that only 5 percent of the national coffee harvest was Robusta. While coffee was introduced to PNG in the early colonial period, commercial production only started after World War II on plantations run by colonial settlers. However, successful efforts were then made to increase smallholder production of coffee. It now is predominantly a smallholder crop – in the mid-1990s it was estimated that 53 percent of the rural population were members of households that obtained some cash income from coffee sales. In 2009, of the estimated national coffee area of 100,000 ha, only about 5,000 ha was estimated to be on plantations (Allen, Bourke, and McGregor 2009).

FAO estimates total annual production of coffee in PNG in recent years to be about 56,000 mt grown on an area of about 53,000 ha (FAO 2021). Almost all coffee produced in PNG is exported – domestic consumption is estimated to be less than 100 mt per year (Allen, Bourke, and McGregor 2009). While coffee accounted for between one-third and half of the value of PNG's agricultural exports in the 1990s, it now accounts for about one-quarter. The drop in the share of the value of agricultural exports made up by coffee is primarily due to the significant expansion in oil palm over the past 20 years. Total annual coffee exports have varied between 40,000 and 70,000 mt per year between 2000 and 2020, with a slight declining trend in quantities exported (BPNG 2021). As with cocoa, reconciling the FAO production figures for coffee with the official export figures will require more research.

Figure 11: Coffee productivity and production areas of Papua New Guinea

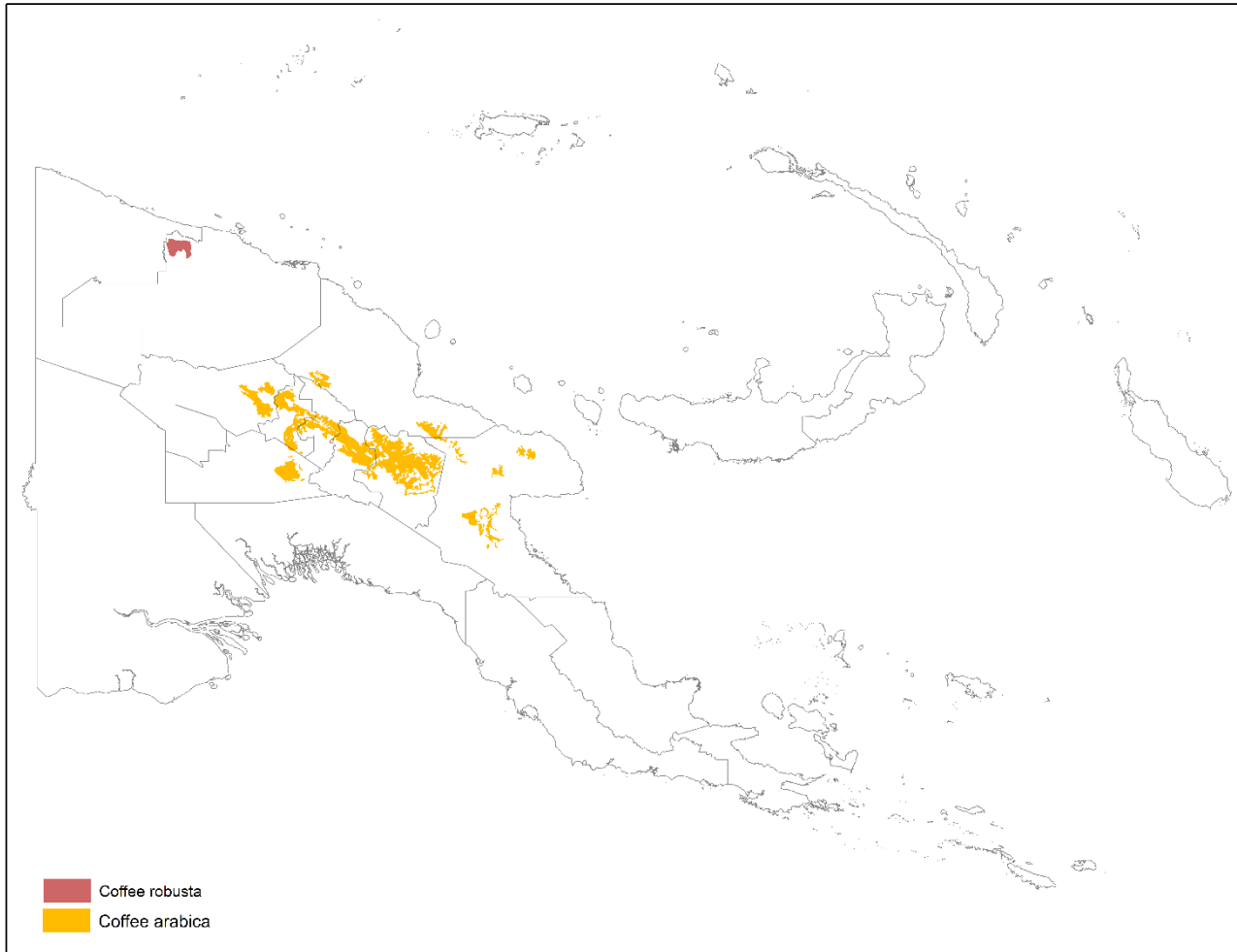
Actual yields:

Arabica: 0.75 to 1.25 mt/ha by smallholders ¹
 1.00 to 2.40 mt/ha on plantations ¹
 Robusta: 0.9 mt/ha ¹

Attainable yields on farm with good husbandry:

Arabica: 1.25 to 2.50 mt/ha ²
 Robusta: 1.90 mt/ha ²

Sources:
 1. Allen, Bourke, and McGregor (2009)
 2. Acland (1971)



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which coffee is commonly seen for sale in local markets.

