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Improving agricultural value chain coordination and gender inclusiveness in PNG

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INTRODUCTION

The welfare of Papua New Guinea's (PNG's) population depends on domestic agriculture productivity and stability. As of 2019, value-added from the agriculture, forestry, and fishing sectors totaled approximately 17 percent of GDP. However, when considering the downstream value chain activities directly related to the agriculture sector (e.g., agriculture processing, domestic food trade and transportation, and domestic food commodity sales), the larger agri-food system in PNG contributes over 25 percent to the country's overall GDP (Pradesha and Dorosh, 2022).

Maximizing efficiency throughout the entire agri-food value chain is critical to fostering greater economic growth and poverty reduction within the country. Growing a globally competitive agriculture sector also demands investments and capacity strengthening in mid-stream value chain operations such as product aggregation, transport logistics, packaging and processing, and handling. It is important that these investments also promote *inclusive* development that benefits both men and women value chain actors. Previous research suggests that where women are economically empowered and have access to decent jobs in lucrative nodes (i.e., activities) of value chains, households have higher incomes and are less likely to be poor (FAO, 2011). In PNG, despite women's greater share of employment in agriculture (60 and 52 percent of women and men work in agriculture, respectively), women participate less in higher-value agricultural production and trade activities (Chang et al., 2016; Omot, Chambers, and Spriggs, 2013; World Bank, 2022).

This study is meant to guide policymakers and stakeholders toward ways to improve productivity, increase revenue, and bolster competitiveness and inclusiveness within the agriculture and livestock sectors. We do so in three main stages.

First, we undertake a detailed review of 3 key value chains: poultry, sweet potato, and fresh vegetables. The three selected value chains collectively capture the country's interests in import substitution (poultry), domestic supply (sweet potato), and export promotion (fresh vegetables). We draw on existing research to outline a detailed picture of how each of these value chains operates, as well as how individuals are benefiting or failing to benefit within each. We find that the booming demand for poultry in PNG is unmet by the lagged domestic poultry supply, of which the primary constraints are restrictive input costs and lack of critical infrastructure. The sweet potato and fresh vegetable value chains face constraints further downstream in the value chain, where poorly coordinated supply, aggregation, transport, and packaging processes decrease efficiency throughout the supply chain. There is a high level of individual farmer involvement across all nodes of both sweet potato and fresh vegetable value chains, resulting in poor specialization of each actor along the value chain.

Second, we carry out a comprehensive literature review on women's participation in agricultural value chains. We draw out information on women's involvement in various nodes within each value chain as well as the barriers women typically face to benefiting fully from participation at various nodes. The existing literature reveals more information about women's involvement in some value chains (sweet potatoes) than others (poultry and fresh vegetables) and suggests that often, it is not women's participation per se, but rather the extent to which they can benefit from lucrative nodes within the value chain, that matters most.

Third, we analyze survey data to provide a more complete microeconomic basis for understanding investment opportunities and policy priorities to generate inclusive growth within the agriculture sector. We use the 2009-10 PNG Household Income Expenditure Survey (HIES) and the 2018 Papua New Guinea Rural Household Survey on Food Systems (RSFS) datasets to analyze the broad patterns of both men's and women's economic participation in these value chains. In doing so, we further consider what women's economic participation more generally predicts for household welfare in PNG. Analysis suggests that women's economic participation is associated with greater participation of women in household decision-making as well as improvements in household welfare on a variety of dimensions. Gender norms opposing women's economic participation, however, decrease the likelihood of women informing household decision-making.

Our study concludes with recommendations for improving economic opportunities in the agriculture and livestock sectors.

ANALYTIC APPROACH AND DATA

We begin with a review of existing literature to explain how the poultry, sweet potato, and fresh vegetables value chains operate at various nodes, and how women and men are involved (often in different ways). This provides a foundation for subsequent analysis – through both descriptive statistics and regression – of two household survey datasets.

The first dataset we utilize is the 2009-10 PNG Household Income Expenditure Survey (HIES). While this survey is dated, it is the most recent nationally representative dataset available from PNG on individuals' employment activities. The survey interviewed 4,191 households nationally, collecting data on both women and men's roles in value chains and their attitudes. It additionally captures household decisions (e.g., which household members make decisions related to asset ownership and consumption), men and women's employment activities, and attitudes toward domestic violence, among other modules.

The second dataset we employ is the 2018 Papua New Guinea Household Survey on Food Systems (RSFS); it is an original, multi-topic survey conducted during May–July 2018, implemented by the International Food Policy Research Institute (IFPRI). The survey covered 70 communities in four lowland areas of PNG: East Sepik, West Sepik, Madang, and the Autonomous Region of Bougainville (ARoB). Among others, it contains modules we analyze in this study on household characteristics; agricultural production; assets; non-agricultural income; consumption and expenditures; and gender roles and attitudes (IFPRI, 2018).

This study will be subsequently augmented by a third dataset of original, qualitative surveying efforts to be carried out in select areas of PNG in September 2022 (after national elections), focused on the poultry value chain – where relatively less evidence is available from our existing quantitative surveys, relative to the fresh vegetables and sweet potato value chains. The qualitative interviews will focus on 4 nodes of the poultry value chain: 1) mini-mill feed owners and operators; 2) farmer customers of mini-mill poultry feed; 3) retail owners and operators that buy and sell mini-mill feed; and 4) mini-mill input suppliers (farmers that supply sweet potato to the mini-mill for feed production). These interviews will allow more in-depth insights of rural poultry farm production and associated value chain nodes across different areas of the country.

OVERVIEW OF THREE KEY VALUE CHAINS: SWEET POTATO, FRESH VEGETABLES, AND POULTRY

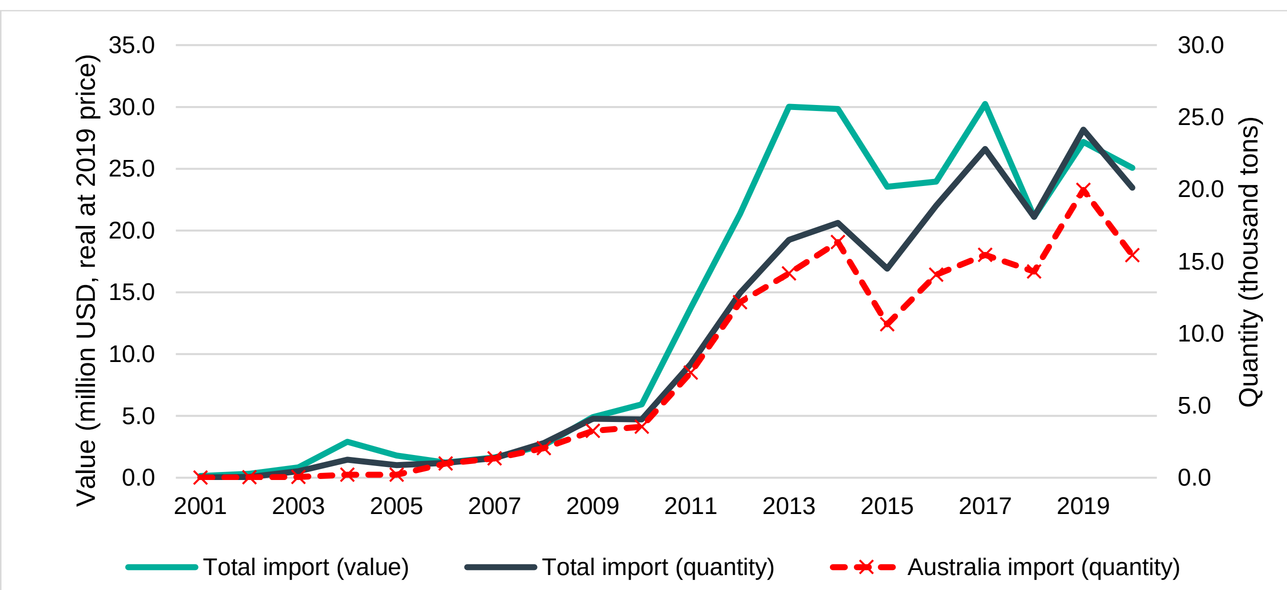
Value chain mapping and opportunities for improved sector development

Given the importance of sweet potato production for domestic food security; the opportunity of domestic poultry production for increasing domestic protein consumption and decreasing import dependence; and the prospect of fresh vegetables to move beyond domestic marketing to wider export markets, we evaluate each of these value chains, in turn, to identify bottlenecks and opportunities to achieving greater efficiency, productivity, and competitiveness. The following section provides a detailed mapping of each value chain, highlighting recent and ongoing studies to promote greater value chain efficiency. After each value chain mapping exercise, we provide a discussion on potential opportunities for improving (e.g., decreasing costs, supporting greater inclusion, enhancing product quality and quantity) the respective value chain operation.

