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The Agrifood System in PNG: Structure and Drivers of Transformation

Xinshen Diao, Paul Dorosh, Luis Escalante, Angga Pradesha, James Thurlow, Junyan Tian

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INTRODUCTION

Although the economy of Papua New Guinea is heavily influenced by the oil and natural gas sector, which accounts for 30 percent of GDP and most of the country's foreign exchange earnings, small-scale agriculture continues to be the major source of livelihoods for most of the population. Much of the food crop production (particularly starchy staples such as sweet potatoes, cassava, yams and sago) is not traded internationally; however, oil palm, coffee and cocoa are major exports. A large share of agricultural production undergoes little value-added through processing and much of it is consumed by farm households themselves. Thus, there would appear to be substantial scope for increases in employment and incomes through further development of the broader agrifood system, including agroprocessing, trade and transport, and food services (Diao, Hazell, and Thurlow 2010; Timmer 1988).

Subsistence farming typically dominates agriculture during the earliest stages of development. As agricultural productivity rises, farmers start to supply surplus production to markets, thus creating job opportunities for workers in the nonfarm economy both within and outside of agrifood sectors (Haggblade, Hazell, and Dorosh 2007). Rising rural incomes generate demand for more diverse products, leading to more processing, packaging, transporting, trading, and other nonfarm activities. In the early stages of agricultural transformation, the agriculture sector serves as an engine of rural and national economic growth. Eventually, urbanization, the nonfarm economy, and nonagricultural incomes play more dominant roles in propelling agrifood system development, with urban and rural nonfarm consumers creating most of the demand for agricultural outputs via value chains connecting rural areas to towns and cities (Dorosh and Thurlow 2013). The exact nature of this transformation process varies across countries because of the diverse structure of their economies and the unique growth trajectories of their various agrifood and nonfood subsectors.

This paper describes the current and changing structure of PNG's agrifood system (AFS) and evaluates the potential contribution of different value chains to accelerate agricultural transformation and inclusiveness. We start by offering a simple conceptual framework of the AFS and then compare PNG's AFS to that of other countries at different stages of development. We go on to disaggregate PNG's AFS across agricultural value chains, taking into consideration their different market structures and historical contribution to economic growth and transformation. Finally, we use a forward-looking economywide model to assess the diverse contributions that specific value chains can make to each of a set of broad development outcomes. We conclude by summarizing our main findings.

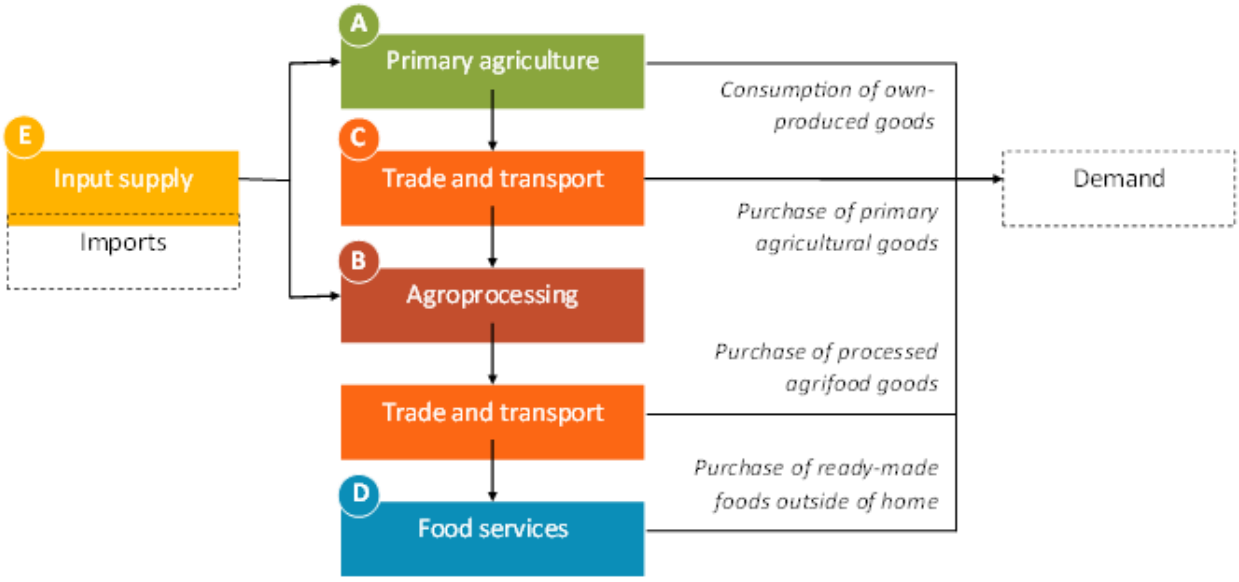
A SIMPLE CONCEPTUAL FRAMEWORK OF THE AGRIFOOD SYSTEM

A country's AFS involves a complex network of actors who are connected by their roles in supplying, using, and governing agrifood products (see Fanzo et al. 2020 for a detailed conceptual description of the AFS). In this paper, we describe key aspects of PNG's AFS, beginning with

estimates of its size, structure, and historical contribution to economic growth and transformation. We then use the International Food Policy Research Institute (IFPRI) Rural Investment and Policy Analysis (RIAPA) model (IFPRI 2023a) to assess the effectiveness of AFS growth (driven by productivity gains in various agricultural value chains) in promoting multiple development outcomes in PNG. Our measurements of the AFS are done from a supply-side perspective; that is, we use national accounts and employment statistics to either track or simulate growth and employment changes over time.

Figure 1 provides a simple conceptual framework of the AFS, made up of five components (see Thurlow et al. 2023 for more details). Primary agriculture (A) comprises the supply and demand of all agricultural products, including crops, livestock, fisheries, and forestry products. Agroprocessing (B) is part of the manufacturing sector and includes those subsectors that process agriculture-related food or nonfood products. Trade and transport services (C) includes those services associated with the transporting, wholesaling, and retailing of agrifood products between farms, firms, and final points of sale. Food services (D) includes services, such as meals prepared at restaurants, food stalls, or hotels. Finally, input supply (E) is the portion of domestically produced intermediate inputs that is used directly in agricultural and agroprocessing production such as fertilizers and financial services.