Oil Palm

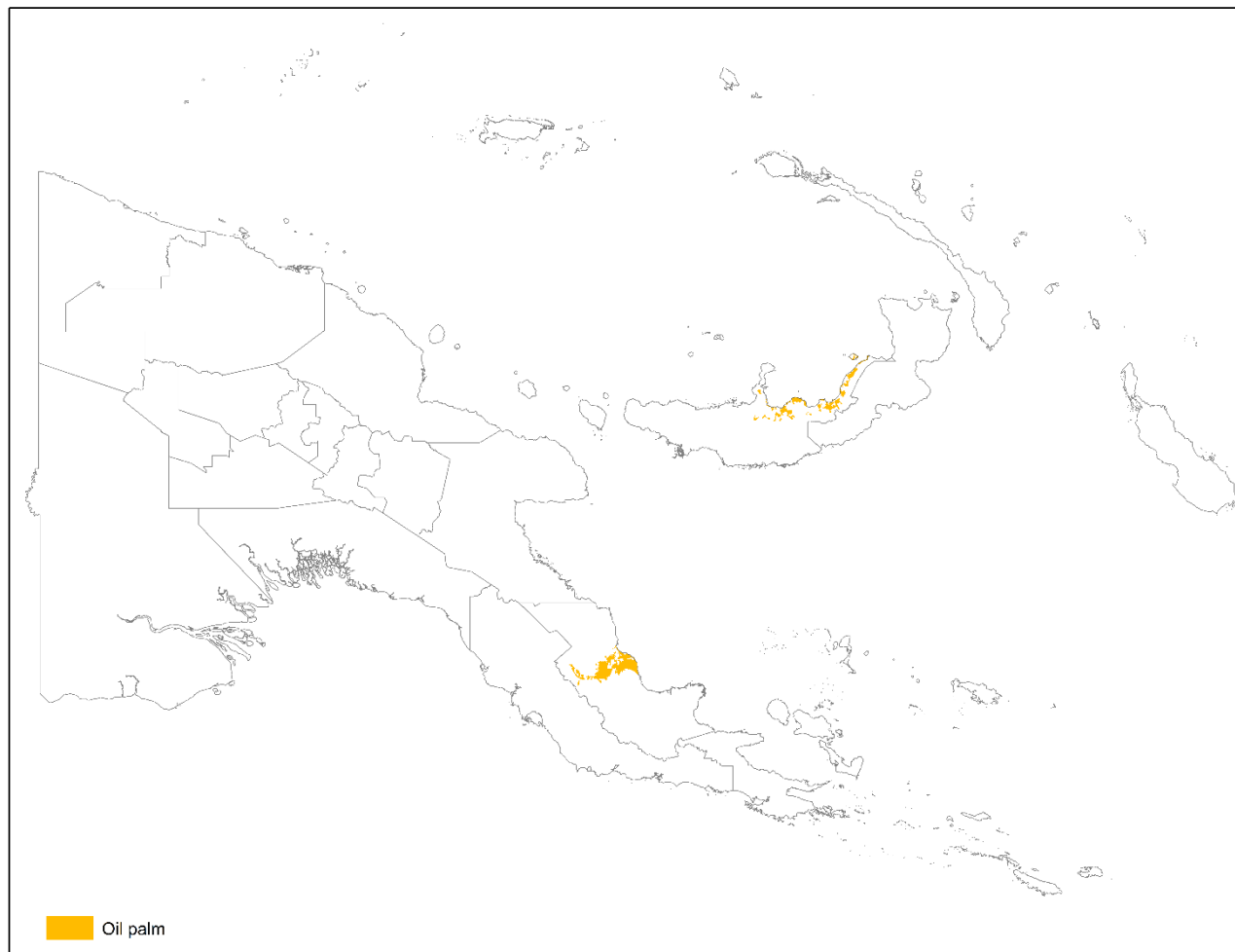
Palm oil is the most important agricultural export of PNG. This has been the case since about 2000, when the value of palm oil exports first exceeded those of coffee. Although a small share of the palm oil produced in PNG is diverted to the domestic market, it is primarily produced for export. In the 1990s, palm oil made up on average just under 30 percent of annual agricultural exports by value from PNG. However, its share has risen significantly since then – its average annual share by value between 2017 and 2019 was 58 percent. The quantity of palm oil exported annually has risen from about 300,000 mt

in the early 2000s to 600,000 mt most recently, growing since 2000 by over 15,000 mt annually (BPNG 2021).¹⁷

Figure 12: Oil palm productivity and production areas of Papua New Guinea

Actual yields (fresh fruit bunches): 6.0 to 14.5 mt/ha by smallholders ¹
19.0 to 21.5 mt/ha on plantations ¹

Sources:
1. Allen, Bourke, and McGregor (2009).



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which oil palm fruit is commonly seen for sale in local markets.