Poultry value chain

Rapid growth in the PNG economy and population has created higher demand for animal-sourced foods such as pork, poultry, and eggs. The import value of poultry meat increased from 4.9 to 27.2 million (real 2019) USD between 2009 and 2019 (Figure 1). One reason for the rapid increase of poultry meat imports is the comparatively high price of domestically produced poultry meat in PNG (retail price in PNG in 2019 was about $8 per chicken; 4.2 $/kg for live weight; and 5.7 $/kg for dressed weight). In Indonesia, the retail price of live chicken was 1.5 $/kg in 2019, about one-third the price in PNG (USAID, 2013; Mehta and Galgal, 2019; Nugroho, 2020). This suggests there may be an opportunity to improve efficiency of domestic poultry production, processing, and marketing in PNG to better meet domestic demand and reduce unit costs.

Figure 1: Value (Real 2019 USD, in million) and quantity of poultry imports (2001-2020)

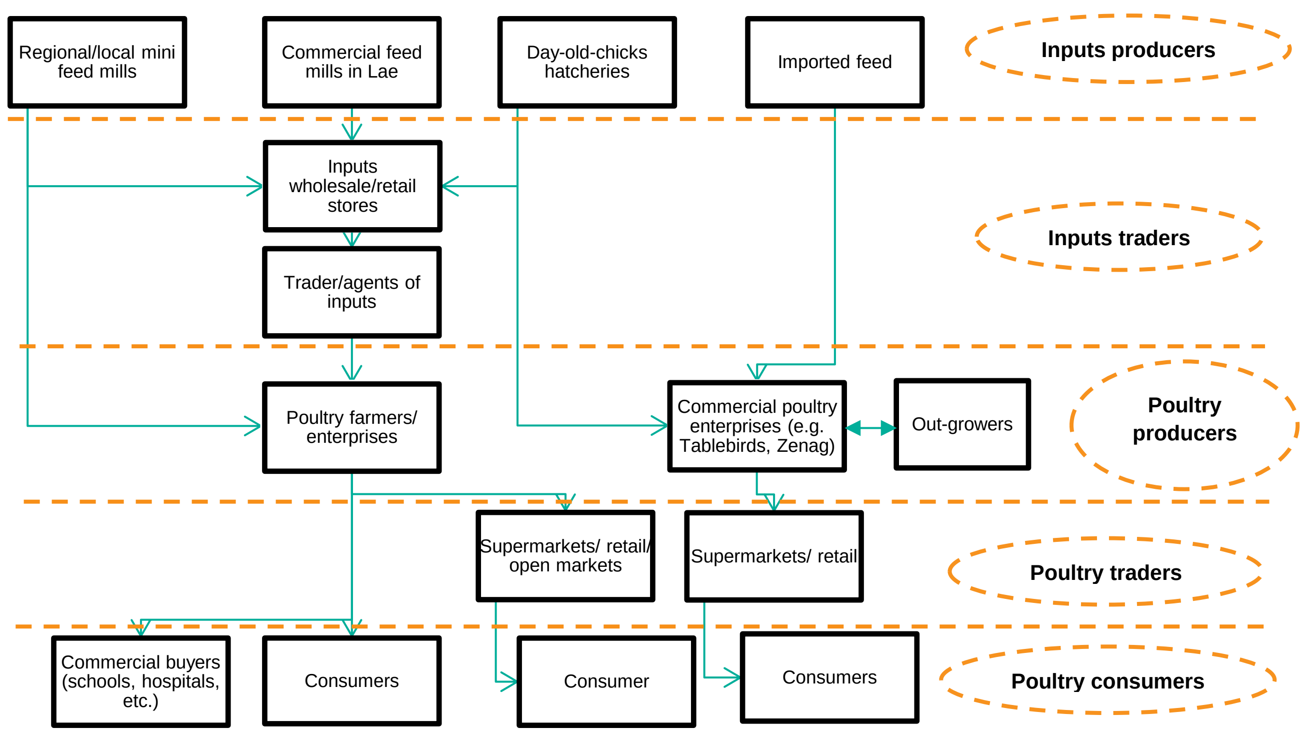


Source: Authors’ calculations using BACI International trade database at the product level (2022)

While animal-sourced food imports continue to increase, the average consumption of protein foods in PNG remains insufficient to meet nutritious diet guidelines, especially in rural areas. Data from the RSFS (2018) reveal that about half of the rural sample in Momase region consumed less than the recommended protein quantity (Schmidt et al., 2020). NARI has highlighted the need to support research aimed at increasing economic returns to value chain actors from production, sale, and added value of livestock. For the poultry value chain, NARI is targeting micro and small poultry enterprises to support effective linkages to rural markets and consumers.

As a first step to better understanding the opportunities and constraints to greater domestic poultry supply, we map each value chain actor and their respective linkages with other actors in the supply chain (Figure 2). For poultry, we focus primarily on broiler chickens, which is the most popular chicken produced, consumed, and imported in PNG (Mehta and Galgal, 2019). Each actor is categorized into one of four key value chain segments. These segments include: input producers, input traders, poultry producers, and poultry traders.

Figure 2: Poultry value chain mapping in Papua New Guinea.



Source: Drawn by authors.

The primary poultry input (day-old-chicks (DOC) and livestock feed) market is dominated by two major suppliers, Zenag and Tablebirds, that are both located in Lae. Tablebirds produces poultry feed at each stage of the poultry growth process while Zenag imports livestock feed from Australia. These two commercial producers manage every node of the commercial poultry value chain, whereby they contract poultry out-growers and supply them with DOC, feed, and necessary training to ensure quality poultry rendering. About 70 and 50 percent of the production of Tablebirds and Zenag, respectively, are supplied by out-growers. According to Mehta and Galgal (2019), Tablebirds contracted with 341 out-growers in 2018.

At chicken maturation, these companies collect the live birds, and proceed to process and sell the processed chicken to supermarkets and other retailers. Although these producers / input suppliers are predominantly oriented toward commercialized poultry production, they also sell feed (in the case of Tablebirds) and DOCs to independent input retailers that supply to traders and independent farmers. While the out-grower model of poultry production is efficient given that the commercial-oriented companies are vertically integrated and managed by a single entity, poultry inputs and poultry supply are geographically constrained because the primary suppliers (Zenag and Tablebirds) are solely located in Lae.

Smaller input suppliers are developing in Mt. Hagen and Western Province (e.g., Innovative Agro Industries PNG), however these remain nascent, with the Western province industry significantly subsidized by OK Tedi Development Foundation. Households and communities further from Lae face greater costs for poultry production, quickly outweighing the benefits of wider domestic production. Thus, outside of the surrounding areas of Lae, most poultry production is small scale and oriented towards subsistence or low-volume wet market sales.

Poultry value chain actors that are supplying chicken to a wider share of the population (small-scale, independent poultry producers) are still reliant on major companies and retailers for input supply. The majority of DOC in the country are supplied to retail stores by Zenag and Tablebirds. Beyond the limited competition to supply DOC to the market (which may contribute to higher costs), input retailers have reported significant challenges in securing a reliable and adequate supply of DOC. In addition, input retailers face high mortality of DOC upon arrival due to poor transportation conditions. Transportation costs (as well as supply risk and mortality) increase with distance from Lae.

Regardless of feed brand, all stock-feed production relies on imported grains and concentrates, whereby pricing is subject to import tariffs and other government policies. While independent poultry farmers have the option to purchase directly from feed mills at a lower cost compared to rural and secondary town retail outlets, these mills are oriented toward larger volume sales and have a minimum required purchasing amount (e.g., around 70 tons per month).

Moving beyond input producers and input traders in the value chain, independent poultry farmers also face specific constraints to expanding their business on-farm. A lack of agricultural extension to improve poultry output and quality is stunting overall performance in the sector. Most rural poultry production (oriented at small markets) remains informal, with limited to no veterinary assistance or disease surveillance. Chickens may not be enclosed, which leads to several risks including death from prey as well as greater risk for chicken-to-human disease contraction. Recent research has demonstrated a greater incidence of child disease due to contamination from the presence of poultry in a variety of developing countries (Headey and Hirvonen, 2016). According to Mehta and Galgal (2019), the most successful small-scale poultry farmers are directly or indirectly linked with an external agency providing extension services and facilitating access to inputs. These farmers, on average, raise 50-100 chicken in a cycle, and predominantly sell live birds to nearby markets.

While the largest constraints in the poultry value chain are located in the poultry input node, poultry processors and traders also face bottlenecks which directly affect decisions on output volume. Small-scale poultry processors that have invested in processing equipment to produce packaged meat for supermarkets incur significant risk due to unreliable electricity. Given unpredictability of electricity, farmers are reluctant to invest in greater poultry production capacity because they are unable to reliably process, flash freeze, and store processed poultry. This has led semi-commercial farming entities to scale back available production capacity. Scaling back has indirect cost implications because the semi-commercial farmer is unable to purchase the minimum required bulk feed volume to access lower costs of feed directly from the feed mill. Hence, throughout the poultry value chain, costs increase as inefficiencies mount.