Figure 1: A simple conceptual framework of the agrifood system



Source: Thurlow et al. (2023)

Using this conceptual framework, it is possible to measure the size and structure of PNG's AFS from a supply-side perspective. Following the definitions of Thurlow et al. (2023), AFS GDP (or AgGDP+) is the sum of the GDP contributions of the five components (A to E), while AFS employment (or AgEMP+) is the total number of jobs across those components. As the economy grows and transforms over time, there will be changes in the relative contributions of the various on-farm and off-farm components of the AFS to total AgGDP+ or AgEMP+. A

transforming economy, for example, will typically be characterized by more rapid growth in the off-farm components of the AFS; there will thus be an increased contribution by off-farm components to AgGDP+ and AgEMP+ and a relative decline in the contribution of primary agriculture. By disaggregating AgGDP+ and AgEMP+ by specific agricultural value chains, we can further assess the contribution of each of those value chains to AFS growth and transformation.

Current Structure of PNG's Agrifood System

Table 1 presents the structure of the PNG Agri-Food System in 2019 based on official national accounts data and sectoral employment statistics (ILO 2020), as compiled in a 2019 Social Accounting Matrix (SAM) for PNG (IFPRI 2023b). National estimates are broken down into estimates for the AFS (that is, AgGDP+ and AgEMP+) and the rest of the economy. The AFS is further broken down into the on-farm (primary agriculture) and off-farm components. The estimates for manufacturing and services (including the trade and transport services subsector) at the bottom of the table include activities in both the AFS and non-AFS sectors, thus providing a perspective on the relative size of the off-farm AFS components within the overall manufacturing and services sectors.

Table 1: GDP and Employment in PNG's Agrifood System (2019)

	GDP ($ billions) (share)		Employment (thousands of workers) (share)	
Total economy	23.7	100.0%	2,599	100.0%
Non-oil Sector	16.6	70.2%	2,514	96.7%
Agrifood system	6.1	25.9%	1,718	55.4%
Primary agric. (A)	4.3	18.0%	1,460	29.7%
Off-farm AFS	1.9	7.9%	258	25.7%
Processing (B)	0.6	2.5%	33	6.5%
Trade & transport (C)	0.9	3.8%	216	10.5%
Food services (D)	0.3	1.4%	6	6.6%
Input supply (E)	0.0	0.2%	3	2.2%
Rest of economy	17.5	74.1%	881	44.6%

Source: Authors' calculation based on the 2019 Social Accounting Matrix for PNG (IFPRI 2023b).

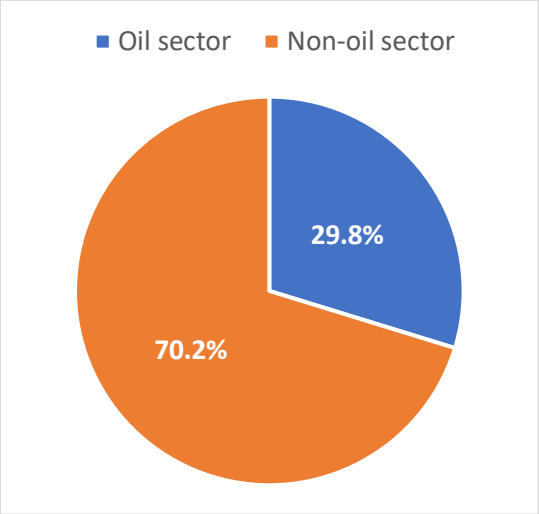
As shown in Table 1, the AFS accounted for 25.9 percent of PNG's national GDP and 55.4 percent of employment in 2019. Primary agriculture alone contributed only 18.0 percent of GDP and 29.7 percent of employment, while the four off-farm components of the AFS contributed 7.9 percent of GDP and 25.7 percent of employment. Thus AgGDP+ is about 40 percent larger than the size of primary agricultural GDP and about 50 percent larger than employment in primary agriculture.

The large oil and natural gas sector accounted for 29.8 percent of GDP (7.1 billion USD), but only 3.3 percent of employment. PNG's manufacturing sector, which consists mainly of wood and metallic products, is small and accounts for only 4.4 percent of total GDP. Agroprocessing, which is part of AgGDP+, accounts for about 70 percent of manufacturing GDP, but only 3 percent of national GDP.

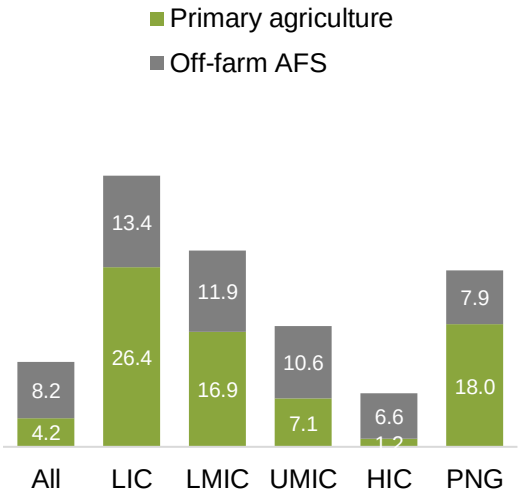
Although PNG's GDP per capita places it as a lower middle-income country (LMIC), the size and structure of its non-oil economy are similar to those of a low-income country (LIC). Thus, the share of the AFS in total GDP (27.9 percent) is similar to the LMIC average (28.6 percent), while the share of its AFS in non-oil GDP (36.9 percent) is only slightly below the average for LICs (40.0 percent), (Figures 2a and 2b).