Palm oil production has risen principally due to expansion in the size and number of oil palm plantations. In 2016, the two largest palm oil producing companies in PNG, New Britain Palm Oil Ltd. and Hargy Oil Palms Ltd., were reported to have around 150,000 ha of land under oil palm (Bito and Petit 2016). The area under oil palm continues to expand. A recent study examining the environmental and social impacts of oil palm plantation development in PNG reported that two new oil palm plantations in East New Britain resulted in the clearing of 43,500 ha of forest since 2007 and a new plantation in Sandaun involved the clearing of 30,600 ha since 2011 (Global Witness 2021). These three are not the

¹⁷ Bourke and Harwood (2009) note that the palm oil exports reported by the Bank of PNG are limited in that they only consider crude palm oil and do not include exports of palm kernel oil, refined palm oil, or palm kernel expellant (the palm kernel residual after oil extraction, which is used for livestock feed).

only new oil palm plantations being planned or now being brought into operation in PNG (Bito and Petit 2016). The 2019 estimate from the FAO of the area under oil palm in PNG is just under 200,000 ha – this likely should be seen as a lower bound to such estimates, given the higher estimates provided by other sources (FAO 2021). Similarly, the map on where oil palm is grown in PNG presented in **Figure 12** represents the situation in about the year 2000, so certainly underrepresents the spatial distribution of the cash crop in PNG today.

Oil palm (*Elaeis guineensis*) is a perennial lowland crop that is grown at elevations ranging from sea level to 200 masl. Unlike the other main export crops, which are mainly produced by smallholders, oil palm production is organized around large plantations (or “estates”). These typically are vertically integrated operations, with the company managing all aspects of production, including land clearing, planting, harvesting, processing, and shipping of the palm oil products produced. However, much of the land on which the plantations are created is under customary tenure and controlled by local ethnic groups or communities. Access to the land by the companies operating the oil palm plantations is generally obtained through long term leases of the land from these local groups, a process that is typically mediated by the provincial or national government.¹⁸ Regular rents or royalties are paid to the land-owning group by the companies.

However, several, possibly most, of the oil palm plantations incorporate the production of neighboring smallholder outgrowers into their palm oil production process. For example, Hargy Oil Palms Ltd. reports that it directly manages about 13,000 ha of oil palm itself in its plantations in West New Britain province, but supplements that production from smallholder producers in outgrower schemes individually farming a similar amount of land in total in land blocks neighboring the plantations (Bito and Petit 2016). Typically, these smallholder outgrowers will receive from the plantation agricultural extension and technical support, planting materials, some social services, and a ready outlet for the oil palm fruits they produce. The price paid for the smallholders’ fruit is determined by the local plantation based on export prices, less transport costs of delivering the palm oil to the importing destination, and the local costs of bringing the fruit to the palm oil mill, adjusted for typical local oil extraction rates (Allen, Bourke, and McGregor 2009). However, since the smallholder production is tied to the neighboring plantation and the area suitable for oil palm production is relatively restricted, the share of all smallholders in PNG who are engaged in oil palm production is relatively small. In 2007, it was estimated that only about 4 percent of the rural population of PNG obtained any income from oil palm production (Allen, Bourke, and McGregor 2009). In consequence, the direct impact of oil palm production on the incomes and consumption levels of rural households is much smaller than the direct impact of coffee, cocoa, or coconut production.

Productivity levels for oil palm fruit on plantations can be double the yields attained by smallholders neighboring the plantation – data from 2007 from five oil palm producing areas computed average on-plantation yields of 20.7 mt/ha in the form of fresh fruit bunches of oil palm fruit, but only 12.4 mt/ha in the smallholder outgrower schemes associated with the plantations (Allen, Bourke, and McGregor 2009). These yield values were noted to be imprecise, given that all palms in the oil palm areas were considered in the yield computations – both mature and immature (oil palm requires four to six years before coming into full production). Nonetheless, the significant difference in productivity levels between

¹⁸ This is the Special Agricultural and Business Lease mechanism that has been used for several decades to facilitate large scale commercial land exploitation. The leases have generated considerable controversy as they are seen to not provide sufficient oversight on sustainable land use. The use of such leases was suspended in 2011, but the leases remain in place and the land governance and oversight challenges have not yet been resolved (Bito and Petit 2016).

the plantation and neighboring smallholders suggests that smallholders should be able to achieve much higher oil palm fruit yields with access to and the use of improved crop management techniques.