To address processing bottlenecks, supermarkets in PNG have invested in processing capacity, and prepare and package meat for their respective outlets. While this is a solution for poultry supply to large supermarkets (and urban populations), this is less viable for smaller commercial entities. In addition, supermarkets taking on processing roles side-steps an important value-added opportunity for peri-urban entrepreneurs to access revenue sources and further specialize in downstream product output.

Opportunities to improve poultry value chain linkages and output

To increase the economic viability of poultry production outside of Lae, local governments and the poultry industry will need to support expansion of poultry clusters in other economic centers. Both Tablebirds and Zenag are evaluating options for regional hatcheries to promote DOC production and feed branches outside of Lae. In addition, smaller input suppliers such as Innovative Agro Industries (in Western province and Mt. Hagen) should be evaluated to understand what support structures are needed to jumpstart nascent poultry industries that are further from Lae and will require logistical support for feed inputs and other infrastructure. A variety of analysis in other developing countries have tailored a cluster development approach for the poultry sector to ease the constraints for producers and traders. These clusters are designed and evolve to facilitate input procurement (e.g., farmers association that can order bulk inputs to distribute among farmers); access to credit and additional capital (generator/electricity, chillers); veterinary services; information sharing and technical training; among other services (Long and Zhang, 2011; Zhang, Moorman and Ayele, 2011; Zhang, Chen and Fang, 2019).

The PNG government could consider investing in feasibility studies (learning from input branch development proposed by Zenag and Tablebirds, and Innovative Agro Industries) to inform investment location priorities and appropriate models for cluster development (if proven applicable). A cost-benefit analysis (in collaboration with the private sector and a national research institute, e.g., NARI) of starting and running a rural, branch level input production facility may be a good first start. In addition, these studies should include consultations with value chain actors, local businesses and local government actors to identify locally appropriate methods for building a rural value chain network that insures positive revenues, sustainable re-investment, and upstream, midstream and downstream transparency and reliability of: key infrastructure investments; actor coordination; and grading, processing, packaging and pricing final output for sales.

While commercialized poultry production must focus on profit maximizing operations, a feasibility study of rural poultry cluster development should include the costs and benefits of food and nutrition security objectives given the current low levels of protein consumption throughout the country. These objectives will likely need to be subsidized in the short to medium term, and will thus require local government participation during planning, as well as built-in incentive systems for success (see discussion of shared tax revenue incentives in Zhang and Hu (2014)). In addition, and discussed in further detail below, these studies should seek to understand how best to integrate rural women laborers and managers into different nodes of the value chain, as their participation could have important multiplier effects on overall wellbeing in rural households.

Given the lack of poultry input markets in rural and small-town areas throughout PNG, the entire poultry value chain (outside of the vertically integrated commercial enterprises in Lae) is likely to remain trapped in a low-level equilibrium characterized by low productivity, no growth, and limited job creation. Currently, there is no incentive for new investors to go into areas with limited infrastructure only to face overwhelming costs associated with first entrants. To address this constraint, local governments, donors, and NGOs in these areas may need to provide financial incentives (e.g., tax incentives, financial credit support, and an improved enabling environment via poultry grower cluster support) for initial infrastructure to improve value chain function, coordination, and efficiency.

While supporting greater expansion of large commercial operations to previously undersupplied regions of the country will be a necessary component of decreasing poultry value chain costs, small-scale, semi-commercial, and subsistence poultry rearing should also be supported. NARI, in collaboration with ACIAR, has developed a mini feed mill model that uses local ingredients such as sweet potato and cassava to produce livestock feed. Assuming success, these mini feed mills would reduce feed costs, improve returns for farmers, and create diversified job opportunities for rural farmers.

Mini mills use small scale equipment to cut, grind, dry, mix, and pellet local raw ingredients into feed. NARI has piloted several trials (Glatz, 2017) of domestically produced poultry feed and has produced practical manuals for running such mini mill businesses (Glatz, Barekatain, *et al.*, 2018; Glatz, Black, *et al.*, 2018). Despite the reported positive results from the NARI trials, the interventions of mini mills remain localized within the pilot project areas, sometimes discontinuing after project completion (Mehta and Galgal 2019). Developing larger, commercialized feed mill operations from the mini mill concept would be technically difficult given that the primary inputs for the local feed are sweet potato and other tubers that spoil more rapidly. Greater spoilage (compared to grain-based feed) will require that demand for mini mill feed is well established to produce, distribute and utilize mini mill feed output in a timely manner.

According to Glatz (2017) and Mehta and Galgal (2019), there is a lack of value chain studies to understand the feasibility of local mini feed mills in PNG. While the mini feed mill model has the opportunity to draw in greater local labor, as well as provide indirect benefits to sweet potato and other tuber farmers supplying the mill, mini feed mill operations will still need to secure adequate and stable supply of imported ingredients (e.g. purchases of agro-industrial by-products and pre-mixes/ concentrates) to meet industry feed nutrient standards. A detailed cost-benefit analysis that includes development targets (such as improved nutrition and diversified labor opportunity) should be the first step to identifying whether these programs can be expanded throughout different regions of the country.

Sweet potato value chain

A commonality across the three study value chains in this paper is their respective shortness, characteristic of few specialized nodes and lesser trade distance—with sales occurring primarily in local wet markets and with small retail sellers. The sweet potato value chain provides a clear example of the opportunity for improvement in volume, quality, efficiency, and specialization along the value chain at all nodes. While the demand for sweet potato has increased in rural and urban areas of PNG[1], the majority of sweet potato supply and sales remain location-specific (Chang, 2017a; Brown *et al.*, 2019).

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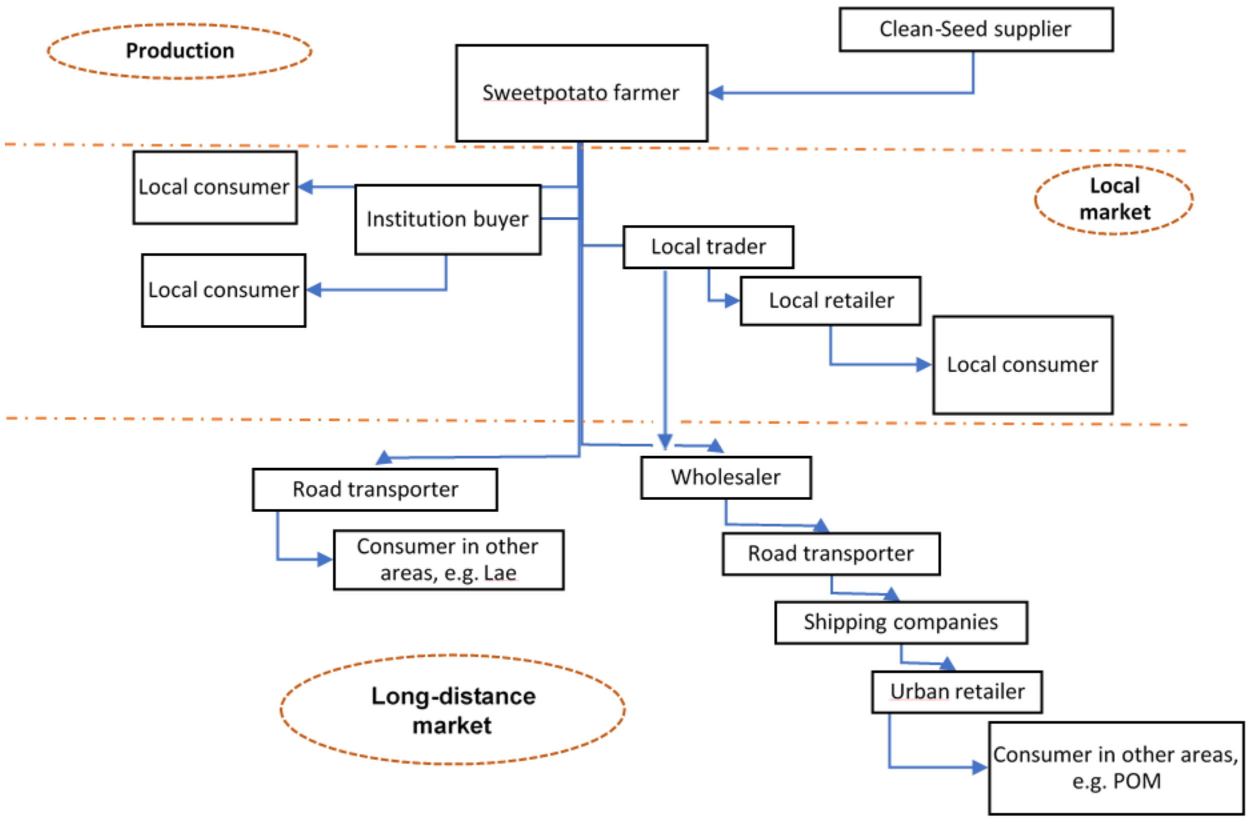
1 According to Fujinuma et al., (2018), due to population growth and greater urban demand, fallowing on sweet potato gardens has decreased from 12.1 to 6.3 years between 2005 and 2014.