Figure 2: Comparing PNG's agrifood system to other countries (2019)

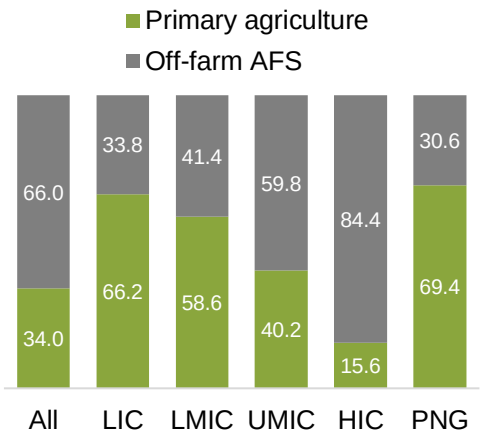
2a: Oil sector share of GDP



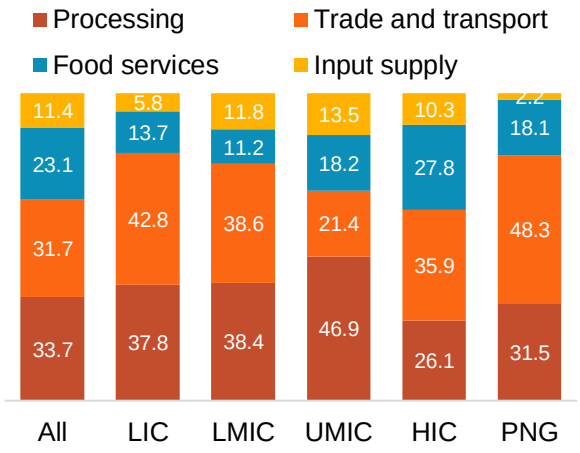
2b: Share of total GDP (%)



2c: Share of AFS GDP (%)



2d: Share of off-farm AFS GDP (%)



Note: LIC = low-income country; LMIC = lower-middle-income country; UMIC = upper-middle-income country; and HIC = high-income country.

Source: IFPRI's Agrifood System Database (Thurlow et al. 2023) and the 2019 Social Accounting Matrix for PNG (IFPRI 2023b).

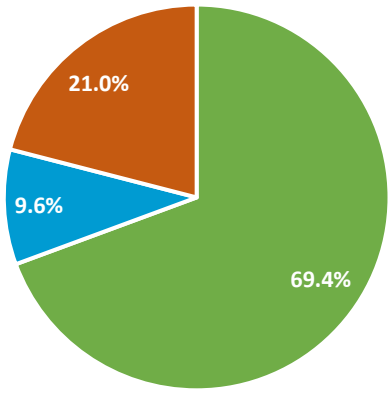
Within the four off-farm components of the AFS, the share of agroprocessing in PNG's AFS GDP (31.5 percent) is relatively smaller than that of other LICs (37.8 percent), while the agrifood trade and transport component in PNG (48.3 percent) is relatively larger (42.8 percent), (Figure 2d). A primary reason for the higher share of trade and transport in the off-farm components of the AFS is the high cost of both domestic land and air travel that is used to transport agricultural goods.

Unpacking the Demand Side of PNG's Agrifood System

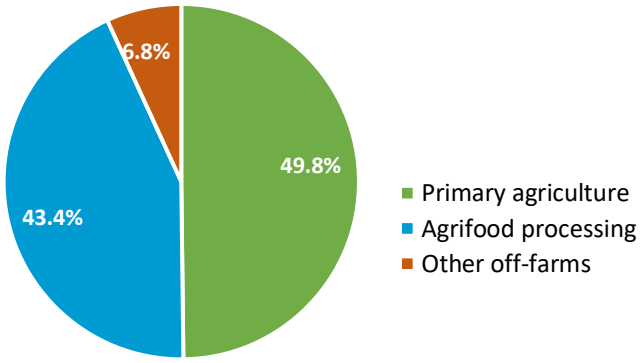
Figure 3 compares the structure of PNG's AFS from the supply side, as measured by AgGDP+ (Panel A), with the structure of PNG's AFS from the demand side, as measured by household consumption of agrifood products (Panel B). While 69.4 percent of AgGDP+ derives from primary agriculture, primary agricultural commodities account for only 49.8 percent of household demand. In contrast, household demand for processed agrifood products accounts for 43.4 percent of total agrifood demand, even though this sector accounts for only 9.6 percent of AgGDP+. Thus, there appears to be substantial scope for expansion of the agrifood processing sector in PNG, though relatively poor infrastructure, small, marketed volumes and high costs of transport may limit investment in many areas.

Figure 3: PNG: Composition of agrifood system GDP and household demand (2019)

3a: AgGDP+



3b: Household consumption (agrifood demand)

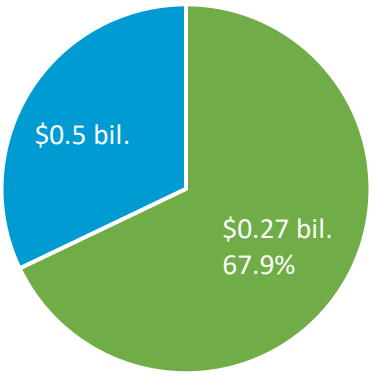


Source: Authors' calculation based on the 2019 Social Accounting Matrix for PNG (IFPRI 2023b).

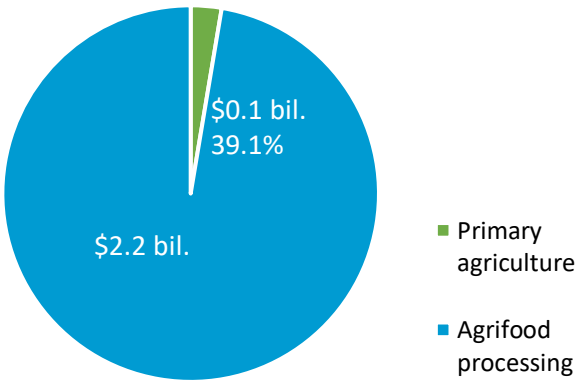
PNG's trade deficit in agrifood products reflect the limited size of the domestic agrifood industry. PNG's agrifood imports are $2.2 billion, but exports are only $0.5 billion. Overall, almost all (97.4 percent) of PNG's total agrifood imports are processed, as compared to 39.1 percent of PNG's total agrifood exports (Figure 4).