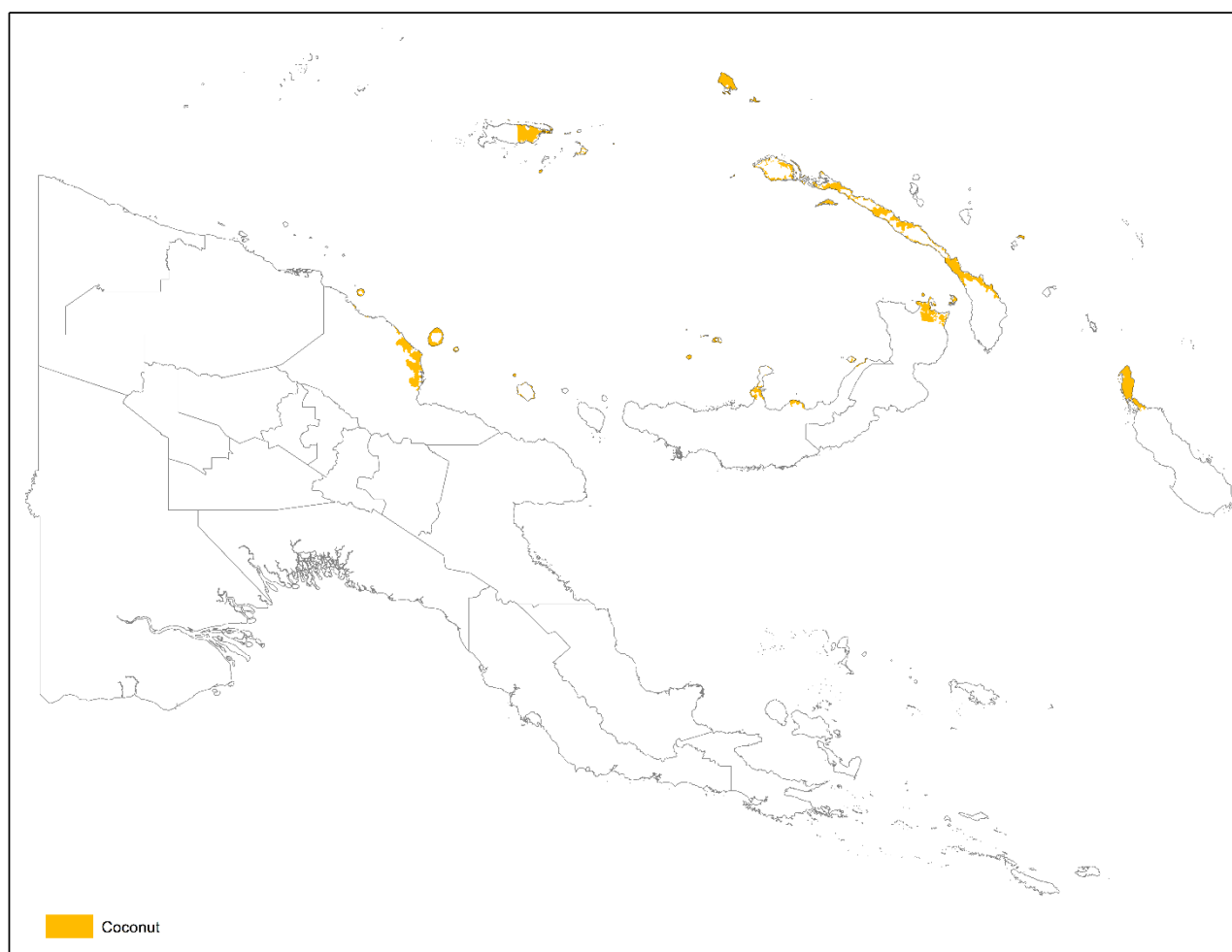
Coconut / Copra

Coconut (*Cocos nucifera*) is a traditional perennial crop that is grown at low elevations (sea level to 1,000 masl) in areas with loose, sandy soils across PNG for food and for sale (**Figure 13**). Coming into fruit after seven years of growth, it reaches full production at ten to twelve years. As a cash crop for the production of copra, it is particularly important in the Islands region and in Madang province where it is grown along the coast at sea level. Copra, the dried meat of dehusked coconut fruit, is used for the production of vegetable oil, with the residue remaining after the oil is extracted being used in animal feeds. Copra was the most important cash crop for PNG from pre-colonial times through the 1960s.

Figure 13: Coconut /copra productivity and production areas of Papua New Guinea

Copra – Actual yields: 0.40 to 0.70 mt/ha by smallholders ¹ Sources:
0.70 to 1.00 mt/ha on plantations ¹ 1. Allen, Bourke, and McGregor (2009).

Allen, Bourke, and McGregor (2009) report that 8.6 mt of full-size coconuts will produce 1.0 mt of copra, which will yield 410 liters of copra oil.



Source: Constructed from LMG-ANU (2000) database. Production areas are defined as those agricultural systems in which coconut or copra is commonly seen for sale in local markets.

Coconut is part of the diet of many producing households in coastal areas and most lowland zones of the country. However, only on small islands in the Autonomous Region of Bougainville and Milne Bay province does coconut make up more than one-third of the area planted to staple crops (LMG-ANU 2000). Nonetheless, coconut is an important part of the diet for over one-third of the population of PNG (Bourke and Allen 2009). It was estimated in 2004 that about 3.5 percent of all calories consumed by the population of PNG were sourced from coconut. In 2000, annual total coconut production for use in the household was estimated to be 100,000 mt (Bourke et al. 2009).

Coconut for copra, as is the case for cocoa and coffee, is grown both by smallholders and on plantations. The share of total copra production contributed by smallholders in 1998 was estimated to be 82 percent (Allen, Bourke, and McGregor 2009). In older coconut plantings, cocoa is often planted as an understory intercrop. FAO estimates total annual national production of coconut fruit (not copra) to be around 1.2 million mt in recent years (FAO 2021). The area under coconut in PNG in 2019 was reported to be about 190,000 ha. This figure has been declining in recent years, even as total production figures remain quite constant. This suggests that higher yields of coconut, now above 6.0 mt/ha based on the FAO data, are being obtained where coconut continues to be produced. However, it should be highlighted that the FAO estimates are noted as being imputed from unofficial production figures.

While in the 1990s, copra and copra oil together made up about 15 percent of annual agricultural exports by value from PNG, their share dropped thereafter to between 5 and 10 percent of annual agricultural exports by value. Exports of copra and copra oil from PNG are quite variable from year to year, reflecting both volatility in global prices for the coconut oil and the production responses of smallholders to these price changes. For example, while copra and copra oil exports constituted 8.8 percent of the value of all agricultural exports from PNG in 2017, in 2019, this share was 5.9 percent. Estimated exports of copra in 2017 were 51,000 mt, while exports of copra oil in the same year were 16,000 mt. In 2019, these values were 37,000 mt and 16,000 mt, respectively (BPNG 2021).