Figure 3 maps the sweet potato value chain actors from production to retail market consumer. Focusing on the producer segment of the sweet potato value chain, a lack of agricultural extension, financing, and technological adoption in tandem with the subsistence-oriented nature of sweet potato have resulted in sub-optimal output for many sweet potato farmers. Sweet potato is vegetatively propagated, whereby farmers use the planting materials from previous crops to establish a new crop at no financial cost. While this is attractive to farmers in low-income countries, this repetitive practice for sweet potato production in PNG has led to a build-up of vine disease (from viruses acquired and transmitted from harvest to harvest), resulting in declining crop productivity and diminished crop quality over time (Gurr *et al.*, 2016; Okrupa *et al.*, 2017; Mwiti *et al.*, 2020).

Figure 3: Sweet potato value chain mapping in Papua New Guinea.



Source: Drawn by authors.

A relatively new (to PNG) value chain node has been introduced and developed to supply 'clean-seed' sweet potato vines to farmers. This clean-seed production node has several advantages beyond supplying virus-free planting material. First, given that sweet-potato is predominantly grown and sold by women, this value chain enhancement potentially provides direct benefits to women via improved linkages to technology and innovation; diversified job creation for clean-seed development and sales; and increased production output and household revenue (assuming clean-seed sweet potato can be marketed to external locations to avoid product surpluses and associated price decreases in local markets). Second, assuming that clean-seed sweet potato can be graded, labeled, and marketed to urban markets, more reliable surplus may free up producers to focus on other types of value-added retail demand (such as livestock feed inputs, processed sweet potato products, etc.), generating a virtuous feedback loop that continues to promote quality and expand employment throughout the value chain.

While remote farmers may not have the market demand to pay for clean-seed sweet potato production, producers that are more connected to intermediate and commercial outlets are looking for stable markets that provide consistent prices for better-quality produce. Due to a large number of sweet potato farmers in the Highlands, local markets can quickly become saturated, resulting in low output prices and inadequate income for rural producers. The current lack of retail-oriented production has also sustained quality gaps in post-harvest management, leading to significant product loss and low output quality (Spriggs, 2005; Chang, 2017a).

As the marketed distance of sweet potato lengthens, the sub-optimal post-harvest practices become more acute. First, the majority of smallholder farmers are unaware of the standards and benefits of good post-harvest practices due to gaps in communication between rural producer and (formal) urban retailer. Very little agricultural extension has been implemented to support practices that will meet retailer requirements. Second, it is unclear if rural farmers reap significant benefits from improving their production and post-harvest practices given that other quality enhancing constraints (e.g., proper handling, storage, transportation, and marketing infrastructure) within the value chain must be simultaneously addressed to ensure reliable quality supply upon arriving at final destination. Thus, producers place a greater importance on least-cost inputs to meet subsistence production output (with surplus to local markets) as the primary emphasis of production activity.

Focusing on the long-distance market segment of the sweet potato value chain, information asymmetries between producer, trader, and retailer cause significant distrust among value chain actors, resulting in a lack of specialization across all nodes (Chang *et al.*, 2016). While the production and sales of sweet potato is dominated by female labor, the intermediate trade and transport of sweet potato are characterized by male labor given heavy lifting requirements of sweet potato bags (approximately 60-100 kgs per bag) and insecure traveling conditions. After sweet potato is packed into poly stock feed bags at farmgate, it is picked up from the village by trucks or public motor vehicles (PMVs), and dropped off alongside the Highlands Highway. Produce is then reloaded onto semi-trailers traveling to Lae, where a share of produce is sold to Lae and surrounding markets. Produce destined for Port Moresby or other locations, unreachable by local transport, is then unloaded and re-loaded again onto shipping containers at the wharf and transported to other urban areas by boat. There is limited training, materials, or incentives to ensure quality during packaging and handling in any of the loading and unloading activities within the sweet potato value chain.

If produce is destined for Lae and surrounding areas, many producers (husband, or wife and husband) transport their own produce to market, bypassing transport and trading actors in the value chain. While farmers that engage in long-distance sales of sweet potato may receive higher unit prices at the final market, they also incur significant costs including: transportation, accommodation, marketing, and handling fees, as well as opportunity costs of their time. Those that do not transport their goods to the final market lack the necessary influence to negotiate prices with transporters, traders, and wholesalers given that farmers are frequently negotiating as sole actors rather than as a producer group (Chang, 2017a).

Opportunities to improve sweet potato value chain linkages and output

Farmers are generally as efficient in their production practices as they see fit to ensure they earn a positive revenue (whether subsistence or marketed). The current delinked segments of the sweet potato value chain are thwarting efforts to increase output, improve quality and enhance value chain efficiency. PNG is not unique to these challenges, and there is an opportunity to learn from other countries how to strengthen the value chain interactions of staple crops sold in domestic markets. Zhang and Hu (2014) demonstrated a detailed example of how a local potato trade association in Anding County (China) was created to support member farmers with extension, inputs, enhanced communication, and real-time price information to foster trust among value chain actors and promote greater value chain integration. Anding county is now a top potato producer in China.

The Anding association organized key members from each node of the potato cluster to communicate with several downstream (or upstream) nodes and become representatives to share information. Appendix 2 shows the Anding county potato association mapping and communication links between members. For example, several potato farmer representatives at the township level act as local sales representatives, whose primary task is to set up potato collection stations, and purchase potatoes from agents or farmers from village level. They then sell the produce to larger wholesalers or traders from elsewhere. Simultaneously, these farmer representatives report back to the township farmers within the association about price trends and other relevant information. Another set of farmer representatives engage directly with the regional trading center (one node beyond the collection stations and county wholesalers and traders). These representatives also report back to the farmer group about prices, trade trends, regional demand and other issues between the production node and regional bulk trading center. The built-in communication and reporting of demand and price trends from farmer producer level to regional trading center decreased information asymmetries throughout the value chain.

The case study presented by Zhang and Hu (2014) underlined the high cost of doing business with individual farmers, echoing similar hurdles that PNG traders face related to unreliable supply and inconsistent quality. For smallholder farmers, the potato association provided a foundation to work as a group to better coordinate trade interactions, lobby for improved handling and transport procedures, and increase bargaining power with traders and wholesalers. Building such an association in the PNG highlands would need to be designed with participating communities in order to address local needs and challenges. This would need to be piloted, improved upon, and redesigned to meet evolving needs. In other words, this endeavor would be a medium- to long-term process. For example, the Anding county potato trade association started with only 30 members in the first year and attracted more than 3,000 members in the 6th year.

In addition, local government support may be an important component to long-term growth of value chain output in rural areas. For example, the Anding county government supported the establishment of a local wholesale market when the supply of potato increased beyond local demand (driving potato prices downward) due to value chain improvements. The Anding potato association and the local government played a critical role during the development of the potato cluster because both entities were able to support a system-wide approach that could evaluate the entire value chain and its function, rather than a specific node within the value chain.