Figure 4: PNG Agrifood exports and imports, Primary and processed product shares (%) (2019)

4a: Exports ($0.5 bn)



4b: Imports ($2.2 bn)



Source: Authors' estimates using the 2019 Social Accounting Matrix for PNG (IFPRI 2023b).

RECENT PERFORMANCE OF AGRIFOOD SYSTEM VALUE CHAINS

To assess the recent performance and future potential of key AFS value chains in PNG, we define fourteen value chain groups, categorized into exportable, importable, and less-traded value chains (Table 2).[1] For each value chain group, we report the shares of its total value added, value added in primary agriculture and value added off-farm in AgGDP+, total primary agricultural GDP, and total off-farm AFS GDP in the off-farm components of the AFS, respectively.

Consistent with Figure 3, Table 2 shows that PNG has a substantial deficit in agrifood trade with an import–consumption ratio of 21.4 percent, as compared to the export–output ratio of 7.9 percent. Of the 14 value chains shown, only three (coffee & cocoa, forestry, and oil palm) are classified as exportable value chains with their export–output ratios near or above the national average for AFS value chains. Substantial processing of forestry, oil palm and oilseed products takes place in PNG, with these sectors alone contributing one-third of all off-farm AFS GDP in the country.

Table 2: Characteristics of Value Chains in the PNG Agri-Food System (2019)

	Share of GDP (%)			Exports / output (%)	Imports / demand (%)
	Total AFS	Primary agric.	Off-farm AFS		
Total	**100.0**	**100.0**	**100.0**	**7.9**	**21.4**
Exportable	**28.6**	**25.6**	**35.1**	**18.8**	**12.7**
Coffee & cocoa	3.0	3.9	0.9	74.9	26.5
Forestry	8.0	6.2	12.1	24.8	3.1
Oilseeds*	17.6	15.6	22.2	7.4	16.3
Importable	**9.3**	**2.6**	**24.5**	**4.7**	**64.3**
Rice	0.8	0.0	2.5	0.2	73.6
Wheat	0.6	0.0	1.8	1.5	68.0
Other crops	2.1	1.4	3.7	13.5	51.9
Cattle**	5.9	1.2	16.4	0.7	62.7
Less traded	**61.6**	**71.7**	**38.6**	**2.0**	**6.4**
Maize	0.7	0.8	0.5	0.0	6.9
Pulses	0.3	0.4	0.0	0.0	1.0
Root crops	17.9	24.8	2.4	0.0	0.7
Fruits & vegetables	20.9	27.7	5.6	0.8	5.9
Poultry	3.0	3.1	2.5	0.0	1.0
Other livestock	4.9	6.6	1.2	1.4	0.9
Fish	13.9	8.3	26.4	5.6	13.8

* Includes oil palm, coconuts, groundnuts and other sources of vegetable oil.

** Includes dairy products.

Source: Authors' calculation based on the 2019 Social Accounting Matrix for PNG (IFPRI 2023b).

Four of the value chains are classified as importable and seven as less-traded. Importable agrifood products account for only a small share of (9.3 percent) of AgGDP+. Many importa-

[1] See Table A1 in the Appendix for details on the mapping of individual value chains and subsectors mapped to value chain groups.

ble value chains require more processing and trade and transport services, and together account for a relatively large share of off-farm AFS GDP (24.5 percent), but only 2.6 percent of primary agriculture GDP.

Less-traded value chains, on the other hand, generally have relatively small off-farm components. For example, roots account for 24.8 percent of primary agriculture GDP in the PNG AFS, but only 2.4 percent of off-farm AFS GDP. Animal production value chains (such as cattle) are clear exceptions, with substantial value addition off-farm. Expansion of some less-traded value chains such as poultry and fish could effectively promote agricultural transformation by boosting value addition and off-farm employment in the value chain.

As shown in Table 3, PNG has experienced a modest 3.0 percent per year growth in both AFS GDP and primary agriculture GDP growth from 2009 to 2019. Less-traded value chains accounted for more than half of total AFS GDP growth, and many of these less-traded value chains had above-average growth rates. Total AFS growth in oilseeds – an exportable value chain – also grew rapidly (4.6 percent).

Much of the growth in AgGDP+ is due to the 3.6 percent growth in processing, mainly due to large increases for two exportable commodities: oil palm (which includes coconuts and other sources of vegetable oil), (6.3%) and forestry (9.4%) (Table 3). In contrast, most sectors had negative growth rates in processing, highlighting the stagnation in these sub-sectors.

Table 3: PNG: Growth in AFS Value Chains (2009-2019)

	Total AFS GDP Share in 2019 (%)	Average annual GDP growth rate (%)			
		Total AFS	Primary agric.	Off-farm AFS	Processing
Total AFS	**100.0**	**3.0**	**3.0**	**3.0**	**3.6**
Exportable	**28.6**	**2.4**	**2.7**	**1.8**	**6.3**
Coffee & cocoa	3.0	-2.0	-2.1	-1.2	-0.8
Forestry	8.0	0.4	2.7	-1.7	9.4
Oilseeds*, #	17.6	4.6	4.5	4.7	6.3
Importable	**12.5**	**4.2**	**4.3**	**4.1**	**-0.9**
Rice#	0.8	16.9	-11.0	21.0	0.1
Wheat	0.6	1.0	2.6	0.9	-1.6
Other crops#	2.1	5.0	6.1	4.2	-0.2
Cattle**, #	5.9	3.3	3.3	3.4	-0.4
Less traded	**61.5**	**3.0**	**3.0**	**3.3**	**1.7**
Maize	0.7	1.4	1.4	1.7	-0.6
Pulses#	0.3	4.7	4.8	3.2	
Root crops	17.9	2.4	2.3	5.3	-0.6
Fruits & vegetables#	20.9	3.1	3.2	2.6	-1.1
Poultry	3	2.8	2.3	4.5	-0.6
Other livestock	4.9	1.7	1.7	1.7	
Fish#	13.9	4.8	7.1	3.5	1.9

* Includes oil palm, coconuts, groundnuts and other sources of vegetable oil.