Appendix 2: Synopses of selected policy and strategy statements of the government of Papua New Guinea that have a bearing on agricultural productivity

Master development frameworks

Papua New Guinea Vision 2050

Published in 2009 by the National Planning Committee, this document lays out the development ambitions that PNG desires to achieve over the following 40 years to 2050 (NPC 2009). These ambitions were identified through a consultative process with people from all political constituencies in the country. The succinct vision statement that emerged from this effort is that “We will be a Smart, Wise, Fair, Healthy and Happy Society by 2050.” As a statement of the country’s development vision in the medium to long term, it is to serve as the foundation for all national, provincial, and sectoral policies and strategies, providing the framework within which those more detailed policies and strategies much fit in a harmonious and mutually reinforcing manner. From a strategic economic standpoint, the document identifies the key development challenge for the country to be “How do we shift an economy that is currently dominated by the mining and energy sectors, to one that is dominated by agriculture, forestry, fisheries, eco-tourism, and manufacturing, between 2010 and 2050 (p. 3)?” The document highlights that economic growth by 2050 will need to be broad-based so that household incomes will be much higher than at present (p. 31). This can only be achieved through expansion in sectors outside of mining and energy. Substantial agricultural growth is an important component of these development efforts.

Vision 2050 is supported by seven development pillars. For improving agricultural productivity, two of the pillars are particularly relevant: (i) human capital development so that the people of PNG are empowered to take ownership of their own livelihoods; and (ii) wealth creation through building a strong, dynamic, competitive, and productive economy. However, Vision 2050 does not have any detail on the role that a growing agricultural sector might play in achieving the development vision nor on how to foster increased growth in the sector through improved productivity. Beyond ambitions to create at least two agricultural projects and to post two agricultural extension personnel in all districts of the country, little detail is provided in the Vision 2050 as to how agricultural growth is to be fostered. Nonetheless, the document identifies development opportunities in “food production for the domestic market, high value export crops, developing import-competing industries, plantations, and forestry (p. 24)” as secondary only to the mining and energy sectors as from where future economic development can most easily emerge. The Vision 2050 document signals clearly that the future economic growth in PNG must include sustainable exploitation of all of its agricultural resources in as productive a manner as possible. However, how this will be done is left for sectoral policies and strategies to detail, particularly through a National Agricultural Development Plan (p. 50).

Papua New Guinea Development Strategic Plan 2010-2030 (PNGDSP)

Oriented towards achieving the development aspirations laid out in both the National Constitution and the Vision 2050, the PNGDSP provide an integrated development plan based on economywide modeling of PNG’s economy that is to guide the content of economic and other development interventions over two decades to accelerate progress towards those broader visions for PNG (DNPM 2010). This document provides somewhat more detail on agricultural sector priorities than either the Vision 2050 or the current medium term development plan (MTDP III). The PNGDSP lays out a set of 20-year targets for cash crops that include raising copra production four-fold, cocoa production six-fold, and oil palm

and coffee production eight-fold (p. 90). Staple production will be increased to fully meet the demand from domestic markets and downstream industries. Two large-scale commercial sago plantations are planned, and domestic rice production will be supported. An overriding aim is to convert most subsistence producing farm households into small and medium agricultural enterprises. These increases in agricultural production are to be achieved through both increasing the productivity of PNG's farmers by 60 percent and by expanding the area of land farmed by 180 percent (p. 91).

Of particular note is an emphasis in the PNGDSP on land reforms to improve tenure security and to create transparent land markets. These reforms are expected to result in higher rates of investment and, notably, higher productivity in agriculture. The PNGDSP also places a high priority on building the research basis needed for higher productivity across PNG's economy, including agriculture. "To lay a strong foundation for sustainable and strong economic growth in the longer term, PNG will need the capacity to identify and adapt technologies, making them relevant, affordable and easily accessible to the local industries and people (p. 64)." The mission of NARI within the agricultural sector of PNG is captured in this strategic approach to technology development and dissemination. Equally important, the PNGDSP also devotes considerable attention to rural development – building rural education services, transportation and communication infrastructure, market systems, and sustainable energy supplies to foster industry and improve the well-being of rural households. These rural development efforts all are critical to providing farmers with the skills and incentives they require to raise their productivity and, thereby, the income and consumption levels of their households.

Medium Term Development Plan III (MTDP III)

The detailed development priorities and strategies of the government of PNG to achieve Vision 2050 are laid out in a succession of five-year plans. These medium-term plans also include financing plans that will enable the actions required to achieve those priorities. The current MTDP, the third under Vision 2050, was published in 2018 and is to run through 2022 (DNPM 2018). A principal course correction for the economic development of PNG that is laid out in MTDP III is an increased focus on investing in renewable sectors of the economy, particularly agriculture, in order to set PNG's economy on an inclusive and sustainable growth path. Explicitly noting that "over-reliance on non-renewable resources has been PNG's biggest policy mistake since Independence (p. xi)", the MTDP III seeks to accelerate growth in agriculture, as well as in the marine and forest product sectors. Three of the eight Key Result Areas (KRA) laid out in the Plan, if significant progress is made on them, will either directly contribute to improved agricultural productivity or provide an enabling context, the skills, or the incentives to farmers to increase their productivity: (i) inclusive economic growth with renewed focus in agriculture, particularly for export (KRA 1: Increased revenue and wealth creation); (ii) continuing infrastructure development (KRA 2: Quality infrastructure and utilities); and (iii) improvement of quality of education and skills development (KRA 3: Sustainable social development).