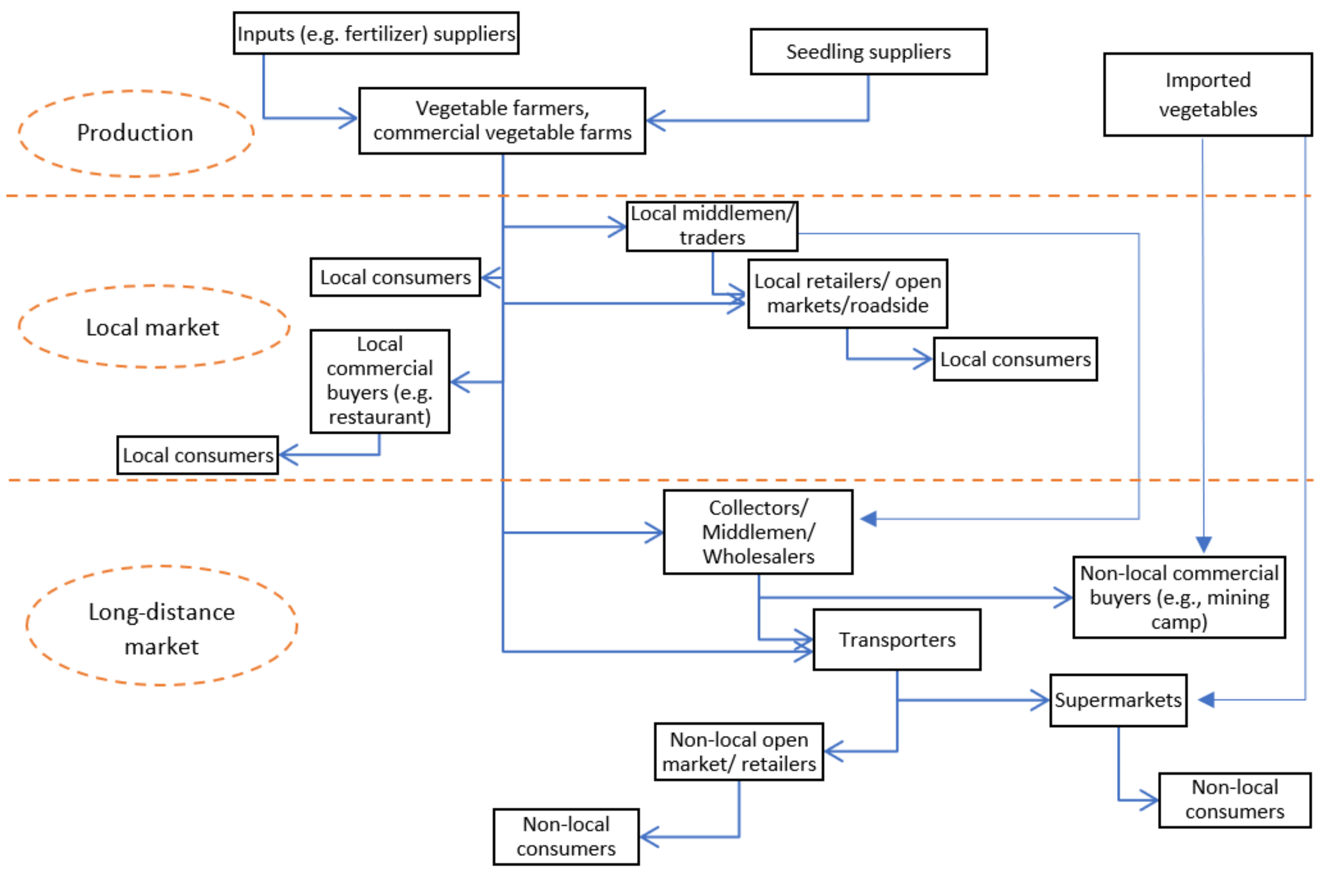
While sweet potato demand may be increasing in urban areas, if rural farmers do not perceive a market outlet for surplus or do not foresee a sufficient return (income stream) for their sweet potato, it will be difficult to convince farmers to take on more costly production practices such as clean-seed sweet potato. The opportunities to expand quality and reliability of sweet potato supply are available in PNG, and it should be evaluated whether some of the areas identified for clean-seed production could serve as initial nuclei to improve linkages throughout the value chain. Feasibility studies of different modalities (e.g., association, lead firm, public-private partnership) of improving value chain coordination could seek to identify the most appropriate sector and entry-point for strengthening incentives across all value chain actors to promote improved coordination.

Fresh vegetables value chain

The Government of PNG aims to increase food commodity exports, including fresh fruits and vegetables, as an avenue to support agriculture as an economic growth engine for the country. PNG has the agro-ecological potential and land area to become competitive in regional export markets. In addition to nascent export demand, domestic demand for fresh fruits and vegetables is growing as household welfare improves and nutritional knowledge continues to expand within the country. A recent analysis by Schmidt et al. (2022) suggests that a majority of the PNG rural household sample does not consume sufficient fresh vegetables and fruits to meet nutritional guidelines for healthy living standards.

Figure 4 maps the fresh vegetable value chain in Papua New Guinea. The Highlands region (with more temperate climates) supplies the majority of fresh produce to Lae and surrounding peri-urban markets, as well as Madang and Sepik markets (PHAMA 2016). The Central province production areas have emerged to supply fresh produce to Port Moresby wet markets and supermarkets given its proximity and comparatively low logistical hurdles to transport goods on road from farmgate to final destination market (Birch et al., 2014).

Figure 4: Fresh vegetable value chain mapping in Papua New Guinea.



Source: Drawn by authors.

The fresh produce value chains in Central and Highlands province, respectively, are characterized by the transportation logistics required between farmgate and market consumer. Central region farmers that are supply urban Port Moresby (POM), however, still face mid-stream value chain hurdles whereby formal aggregation, trade and wholesaling at rural collection centers are not common.[2] While some aggregation of smallholder farmer output occurs on roadsides outside of POM urban markets, most aggregation activities occur at market gates where farmers sell to middlemen or market vendors who then sell to final consumers. While this allows for more producer control over revenues, the producer must independently package and transport (usually informally on PMV or truck with no infrastructure to preserve quality – e.g., cold storage, proper handling) goods to the market.

In addition, the POM market gate sales (from producer to aggregator or trader) are predominantly informal and opportunistic (when surplus is available), with no long-term contracts or incentives for farmers, transporters, or traders to ensure quality for future long-term sales relationships. While some entrepreneurial farmers have expanded their business by collecting vegetables from other farmers within the village before selling to traders, this is less common than direct independent smallholder production and sales. In addition, a selection of transporters (PMV owners/drivers) occasionally play the role of middlemen, however these individuals are generally not formally contracted by a supermarket (downstream) or a farmer group (upstream), and also represent short-term or one-off transactions that do not incentivize quality assurance at any node of the value chain.

Larger commercial farms (e.g. Pacific Adventist University and Innovative Agro Industry) have emerged during the last two decades in Central Province and peri-urban POM, with the majority of their output oriented towards formal supermarkets. These larger commercial growers have greater access to credit and capital to finance production supply, as well as greater market strength and production practices to meet quality demand of urban consumers. Similar to the sweet potato value chain discussion, urban retailers are less interested in working with multitudes of smallholder farmers that provide unreliable quality and quantity supply (Chang et al. 2015; PHAMA 2016). Hence, the fresh produce value chains could potentially benefit from a well-organized association that can collect, grade and sell bulk produce of smallholder farmers for greater added value and sales to commercial supermarkets. A transparent grading system, based on supermarket quality demand, could support improved quality output which will be needed to attract regional export demand as well.

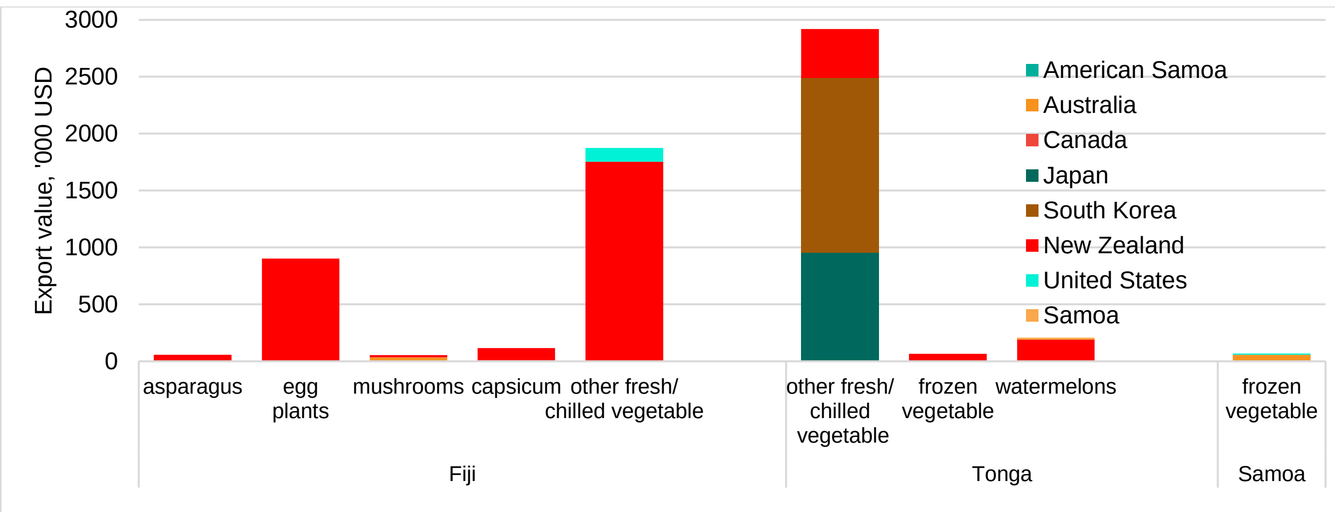
In comparison to the Central province vegetable value chain, the Highlands fresh produce value chain is longer (i.e., has more specialized nodes), however confronts greater challenges of packaging, processing, and transport for commercial market retail. A major disadvantage to Highland farmers is their relative remoteness (even when connected to a rural feeder road). For example, the road/sea journey from the Highlands to POM via Lae usually takes about 10 days (Bonney, Worinu, and Muscat 2012), whereby limited to no cold storage or transport is available. There are very few refrigerated crates on shipping boats, with long port waits that increase wilting and spoilage of fresh vegetables (IFC, 2021). An increasing number of traders (including local collectors and larger wholesalers) are aggregating vegetables from the Highlands and selling to other larger cities (some transporters also play

2 There are also peri-urban production areas of Port Moresby (in Central province), however these areas are not a sustainable nor expandable solution to supporting greater fresh produce marketing due to limited land size (many smallholder gardens are less than 0.5 hectares), insecure land tenure, and increasing soil erosion.

the role of traders), suggesting that specialization is occurring within this value chain. However, similar to Central province, there is no coordination among value chain actors to ensure quality produce from farmgate to market.