** Includes dairy products.

Sectors with above average growth rate of AgGDP+ (i.e., greater than 3.0%).

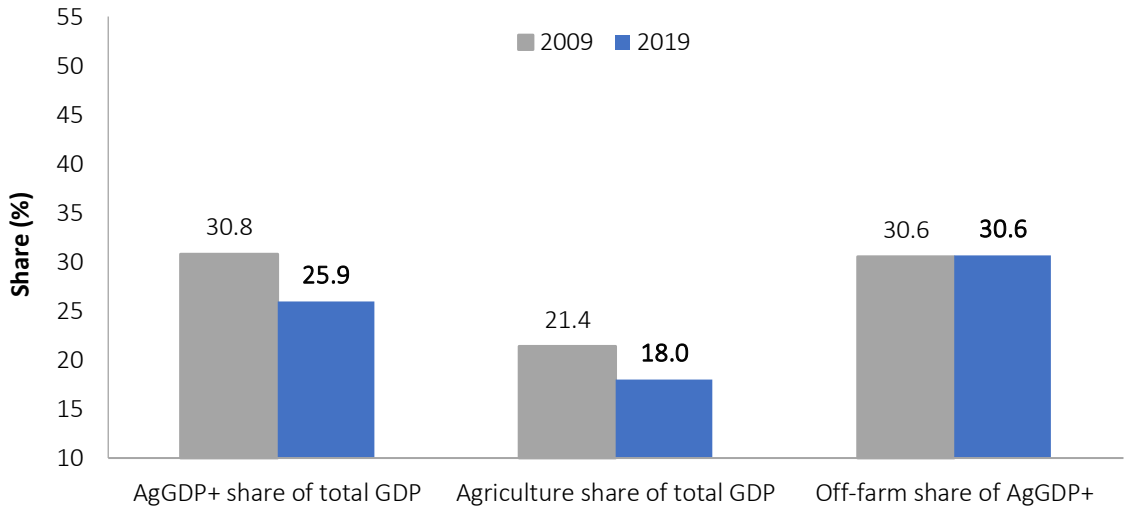
Source: Authors' calculation based on the 2019 Social Accounting Matrix for PNG (IFPRI 2023b).

Structural change in the PNG Economy

Structural change in the economy, as measured by declining shares of agriculture in total GDP and employment, and corresponding rising shares of industry and services, is a typical feature of economic growth. In most countries, average labor productivity is lowest in primary agriculture, and higher in off-farm activities, such as in agrifood processing and food services, and in sectors outside the AFS. Increased employment in these more productive nonagricultural sectors, often located in more urbanized areas, promotes overall economic growth.

Overall, the shares of both AgGDP+ and agriculture in total GDP fell by around 4 percentage points from 2009 to 2019 (Figure 5), but agricultural employment fell even more sharply (from 67.2 percent to 56.2 percent). Thus, labor productivity in the agriculture sector as measured in the national accounts rose significantly over this period (likely reflecting less underemployment in the agricultural sector). The structure of PNG's AFS changed very little in this decade, however. The share of off-farm components in total AgGDP+ fell by only 0.1 percentage points (from 30.7 to 30.6 percent).

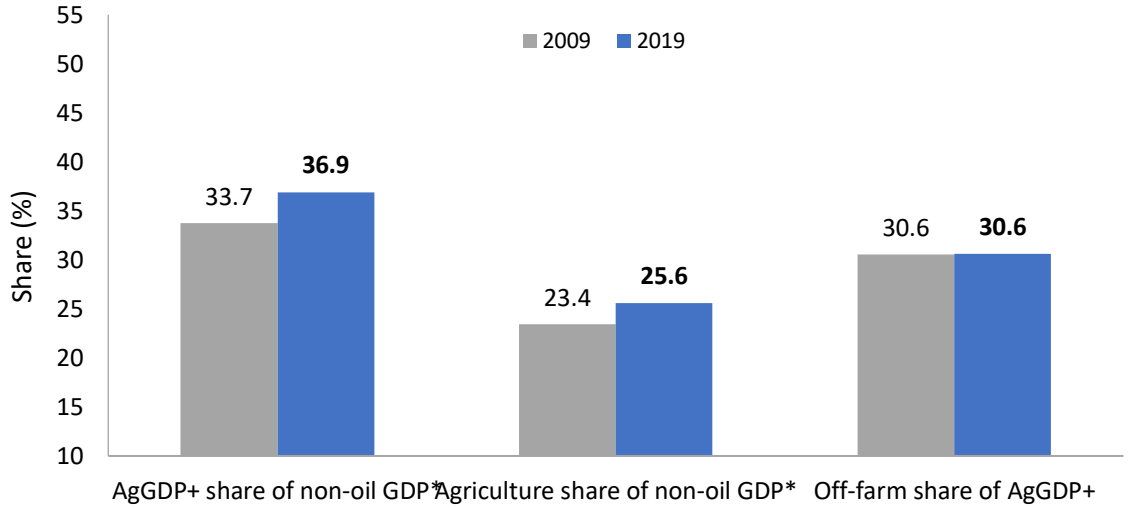
Figure 5. Drivers of PNG's AFS GDP growth (2009–2019)



Source: Authors' analysis using the 2009 and 2019 Social Accounting Matrixes for PNG (IFPRI 2023b).