However, the financing plan of the MTDP III has no detail on public support to the agricultural sector. As described in the medium-term plan, public investment in the sector is part of an overarching "Economic" category, which has a planned allocation of 12 percent of the K27.2 billion in the MTDP III budget. Without additional detail on how these funds will be allocated across the sectors of PNG's economy, it is not clear whether we should expect improvement in agricultural productivity during the five years of implementation of the MTDP III.

The MTDP III pays particular attention to weaknesses in biosecurity systems as an important policy challenge that may constrain the achievement of the agricultural development goals of the plan, particularly those requiring greater agricultural exports. It notes that access for PNG's agricultural products to

export markets will be increasingly restricted without putting in place robust biosecurity policies and monitoring mechanisms. Increasingly, access to export markets requires such safeguards. Moreover, PNG's principal cash crops are at risk if investments are not made to protect PNG's farmers from crop pests and disease that come from PNG's trading partners.

Agricultural sector policies and strategies

National Agriculture Development Plan (NADP) 2007-2016

The NADP is ambitious, consisting of a 200 page narrative document on policies and strategies to enable the rural population "to participate actively in the economic development of this nation and thereby guarantee food security and improved livelihood for all the citizens of Papua New Guinea (DAL 2007, p. xi) and an almost 300 page implementation plan in which are specified for each of the eight priority areas of the NADP their implementation framework, implementation schedule, and budget. The NADP is specifically identified in the earlier PNG Vision 2050 document as the basis for how economic growth in PNG will be achieved through sustainable exploitation of all of the country's agricultural resources in as productive a manner as possible.

The NADP focuses on both management strategies and production strategies. The production strategies to accelerate agricultural development in PNG extend along the length of agricultural value chains from input supply to high productivity production to value addition and reducing post-harvest losses. Implementation of the plan is to result in a sequence of three high-level outcomes – (i) Higher agricultural production, productivity, and profitability; which is to result in (ii) Increased household income; and, ultimately, (iii) Enhanced quality of life.

Of the eight priority areas, three are particularly pertinent to improving farmer productivity

- Food and horticultural crops development – This priority area focuses on the production, processing, and marketing of food crops – the traditional staples discussed in this paper, fresh vegetables, and domestically-produced wheat and rice. To enhance food production, efforts will be made to more closely link producers to markets so that their commercial production is not solely a residual surplus after the subsistence needs of their household are met. A range of actions will be taken to foster commercial food production, including strengthening the supply of improved planting materials, organizing farmers into groups to facilitate knowledge exchange and training, developing food processing opportunities and preservation techniques suitable for commercial and cottage industries, and improving marketplace, transportation, and communication infrastructure for the profitable marketing of fresh produce.
- Tree and industrial crops development – The cash crops discussed earlier, with the addition of tea and rubber, are the focus of this priority area. The sub-priorities for cash crop development include creating an apex oversight body for the cash crop sector, rehabilitation of run-down cash crop plantations, and facilitating the development of cooperatives among smallholder cash crop producers to add value on price and crop quality. In setting the context for these sub-priorities for cash crop development, the NADP specifically notes that coffee, cacao, and coconut all saw negative investment trends in the years before the formulation of the Plan, largely due to declining productivity. Only oil palm has been growing. There is a clear productivity element to the varying performance over recent decades of the various cash-crops of PNG.

- Agriculture research, extension, information, and training – To strengthen research and extension, the sub-priorities under this priority area include the development of an effective national agricultural research system that involves coordinated efforts between NARI, commodity-specific research institutes, private research efforts, and economic and socioeconomic research institutes; using a ‘package of technologies’ approach to addressing productivity gaps; and substantially improving farm household access to relevant and high-quality agricultural extension, education; and information services through an effective network of service providers under a National Agricultural Research and Extension System.

The NADP proposes a budget for plan implementation for the ten-year period from 2007 to 2016 of 1.2 billion Kina. Of this, 11.9 percent is for the food and horticultural crops development priority, 50.3 percent for the tree and industrial crops development priority, and 22.0 percent for the agricultural research, extension, information, and training priority.

Agriculture Medium Term Development Plan (AMTDP) 2020-2022

The AMTDP is the agriculture sector plan aligned with the MTDP III that sets out how the sector will achieve the policy directives and targets established for agriculture in the medium-term plan or otherwise by government – the chief target is to “increase cash crops, food and grain crops, fresh fruits and vegetables, and livestock production by 30 percent by 2022 (DAL 2020, p. 3)”. The alignment of the AMTDP with the overarching MTDP III, PNGDSP, and Vision 2050 development policy and vision statements is explicitly presented in the document through specifying how the agricultural sector will contribute to Key Results Areas (KRA) specified in those higher policy statements. Moreover, the AMTDP is grounded in the policy framework and sector development priorities laid out in NADP 2007-2016, even while acknowledging that the earlier sector plan should now be replaced.