International trade data suggest that there is potential for greater export of fresh vegetables to surrounding countries in the region. Currently, Fiji and Tonga are leading exporters (among the small Pacific Island countries) of perishable produce, primarily to New Zealand and Australia (Figure 5). Analysis by PHAMA (2016) evaluated export potential of PNG highland production areas and identified comparative advantages in producing a variety of vegetables including asparagus and chilis. In addition, Australia has stated interest of importing capsicum from PNG. However, the feasibility study concluded that the PNG fresh produce sector is not export ready (PHAMA, 2016), with high production cost (i.e. immature fresh produce value chain) being one of the main factors. In addition to improved transport and logistics, a transparent and internationally recognized biosecurity policy and infrastructure, with ongoing monitoring and auditing, will need to be in place to attract significant regional import demand for PNG fresh produce products [3].

Figure 5: Average (2014-2018) real (2018) value of main perishable produce exported by main exporters (Fiji, Tonga and Samoa) in Pacific Island countries, by importing country



Note: The trade values smaller than 10,000 dollars are not reported in this figure. Values are rebased to 2018 price using the FAO CPI food price index. No detailed information is available regarding what are included in 'other vegetable'. **Source**: Authors' calculations using the BACI International trade database at the product level (2021)

Opportunities to improve fresh vegetable chain linkages and output

Several donor-funded projects have developed efficient systems for addressing some of the bottlenecks in the Highlands fresh produce value chain. The Tininga Fresh project and NKW Fresh project, in collaboration with the International Finance Cooperation (IFC), the Australia DFAT, New Zealand via the Joint Commitment for Development (JCFD) and the Market Development Facility (MDF) has piloted a 'lead firm approach' to promote more coordinated and efficient value chain processes of fresh vegeta-

3 The PNG National Agriculture and Quarantine Inspection Authority (NAQIA), in collaboration with international partners, drafted a biosecurity policy that has been submitted to the PNG government for review and endorsement in early 2022.

ble output. The selected lead firms are those which already have forward or backward commercial linkages with businesses and farmers. Lead firms (via financial support from donors and participating private lead firms) provide services and insurance of market demand in the form of buying, trading, input supply, and aggregation of farming outputs for smallholder farmers.

Over the two years of the Tininga project, 30 lead and 600 other farmers have registered to work with Tininga. With their supply, the amount of fresh vegetables supplied to POM market increased from 14 to approximately 140 tons per month. The project has integrated a large capacity strengthening component (60 percent of participants being women), to improve farmers' knowledge of quality standards and processing throughout the value chain. While this approach has increased commercial viability of fresh produce, it targets more 'professional' farmers as producers, and hence has more focus on economic growth rather than poverty reduction of more vulnerable farming households. It is worth evaluating whether an intermediate program to move farmers from purely subsistence to greater commercial farming could link to this lead firm approach.

Similar to the sweet potato value chain analysis, a fresh produce association that benefits from local government support may be a possible solution to incentivize PNG smallholder farmers to invest in quantity- and quality-enhancing production practices and technologies. A well-functioning farmer association /cooperative could learn from the Tininga lead firm project to better identify reliable value chain actors, promote growth of mid-stream actors, and facilitate linkages between up- mid- and downstream value chain actors. With more farmers engaging in the commercial vegetable value chain in the Highlands (in part due to the NKW and Tininga projects), many producers have significantly improved their output capacity (Adam Smith International, 2018).

Lessons and emerging recommendations from case studies

A wide breadth of research has demonstrated that rural farmers are economically efficient in choosing appropriate production techniques to maximize benefits. Subsistence and commercial farmers must carefully assess the costs of available technologies, the perceived or realized production risks related to specific farming choices, and the available incentives that shape decisions on what to produce and at what level of production. Farmers allocate their available labor, land, and other factors of production up to a level at which the returns to doing so are no greater than the value of output they obtain from the use of each factor in their farming.

PNG will need to take a multi-faceted approach to improve and secure the supply and quality of domestically produced food items for domestic and export demand. This approach must include raising farm productivity, as well as significant investments to support transportation and communication infrastructure, consistent electricity supply, expanded and reliable cold storage capacity, and well-maintained, secure market facilities. Mid-stream value chain actors and infrastructure should be a priority and could be supported via well-organized farmer and trader associations, cluster investments, and lead firms that invest in capacity strengthening and foster long-term business relations that remunerate quantity and quality assurance.

REVIEW OF GENDER ISSUES IN VALUE CHAIN PARTICIPATION IN PNG

A critical aspect of reaping the full potential benefits from value chains involves ensuring that human capital itself is optimally deployed. Beyond increasing value chain efficiency and maximizing growth, ensuring that growth is inclusive – such that all individuals benefit, irrespective of their gender or position in society – makes that growth more sustainable and enduring. This section analyses to what extent women's participation in off-farm work (value chain nodes outside of production) and household decision-making authority is associated with greater human development outcomes. We find that women employed in sales, trained work, and other services are associated with improvements in household durable asset wealth and – for the case of women's involvement in sales and other services – a higher Household Dietary Diversity Score. Women's employment in on-farm agriculture is not associated with either improvements or declines in any of the household welfare measures[4] that we use in the study. However, households that report women's participation in solely domestic work are associated with less per capita calorie consumption. Overall, we conclude that there are some benefits and few costs to households in which women are economically active. Program designs to improve value chain efficiency should include detailed roadmaps for ensuring women are actively participating in and benefiting from work opportunities throughout the value chain. One avenue for supporting inclusive community and household participation is via adding a behavior change communication component focused on women's engagement and input to value chain strengthening activities.

Similar to what we find in PNG, previous research has demonstrated how greater empowerment of women signals their increased involvement in household decision-making and has been associated with greater total household investments in health and education (Thomas, 1990; Quisumbing and Maluccio, 2003; Behrman, Foster and Rosenzweig, 2015) (particularly for girls (Kumar and Quisumbing, 2012)), higher food expenditures (Doss, 2006), greater calorie availability and dietary diversity (Sraboni *et al.*, 2014), better child nutritional status (Smith and Haddad, 2001; Smith *et al.*, 2003; Lépine and Strobl, 2013; Imai *et al.*, 2014; Amarante *et al.*, 2016; Ekbrand and Halleröd, 2018), and more use of prenatal care and contraceptives (Beegle, Frankenberg and Thomas, 2001; Dinçer, Kaushal and Grossman, 2014). Thus, there is a strong business case for empowering women throughout the value chain.

In PNG, rural women play critical roles in agricultural and livestock value chains. In addition to production, they sell agricultural produce at local markets, and operate numerous small and medium-sized enterprises (FAO 2019; Schmidt, Mueller, and Rosenbach, 2020). They also play an important role in livestock production, taking care of an estimated 80% of subsistence livestock and poultry (Brandenburg, 2016). Additionally, women in PNG have long dominated food cropping and sales of subsistence tuber crops (including sweet potato) and fresh vegetables.

However, previous research suggests that women, for a number of reasons, may refrain from participating in various nodes of key value chains due to cultural norms, lack of access to key technologies (e.g., information and communications technologies or mechanization) and services (e.g., financial services, credit), and restrictions imposed on their mobility (FAO, 2019). Where such structural barriers inhibit women's participation, policies and programming that effectively overcome them are often necessary to ensure equitable growth from the value chains in which women are disproportionately excluded.

Women's involvement in the poultry value chain

Women play critical roles in poultry production in PNG. This production takes many forms, each defined by the type of poultry, feeding method, management practice, and level of investment. There are four

4 We measure effects of women's participation on 6 household welfare measurements: per capita calorie consumption, daily expenditure on food away from home, HDDS, livestock assets, production assets and durable assets.

distinct poultry production systems, reflecting different levels of inputs and investments: large-scale commercial farms; medium-scale commercial farms; small-scale commercial farms; and small-scale semi-scavenging (Dom *et al.*, 2017). Across the different sizes of commercial poultry farms, about 9,000 workers are employed—90 percent of whom are women. There are furthermore about 170,000 small-scale, semi-scavenging poultry farmers in PNG; in these smaller operations, women carry out 80 percent of the work of caring for poultry (Brandenburg, 2016). Thus, irrespective of farm size, women are central to poultry production.

While in PNG women's rights to manage non-land assets and decide how assets are utilized for household welfare and reinvestment are legally protected, social norms often influence women's *de facto* ownership and control over these assets (Van der Meulen Rodgers and Kassens 2018). This results in women having ample responsibilities but relatively limited agency. Given that women are already active in most livestock value chain nodes, there may be a greater need to promote women's rights to decision-making over investment in and income from poultry production and marketing, rather than focusing development planning on merely increasing employment opportunities within the livestock sub-sector.