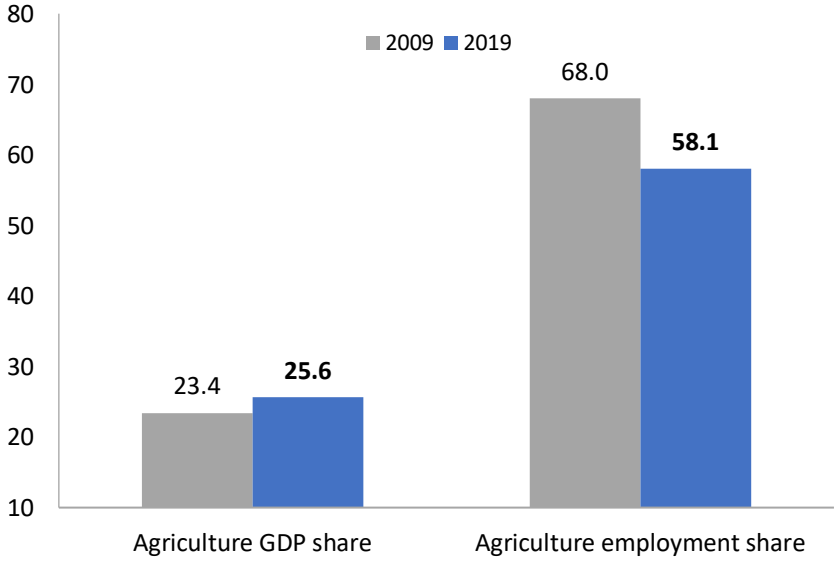
The shares of agriculture and AgGDP+ *in total GDP* declined between 2009 and 2019. However, considering only the non-oil and gas part of PNG's economy, the share of agriculture actually increased by 3.1 percentage points, from 33.8 to 36.9 percent between 2009 and 2019 (Figure 6). Thus, total agricultural income is actually increasing relative to the total non-oil economy. The share of AFS employment in non-oil employment also increased, (by 2.2 percentage points from 23.4 to 25.6 percent), (Figure 7). These data indicate that the typical structural transformation that normally accompanies economic growth is not occurring in PNG.

Figure 6: Shares of AFS and agricultural GDP in non-oil GDP and off-farm share of AgGDP+ in 2009 and 2019 (%)



Source: Authors' analysis using the 2009 and 2019 Social Accounting Matrixes for PNG (IFPRI 2023b).

Figure 7: Shares of agriculture in non-oil GDP and employment in 2009 and 2019 (%)



*Shares of non-oil/gas GDP

Source: Authors' analysis using the 2009 and 2019 Social Accounting Matrixes for PNG (IFPRI 2023b).

EVALUATING ALTERNATIVE AFS INVESTMENTS: A GENERAL EQUILIBRIUM ANALYSIS

IFPRI's Rural Investment and Policy Analysis (RIAPA) model is a tool for conducting forward-looking, economywide country-level analysis (IFPRI 2023a). RIAPA has been used in a wide variety of contexts to simulate the impacts of policies, investments, and economic shocks. Here we employ RIAPA to assess the effectiveness of productivity-led growth in PNG's different agricultural value chain groups for promoting multiple development outcomes. We considered four development outcomes:[2]

- A poverty–growth elasticity that measures the percentage-point change in the poverty headcount rate[3] per unit of agricultural GDP growth generated within the targeted value chain;
- A growth multiplier that measures the change in GDP per unit of increase in agricultural GDP in the targeted value chain;
- An employment multiplier that measures the change in the number of jobs created per unit of increase in agricultural GDP in the targeted value chain;
- A diet-quality indicator that measures the percentage change in a diet quality index[4] per unit of agricultural GDP growth generated within the targeted value chain; and

The simulations show the effects of an increase in on-farm productivity in individual value chains (shocking one value chain at a time). We then compare development outcomes across the value chains. While this exogenous productivity shock is imposed only in the primary agriculture component of each value chain, there are spillover effects into that value chain's off-farm components, as well as into other agricultural value chains or sectors outside the AFS.

Structural differences in production across value chains help determine the size of links to other productive sectors that supply or compete for use of intermediate inputs. Each sector also has unique links to rural or urban households in different income groups because of the types of workers they employ or the consumption preferences of households for the agrifood products produced by those value chains.

As such, each value chain growth scenario is expected to have a unique impact on the development outcomes; moreover, not all value chains will be equally effective at improving all outcomes. In some cases, there may even be trade-offs due to competition for resources across value chains. With the aid of the RIAPA model, these complex effects can be unpacked, thus providing information to governments or development partners that can inform value chain prioritization, subject to the development outcomes they value most highly.

[2] Because of a high correlation between impacts on poverty and impacts on hunger impacts across value chains, we do not report a hunger index score.

[3] Poverty is measured using the international US $2.15-a-day poverty line.

[4] The diet quality index is derived from the Reference Diet Deprivation (ReDD) index (Pauw et al. 2023).

Figure 8 shows the scores of selected major value chain groups analyzed here[5] for each of the four development outcome indicators. The value chains are ordered by their poverty score (i.e. the vegetable value chain is in the top row, followed by root crops, etc.).

Value chains clearly differ significantly in terms of their effectiveness in improving different development outcomes. For example, the root crops value chain group can be effective at reducing poverty but is relatively ineffective in improving diet quality. In contrast, the vegetables value chain group, is most effective at improving diet quality, but is less effective than poultry and cattle in increasing GDP.[6] These results highlight the possible trade-offs that emerge when prioritizing individual value chains, as no single value chain is the most effective at achieving every development objective. Promoting a few value chains jointly will not only diversify agricultural growth; it can also help to simultaneously achieve multiple development objectives.