The AMTDP is organized around eleven sectoral growth drivers: (1) Sector coordination and management; (2) Food security, quality, and nutrition; (3) Strong partnerships; (4) Agricultural services; (5) Agricultural statistics and information; (6) Digital agriculture; (7) Agricultural trade and investment; (8) Agricultural marketing; (9) Downstream processing; (10) Natural resource management for sustainable agriculture development; and (11) Agriculture land mobilization. For each, strategic actions and interventions are outlined.

Issues around improving productivity at farm level arise under several drivers. That on food security, quality, and nutrition highlights the importance of increased domestic food production, as well as downstream processing and preservation of agricultural produce, while the driver on the improved provision of agricultural services is centered on how those services will increase agricultural productivity. Less directly, the drivers on agricultural trade and investment, on agricultural marketing, and on downstream processing are critical to providing enhanced incentives to farmers to raise their agricultural production, in part through greater productivity. The overall growth of the agricultural sector will also be significantly accelerated with several of the actions under the agricultural land mobilization driver, as it will

bring into production land that can be farmed in a sustainable manner but which is not now being used for agriculture.¹⁹

The AMTDP presents a comprehensive set of specific measurable targets to achieve by 2022 that are aligned with the MTDP III KRAs. These are then expanded into a detailed logframe for PNG's agricultural sector for the three years from 2020 to 2022 in which annual targets are proposed for quite detailed sub-sectoral development objectives. Most of the targets have to do with improving cash crop exports, reducing food imports, or undertaking policy or administrative reforms in the sector. Beyond production of domestic rice, fresh fruits, and vegetables, there are only a few targets related to improving the productivity or increasing production levels of staple foods. Increased production of the traditional staples is acknowledged only under the generic Agriculture logframe – rising annual targets for the Composite Staple Food production index are set (p.42) – and under the Food Security logframe – “Promote and increase production of staple food products with nutritional values (p. 68)”, but without any targets.

NARI Strategy and Results Framework 2011-2020

NARI has a mandate to conduct research on all aspects of agricultural development in PNG, with particular attention to meeting the information and technology needs of smallholder farmers and rural communities. With such a broad potential scope of work, the NARI Strategy and Results Framework (SRF) for the period 2011 to 2020 (NARI 2011) was developed to prioritize NARI's efforts in support of achieving the development vision for the country laid out in the Vision 2050 document. The SRF is organized around an Agricultural Research for Development (AR4D) concept in which research efforts are informed by and integrated with the development challenges and ambitions of all stakeholders engaged in agricultural production. The aim of research is to facilitate innovation by all stakeholders involved to assist them in overcoming those challenges and achieving desired short and long-term development outcomes. The overall strategic objective for NARI under the SRF is the “enhanced productivity, efficiency, stability, and sustainability of the smallholder agriculture sector ... [through] ... enhanced food and nutritional security, increased cash income generation, increased gainful rural employment, and a sustainable resource base (p. vii)”. NARI's efforts are to contribute to the higher-level impact of improved welfare for rural families and communities.

Four programs are described under the SRF: (1) Agricultural systems, which focuses on improving the productivity, efficiency, and stability of agricultural systems; (2) Enabling environment, which is focused on market development as well as institutional and policy reforms needed to reliably provide farmers with inputs and incentives for increased production; (3) Information and knowledge, which is focused on meeting the learning needs of smallholder farmers and putting in place effective agricultural extension service delivery mechanisms; and (4) Institutional management and development, which is focused on making the operations of NARI more efficient and effective.

This now outdated SRF for NARI is conceptually strong. The strategic priorities laid out in it are well justified. These priorities are as important for agricultural development in PNG ten years after the SRF

¹⁹ The AMTDP sectoral growth driver on agricultural statistics and information is particularly important for improving the quality of policy debate and priority setting in the agricultural sector in PNG. The difficulties experienced by the authors of this report in compiling recent information on agricultural production levels across PNG suggests that much of the empirical justification for current agricultural development priorities and for how they are to be achieved relies on quite dated information or on anecdote.

was written as they were in 2011. Whether much progress has been achieved in attaining the objectives of the SRF programs will to a large degree have been dependent on whether NARI was able to amass sufficient qualified staff and material and financial resources to implement the strategic programs effectively – that is, whether SRF program 4 on NARI institutional management and development was successfully implemented.

NARI Strategy and Results Framework 2021-2030 (June 2021 draft)

With the end of the period of application of the 2011-2020 NARI SRF, a new SRF is now under preparation for the period 2021 to 2030. While still in draft form, this document was shared for review. Its content is built from the earlier SRF and retains the objective of “enhanced productivity, efficiency, stability, and sustainability of the smallholder agriculture sector” and the AR4D framework. However, some important changes are made to its content. These include more explicit attention to the ability of households to pursue livelihoods that are resilient in the face of shocks, to improving the diets of rural households to achieve improved nutritional outcomes, sustainable management in applying agro-ecosystem goods and services to agriculture, and greater attention to socio-economic equity and inclusion. Three priorities are set that differ significantly from those of the earlier SRF. NARI is to contribute to: (1) Economic resilience and development by enhancing agricultural markets, value chains, and trade; (2) Enhanced resilience of rural communities and systems in light of climate, economic, and demographic changes and associated threats to livelihoods and the environment; and (3) Enhance consumption of healthy and sustainable diets by rural and urban households.