Women's involvement in the sweet potato value chain

Sweet potato production is a joint household operation between men and women. Land preparation, which requires greater physical strength (e.g., falling trees, clearing debris, etc) is generally reserved for men, while tasks including planting, weeding, and harvesting are typically performed by women—often collaboratively with female family members and neighbors (Chang, 2017a). Beyond production activities, women are the main vendors of sweet potato, as well as other domestic staple food crops. Specifically for sweet potato, approximately 68 percent of all sellers in the Port Moresby (capital city) open markets are women; 95 percent of sellers in Lae city are women; and 98 percent of sellers in the Highlands towns are women (Chang *et al.*, 2010).

While women are the primary producers and sellers of sweet potato, they are less involved in the sweet potato value chain nodes between initial production and final sales. Given that women are almost absent from the mid-stream nodes of the value chain, they have limited direct access to information on intermediate costs (of labor and services of transport, handling and trade) and final (long-distance) market retail prices. Part of this lack of information is structural; both rural men and women (at farmgate) face significant barriers (e.g., poor price information transmission, and inadequate transportation, packaging, handling, and storage infrastructure). However, women's more limited access to information on sweet potato prices at various markets is also exacerbated by lower average literacy levels, narrower social networks, or less (compared to men) access to information communications technology (ICT) (Udry, 1996; Kosec *et al.*, 2021; Hidrobo *et al.*, 2022).

Overall, empowering women in the sweet potato value chain does not seem to require expanding their involvement in production; it is more related to ensuring that they have complementary services that allow them to be *more* productive. Further, women are already heavily involved in sales, but it is key that they have reliable, real-time price information, decent market infrastructure, and are able to formally, efficiently, and safely negotiate to contract other service providers to transport, package, and store sweet potato. Policies and programming that can ease information asymmetries for women, facilitate their connections with providers of key complementary services, and train women to read and digest market information, seek higher output prices, and negotiate intermediate service costs are thus promising avenues for increasing their opportunities in mid-stream activities in the sweet potato value chain.

Women's involvement in the fresh vegetables value chains

Similar to the sweet potato value chain, women involved in the fresh vegetable value chain face considerable challenges and safety risks with transport and price negotiation (for services) and have less authority over how income generated from fresh vegetables is used within the household (Benediktsson, 1998; Spriggs and Chambers, 2007).

Omot et al. (2013) underline the challenges in PNG for long-distance transport of fresh produce. The fresh vegetable value chain requires specialized packaging and processing needs which could be potential areas for greater women's employment. Assuming that PNG could position itself for greater export of key fresh vegetable value chains, a concerted effort to encourage women's equal or independent control of earned income will be necessary. In recent studies of cash crop production, Curry et al. (2019) highlight that a factor incentivizing women's priority in producing and marketing staple food crops is associated with their greater knowledge of market conditions and their greater control over the associated income generated.

QUANTITATIVE ANALYSIS OF MEN'S AND WOMEN'S INVOLVEMENT IN THE 3 CHOSEN VALUE CHAINS

Our discussion of our selected value chains, as well as the state of existing information on gender dynamics within them, provides a foundation for further analysis on how value chain engagement varies by gender within the household. In this section, we undertake such an analysis using the RSFS (2018) and HIES (2009-10) datasets described in Section **Error! Reference source not found.**. We first evaluate the importance of each of the study value chains for household consumption, employment, and small business activities. We then look one step beyond the farm to assess nonfarm enterprise (NFE) ownership and decision-making by gender to better understand opportunities for both men and women in rural areas to diversify into more value-added labor, including mid-stream value chain activities. We find that women's economic participation (especially their operation of NFEs and engagement in sales jobs and in commercial farming) is associated with greater participation of women in decision-making within their household as well as improvements in household welfare on a variety of dimensions.

Importance of studied value chains for men and women in PNG

The RSFS (2018) survey collected data on a limited list of crop production activities by gender, focusing on the major crops produced within the sample areas (primarily lowlands) of the survey (E. and W. Sepik, Madang, and ARoB). Within the RSFS sample, sweet potato is the third most popular crop for households to grow, after yam and taro (**Table 1**). Comparing men and women participation in production and harvest activities, a greater share of households (29 percent) reported that only women work on sweet potato production (29 percent) compared to only men working on sweet potato production (2 percent). The majority of households reported jointly working on sweet potato production and harvesting activities (with men clearing gardens for women to plant, weed, and harvest). Men's greater sole production and harvesting of yam reflects unique social and cultural traditions whereby in specific survey sample areas, yam is considered a male crop (and incorporated into different community ceremonies). Overall, for every crop, at least 66 percent of households in the sample employ a dual gender production strategy.

Table 1: Share of households growing crops and participation by gender for key crops

Crop type	HH growing the crop		Who works the most on production/harvest activities with each type of crop?			
	% of HH	N	Only Women (% HH)	Only Men (% HH)	Both (% HH)	N
Chinese taro	51.0	880	31.9	1.8	66.4	449
Betel nut	52.7	880	11.2	16.8	72.0	464
Cassava	42.5	880	23.3	1.6	75.1	374
Sago	47.3	880	9.6	3.6	86.8	416
Sweet potato	**68.5**	**880**	**28.9**	**2.2**	**69.0**	**603**
Taro	72.8	880	24.2	1.9	74.0	641
Yam	86.7	880	8.3	18.6	73.1	763

Source: RSFS (2018).

An area where women are more engaged in agricultural value chains is in the sales (downstream) segment. The RSFS 2018 survey included a question in the consumption module (which includes a comprehensive list of crop items) asking households that reported selling a specific crop who (man or woman) most commonly sold the crop. Table 2 reports these crop sales by gender. While 68 percent of households grow sweet potato, only 25 percent sell it, reflecting the significant subsistence production lifestyle of rural households in the sample. However, when analyzing participation in sweet potato sales, women are the only vendors in 89 percent of households. Compared to sweet potato sales, more than double the share of households (58 percent) sell vegetables (including green beans, carrots, cucumbers, tomato, onion, garlic, squash and leafy greens such as pumpkin tips, aibika, tulip, choko, kangkong, cabbage). Moreover, women dominate sales of vegetables even more than they dominate sales of sweet potato, with 92 percent of households reporting that women are the only vendors.

Only for select, cash-crop value chains – specifically, coffee, cocoa, and vanilla – do men have a greater sole sales role. Conversely, given the local oriented nature of betel nut sales, women still have a larger sole vendor role (almost 60 percent of households reported women as sole vendors) in this value chain.

Table 2: Share of households selling crops for each value chain and participation by individual's gender

Crop type	HH sells the crop		Who usually sells the crop?			
	% of HH	N	Only Women (% of HH)	Only Men (% of HH)	Both (% of HH)	N
Yam	16.6	880	78.5	11.1	10.4	144
Sago	23.3	880	70.5	7.0	22.5	200
Sweet potato	**25.2**	**880**	**89.0**	**6.0**	**5.1**	**218**
Taro	18.9	880	82.4	8.5	9.1	165
Chinese taro	19.8	880	90.1	5.3	4.7	171
Cassava	13.1	880	86.0	7.5	6.5	107
Betel nut	49.8	880	55.9	17.3	26.8	429
Irish potato	0.11	880	-	-	100.0	1
Rice	2.4	880	52.4	19.1	28.6	21
Corn/maize	25.6	880	93.2	3.6	3.2	221
Banana	36.7	880	91.8	2.8	5.4	318
Vegetables	**57.8**	**880**	**92.2**	**3.4**	**4.4**	**497**
Other fresh fruits	13.4	880	93.0	2.6	4.4	114
Groundnut/peanut	21.6	880	94.1	1.6	4.3	187
Other nuts	2.5	880	90.5	-	9.5	21
Sugar cane	16.0	880	89.9	3.6	6.5	139
Coconut	11.8	880	93.9	1.0	5.1	99
Copra	0.45	880	-	100.0	-	3
Cocoa	60.3	880	17.8	29.9	52.3	528
Mustard	17.4	880	75.7	5.3	19.1	152
Vanilla	30.5	880	10.9	48.3	40.8	265
Coffee	0.91	880	-	57.1	42.9	7
Tea, tobacco, chili pepper or other spices	12.5	880	43.0	14.0	43.0	107
Other	0.68	880	83.3	-	16.7	6

Source: RSFS (2018).

Non-farm enterprise operation by gender

The structural transformation literature underlines the importance of NFEs in supporting rural-urban linkages through a greater focus on value-added agricultural output. For rural PNG, the primary source of off-farm employment is NFEs given the absence of rural wage labor activity. Table 3 describes NFEs by type of business, and women's participation in its ownership and decision-making. Out of 474 NFEs, non-agricultural trade shops, prepared food and alcohol sales, and agricultural trade businesses are the most prevalent, and collectively represent 61 percent of the total NFEs reported in the RSFS survey sample. For prepared food and alcohol, 59 percent of businesses are owned by only women, and 28 percent have decision-making roles performed solely by women. Women had no participation in transportation businesses, reflecting, in part, security risks to women's mobility outside of their home communities.