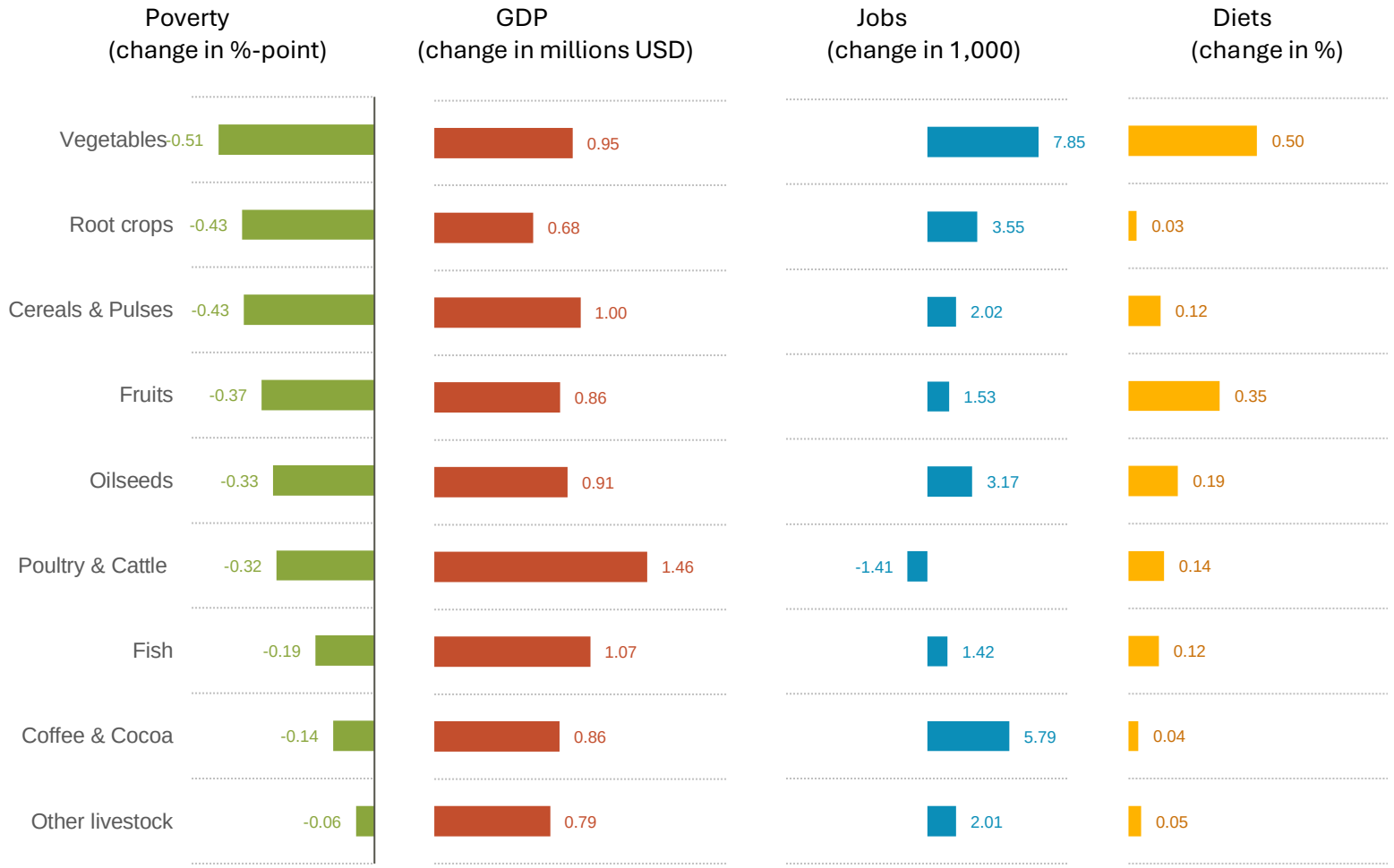
To help prioritize value chain investments, we also calculate a composite score across different outcome indicators. Since the different outcome indicators have different underlying units, the individual outcomes are normalized so that they are comparable while still retaining their ranking within the outcome category. Normalization entails assigning a score of 1 to the value chain that is most effective within an outcome category and a score of 0 to the least effective value chain.[7] The individual normalized scores for the outcomes are then combined into a composite score for each value chain. The default approach assumes that each of the four outcome indicators is equally important, so an equal weight is assigned to each score; however, if policymakers consider a particular development outcome to be more important than the other outcomes, the weights can be adjusted accordingly.

[5] In these simulations, the poultry and cattle value chains were combined and shocked at the same time. However, the fruits & vegetables group shown in Tables 2 and 3 has been split into separate “fruits” and “vegetables” sub-groups.

[6] Poultry and cattle are aggregated in this analysis, however previous research suggests that cattle may not be a good investment option for PNG (Vincent and Low, 2000).

[7] All value chains with adverse effects on an outcome are also assigned a score of 0. This includes value chains with a growth multiplier of less than one or those with negative employment effects. The remaining value chains receive a score between 1 and 0 that is proportionate to their original score relative to the highest-ranked value chain.

Figure 8: Impact of value chain growth on development outcomes*



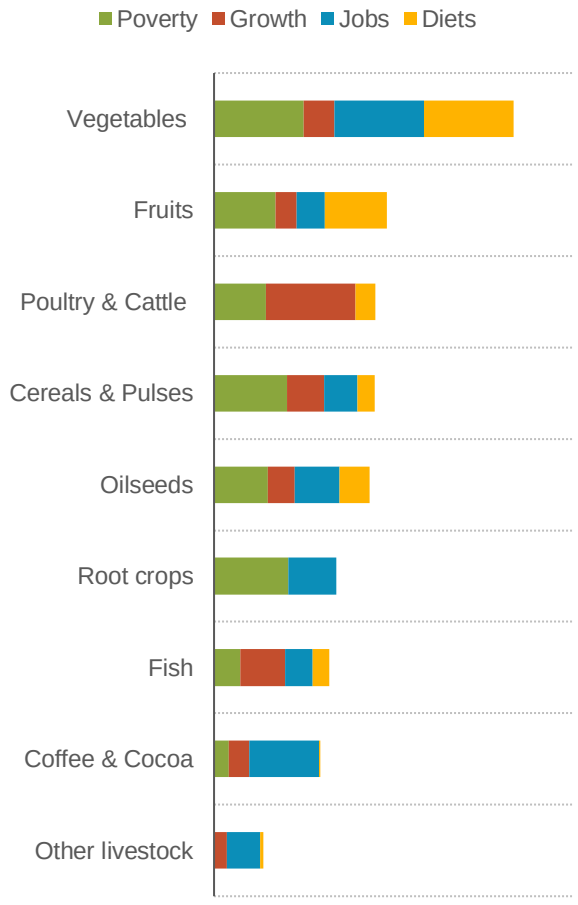
Source: RIAPA model results.