Setting aside any focus on increased productivity to foster growth in the agricultural sector, the draft SRF shifts the focus of NARI’s efforts to commercialization of production, to building resilient farming systems in the face of shocks, and to improving nutrition. An immediate question that arises with this movement away from NARI’s traditional priority of sustainably improving agricultural productivity is whether NARI has the capacity and expertise and is best placed among public institutions in PNG to address the three priorities laid out in the draft SRF. The expertise needed to improve market systems and specific agricultural value chains or to improve the nutritional status of the population of PNG are quite different from the classic areas of expertise in plant breeding, agronomy, plant pathology, soil science, agricultural production economics, and so on that enabled NARI to develop and adapt new more productive and sustainable agricultural production technologies. Can NARI effectively take on the new priorities laid out in the draft SRF for 2021 to 2030, which have somewhat higher-level objectives than what NARI scientists are trained to address?

However, the outcome matrix for the draft of the new NARI SRF does not neglect improving agricultural productivity as a central measure of the performance of the Institute. Increases in agricultural GDP attributed to smallholder food production, increases in factor productivity and resource use efficiency, and increased productivity per unit of limiting resource in specific farming systems are all listed as targets and indicators of success for the SRF. However, there remains a conceptual gap between actions to address the three new priorities under the draft SRF and actions to achieve these production and productivity-focused outcomes.

Papua New Guinea E-agriculture Strategy

At the core of the situation analysis justifying the formulation of the E-agriculture Strategy is that access to suitable and timely information is one of the key constraints to significant agricultural development in PNG. The increased use of mobile phones and internet and other ICT services provides an opportunity for farmers and rural communities to overcome this constraint. In the E-agriculture Strategy a long list of

likely benefits that increased ICT use in agriculture will bring about is enumerated, including making information available to farmers and other stakeholders in near real time, effective monitoring of activities in the sector, capacity strengthening through efficient provision of agricultural advisory services, and timely dissemination of market information, among others. It is highlighted that making use of these new ICT tools should result in increased efficiency in the production of a diverse range of crops. However, the exact mechanisms through which increased use of ICT will bring about these improvements in agricultural sector performance are not detailed in the strategy. Its principal focus is with the supply side of e-agriculture in PNG and the policy, legal, institutional, and technical requirements that must be met if ICT is to reach farmers and potentially have transformative effects within the sector.

Non-agricultural policies and strategies with relevance for improving agricultural productivity

Papua New Guinea National Food Security Policy, 2018-2027 (draft)

That the Food Security Policy focuses strongly on the role agriculture might play to achieve a food secure country is not surprising given that much of the population of PNG relies upon agricultural livelihoods. The Policy is conceptually grounded in the definition of food security advanced by the 1996 World Food Summit Plan of Action – “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO 1996). It also utilizes the four dimensions of food security – availability, access, stability, and utilization – to make it clear that food production alone does not equal food security. Rather, food security entails reliable access to food and its proper use to meet dietary needs.

The principal strategies advanced in the Policy to ensure that the country as a whole and that individual households are able to maintain food security are focused on improving both food availability and food access within PNG. Productivity is rightly an important element of these efforts. The first of the five strategies laid out in the Policy is closely aligned to the earlier conceptual discussion in this paper on why increased productivity matters and how it might be achieved. The four other strategies of the Food Security Policy are necessary complements to efforts to increase production of food and, thereby, enable improved access to food for all. They include an increased focus on resilience and sustainability in the food systems of PNG, increased attention to dietary quality and to the needs of the households most vulnerable to food insecurity, fostering increased opportunities for women to enhance their economic access to nutritious food for themselves and their households, and establishing the coordination structure necessary for multi-sectoral food security monitoring and policy oversight.

The first strategy seeks to achieve productivity growth for the main food staples, horticulture, small livestock, and fish farming and to increase efficiencies along food value chains. A list of eleven sub-elements to the strategy are laid out. These summarize to a large degree many of the objectives of the agricultural sector policies and strategies already reviewed. However, these is a notable expansion in the scope of these efforts to pay attention to the quality of the food produced, to address seasonality in food production so that food is available at all times, and to the integration of production, distribution and marketing, and consumption in developing efficient food value chains. For example, the sub-element for crop production involves “increase focus on greater productivity and consistent supply of a diverse range of quality nutritious food crops in rainfed low input systems”, while that on food distribution seeks to “facilitate the establishment of efficient viable competitive food production, distribution and marketing from input suppliers, through farm production, distribution, and processing to end markets

and consumers.” These priorities are sound and, if effective action is taken to achieve them, will result in smallholders across PNG achieving higher crop productivity levels.

As a supplement to the draft National Food Security Policy, a draft Action Plan for the period 2018 to 2022 was also formulated. This document further refines the sub-elements under the five strategic areas of the Policy. That on agricultural productivity growth has six intermediate outcomes in the Action Plan – increased investment in agricultural research and development; strengthened agricultural extension services; increased productivity and production, building efficient and inclusive nutrition-sensitive food value chains; transportation, storage, processing, and marketing infrastructural development; and increasing the number of food-focused enterprises. The intermediate outcomes are further detailed through establishing key outputs for each – for increased productivity and production, the key outputs are strengthening farmer organization, increasing farmer access to productivity-enhancing inputs and technologies, and providing financing to smallholders. The document then goes on to lay out the risks to successful implementation of the Action Plan, particularly focusing on challenges associated with a lack of political will, insufficient engagement and participation, and poor coordination. An indicative costing by intermediate outcome of implementing the Action Plan over five years is also provided – 720 million Kina, of which 46 percent is for activities to achieve the agricultural productivity growth outcome.

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