Note: Panel A shows the percentage point changes in poverty rate that are associated with a 1 percent increase in agricultural GDP; Panel B shows the percentage point changes in total GDP (in US$ millions) that are associated with a US$1.0 million increase in agricultural GDP from the targeted value chain; Panel C show the change in total economywide employment (in thousand persons) that is associated with a US$1.0 million increase in agricultural GDP from the targeted value chain; and Panel D is the percentage improvement in diet quality that is associated with a 1 percent increase in agricultural GDP. The value chains in the figure are shown in order of their poverty rate outcomes.

“Oilseeds” includes oil palm, coconuts, groundnuts and other sources of vegetable oil.

Figure 9 presents the composite scores using equal weights across the four development outcome indicators. Each component in the bars shows the relative contribution of a particular outcome indicator in the final score. For vegetables, the highest-ranked value chain, the potential contributions for all development outcomes per unit of growth in that value chain are significant, although since the sector is still very small it would have to expand significantly for these impacts to be meaningful in absolute terms. For poultry and cattle value chains, there is a large impact on GDP growth per unit of increased value of output, but very little impact on jobs. Thus, a moderate expansion of this sector would not contribute significantly to job creation, even though it could have important impacts on growth and diet outcomes. Since no value chain ranks highest in all development outcomes, trade-offs clearly exist as to which outcomes are most significantly affected by productivity-led growth in each value chain.

Figure 9: Impact of value chain growth on a composite score of development outcomes



Source: RIAPA model results.

Note: The composite score is a simple average (equally weighted) of the scores for each of the four outcome categories shown in Figure 8; In Figure 9, however, the value chains are shown in order of the composite scores.

"Oilseeds" includes oil palm, coconuts, groundnuts and other sources of vegetable oil.

SUMMARY AND CONCLUSIONS

PNG's economy grew rapidly at 6.6 percent per year in the decade prior to the COVID-19 pandemic. Although the agrifood system (AFS) did not grow as fast, it still achieved a respectable growth rate of 4.2 percent per year. Relatively rapid economic growth in the last decade has been accompanied by a significant structural change in the overall economy in terms of shares of GDP, as oil and natural gas revenues have increased and the share of agriculture in total GDP has fallen. However, the share of agricultural employment (another standard measure of structural transformation of the economy) has not declined significantly. Moreover, contrary to the usual pattern of economic growth observed in non-oil developing countries, agriculture's share of the non-oil economy has actually increased.

Within PNG's AFS, the growth rate for the off-farm component of the AFS was slightly higher than the growth rate in primary agriculture (3.0 and 2.9 percent, respectively). As a result, the off-farm components accounted for almost half of AFS growth in 2019, up from 43.8 percent in 2009. Almost all (72.5 percent) of this growth in PNG's AFS between 2009 and 2019 was contributed by less-traded value chains The large contribution from the group of less-traded value chains is explained both by its large initial size and above-average growth rate.

The RIAPA model-based comparison of future sources of growth shows that there is no single value chain group that is the most effective in achieving all desired development outcomes, that is, declining poverty, economic growth, job growth, and improved diets. The vegetables value chain ranks highest in terms of the composite outcome score, with significant contributions to all development outcomes per unit of growth in the value chain. However, this small sector would have to expand significantly for these impacts to be transformative at an economywide level. The fruits, poultry, cattle, cereals and pulses, and oilseeds value chains also rank highly, although they differ in terms of their relative effectiveness in achieving different development outcomes. For instance, fruits have important dietary impacts; poultry and cattle perform strongly on growth; cereals and pulses have strong poverty effects; and oilseeds can contribute significantly to employment. Jointly promoting several value chains therefore offers an effective way to achieve multiple development outcomes in PNG.

APPENDIX

Table A1: Value chain groups and their corresponding agricultural subsectors

Value chain group and share of AgGDP+	Individual products and their share of group's agriculture GDP
Maize and other cereals (0.8%)	Maize 81.3% | Rice 18.7%
Fruits (14.5%)	Bananas 32.3%|Other fruits 56.4%|Nuts 11.4%|
Oilseeds* (13%)	Oil palm 94.4%|Groundnuts 5.4%
Root crops (22.0%)	Cassava 6.6%|Irish potatoes 0.7% | Sweet potatoes 34.8% | Other roots 57.9%
Vegetables (8%)	Leafy green vegetables 14.7% | Other vegetables 85.3%
Coffee & cocoa (3.4%)	Coffee 69.7% | Cocoa 28.1%
Other crops (2.1%)	Sugarcane 12.3%|Other crops 77.5% | Rubber 10.3%
Cattle & poultry (4.9%)	Cattle meat 14.1% |Raw milk 10.7% |Poultry 71.1%
Other livestock (5.9%)	Small ruminants 12.3% | Other livestock 87.7%
Fish (12.0%)	Aquaculture 5.1% | Capture fisheries 94.9%
Forestry (15%)	Forestry 100%

* Includes oil palm, coconuts, groundnuts and other sources of vegetable oil.

Source: Authors' calculations based on the 2019 Social Accounting Matrix for PNG (IFPRI 2023b).

ABOUT THE AUTHORS

Xinshen Diao (x.diao@cgiar.org) is a Senior Research Fellow in the Foresight and Policy Modelling Unit of the International Food Policy Research Institute.

Paul Dorosh (p.dorosh@cgiar.org) is a Director in the Development Strategies and Governance Unit of the International Food Policy Research Institute, Washington, DC.

Luis Escalante (l.escalante@cgiar.org) is an associate Research Fellow in the Foresight and Policy Modelling Unit of the International Food Policy Research Institute.

Angga Pradesha (a.pradesha@cgiar.org) is a Senior Scientist in the Foresight and Policy Modelling Unit of the International Food Policy Research Institute.

James Thurlow (j.thurlow@cgiar.org) is a Director in the Foresight and Policy Modelling Unit of the International Food Policy Research Institute.

Junyan Tian (j.tian@cgiar.org) is a Research Analyst in the Development Strategies and Governance Unit of the International Food Policy Research Institute, Washington, DC.

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IFPRI is a CGIAR Research Center

1201 Eye Street, NW, Washington, DC 20005 USA | T. +1-202-862-5600 | F. +1-202-862-5606 | Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info