Agricultural trade (including livestock and inputs) is a sector in which both women and men participate. Approximately 35 percent of agricultural trade businesses are owned by only women and 24 percent have sole women decision-making. This suggests that there may be ample opportunity to enhance women's off-farm participation and decision-making authority in, for example, the clean-seed sweet potato and poultry feed nodes, as well as in the mid- and downstream nodes of the fresh vegetable value chain.

Table 3: Ownership/Decision-making by type of NFE

Type of NFE	Ownership			Decision making			N
	Only men (% of NFE)	Only women (% of NFE)	Both (% of NFE)	Only men (% of NFE)	Only women (% of NFE)	Both (% of NFE)	
Agricultural trade (including livestock and inputs)	8.7	34.8	56.5	4.4	23.9	71.7	46
Betel nut	33.3	35.7	31.0	21.4	38.1	40.5	42
Cash crops	20.7	6.9	72.4	17.2	3.5	79.3	29
Non-agricultural trade shops	38.8	14.1	47.1	38.8	10.0	51.2	170
Fuel, batteries, wood	34.9	14.0	51.2	27.9	14.0	58.1	43
Prepared food and alcohol	11.0	58.9	30.1	9.6	48.0	42.5	73
Crafts and sewing	12.5	68.8	18.8	6.3	68.8	25.0	16
Transportation	53.1	-	46.9	43.8	3.1	53.1	32
Other services (incl. construction, herbal medicine, quarry)	69.6	4.4	26.1	47.8	-	52.2	23
All types	**31.2**	**24.9**	**43.9**	**26.8**	**20.7**	**52.5**	**474**

Source: RSFS (2018).

While NFEs are important for moving rural subsistence farmers to higher value-added rural activities, these enterprises employ a relatively small number of laborers (on average, two individuals) and labor is frequently sourced from the enterprise-owning household. Male workers outnumber female workers in NFEs that earn the greatest income per year, including those engaged in the trade of cash crops; non-agricultural trade; fuel, batteries, and wood; transportation; and other services (including construction, herbal medicine, and quarries) (Table 4). However, in all other types of businesses, female workers outnumber male workers. Identifying the complementary investments needed for NFEs to link to larger rural and secondary city businesses, especially in the agricultural wholesale and light processing sectors, may be one way to increase revenue among women-operated NFEs.

Table 4: Information about NFE's operations by type of business and ownership

Type of NFE	Avg. N of male workers	Avg. N of female workers	Avg. N of total workers	Avg.days operating/ year	Avg.income/ year (PGK)	N
Agriculture	**0.8**	**0.9**	**1.7**	**37.5**	**2,107**	**117**
Male owned	1.1	0.4	1.5	23.8	2,945	24
Female owned	0.2	1.2	1.4	45.2	828	33
Jointly owned	1.0	1.0	2.0	38.7	2,475	60
Non-agricultural trade	**0.9**	**0.9**	**1.8**	**79.4**	**2,096**	**286**
Male owned	1.2	0.5	1.7	78.3	2,383	89
Female owned	0.4	1.2	1.6	44.0	916	73
Jointly owned	1.1	1.1	2.1	101.0	2,606	124
Crafts and sewing	**0.3**	**1.3**	**1.6**	**48.1**	**935**	**16**
Male owned	1.0	1.0	2.0	6.5	1,000	2
Female owned	0.1	1.4	1.5	55.7	611	11
Jointly owned	0.7	1.0	1.7	48.0	2,080	3
Transportation	**1.2**	**0.5**	**1.7**	**96.4**	**8,477**	**32**
Male owned	1.2	0.2	1.4	104.2	8,924	17
Female owned	-	-	-	-	-	-
Jointly owned	1.2	0.8	2.0	87.5	7,970	15
Other services	**1.1**	**0.6**	**1.7**	**80.2**	**3,497**	**23**
Male owned	1.2	0.6	1.8	78.8	2,914	16
Female owned	1.0	1.0	2.0	300.0	5,000	1
Jointly owned	1.0	0.7	1.7	47.3	4,828	6
All types	**0.9**	**0.9**	**1.8**	**69.2**	**2,558**	**474**
Male owned	1.2	0.5	1.6	71.5	3,281	148
Female owned	0.3	1.2	1.5	47.6	898	118
Jointly owned	1.0	1.0	2.0	79.8	3,011	208

Source: RSFS (2018).

Notes: The Agriculture category aggregates three categories from the previous table (Table 8): "agricultural trade (including livestock and inputs)," "betel nut," and "cash crops." The non-agricultural trade category aggregates three categories from the previous table: "non-agricultural trade shops," "fuel, batteries, wood," and "prepared food and alcohol."

RELATIONSHIP BETWEEN WOMEN'S ECONOMIC PARTICIPATION AND MEASURES OF WOMEN'S EMPOWERMENT

Research examining women in off-farm activities has highlighted that a combination of greater women's participation *and* empowerment as a driving factor of improved household welfare outcomes. In this section, we use the Women's Empowerment in Agriculture Index (WEAI)[5] as a guide to define four proximate indicators using the HIES 2009/10 data following the logic of Pro-WEAI guidelines. Given that the HIES does not have the same indicators as the WEAI, we underscore that the analysis presented in this section is imperfect and more research—including implementation of a full WEAI study capturing all domains of women's empowerment in agriculture—is needed to better understand women's opportunities vis-à-vis men and the barriers to their accessing them in PNG.

5 An internationally recognized approach for measuring women's empowerment in the context of agricultural production, originally developed by IFPRI, the Oxford Poverty and Human Development Initiative, and United States Agency for International Development (Alkire *et al.*, 2013). Project-level (Pro) WEAI, a variant of WEAI, includes 12 indicators allowing us to examine the levels of empowerment of men and women and their relative empowerment within a household (Quisumbing *et al.*, 2021).

The Pro-WEAI indicators seek to identify whether an individual is deemed adequate they meet a certain threshold for empowerment specific to that indicator (see Appendix 3 for the definitions of the four indicators based on HIES (2009/10) data). Asset ownership adequacy is defined as owning (solely or jointly) at least one of the six assets listed in Appendix 3. Credit decision adequacy is defined as the individual being able to decide on requesting or paying off a debt. Consumption control adequacy is defined as the individual being able to make decisions on all of the household purchase, spending, and education decisions listed in Appendix 3. Finally, freedom from domestic violence adequacy is defined as believing a husband is not justified in hitting or beating his wife due to any of the five reasons listed in Appendix 3 (we recognize that domestic violence also encompasses violence inflicted on men by women—however, the HIES (2009/10) data do not report on this indicator).

Considering the four adequacy indicators, the shares of husbands and wives that are adequate on each indicator are presented in Table 5**Error! Reference source not found.**, and t-tests are run to statistically compare the values for husbands and wives. The indicators of asset ownership and credit decision adequacy are relatively high (about two-thirds of husbands and wives are adequate). However, women are significantly less likely to be adequate than are men for both. The adequacy indicator on freedom from domestic violence is relatively low for both husbands (33 percent) and wives (28 percent), suggesting that greater policy, advocacy, and investment is needed for both men and women to acknowledge that violence (in any form) is not acceptable. Compared to wives, a greater share of husbands (72 percent) are permissive (or with worse attitudes) towards domestic violence than are wives. However, perhaps more surprising, approximately 67 percent of wives report permissiveness to domestic violence.[6] The adequacy levels on the consumption control indicator are similar between husband and wife (both about half), suggesting that only half of married men and of married women agree that their spouse should have equal decision-making authority on household purchases.

Table 5: Share of husbands and of wives that achieve adequacy (on different empowerment indicators)

	Husbands	Wives	t-test
Asset ownership	77%	68%	***
Credit decision	69%	50%	***
Consumption control	49%	50%	
Freedom from domestic violence	28%	33%	***
Number of individuals	*2,935*	*3,063*	

Notes: (1) Definitions of each indicator are presented in Appendix 3. (2) There are 318 married couples with their spouses living in other areas (e.g. migration), and 38 households with more than one wife. Therefore, the number of husbands and wives are different.

*** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$.

Source: HIES (2009-10).

We underlined earlier that women's participation and decision-making authority, in tandem, is important to promoting greater household welfare. Thus, we re-evaluate women's adequacy indicators presented in Table 7, considering whether women engage in a sales job (no or yes) or engage in commercial farming (no or yes). These activities comprise two distinct nodes in value chains and may be accompanied with different levels of the agency. Data suggest that wives engaging in a sales job is

6 It is important to note that sensitive questions that form this indicator may be subject to reporting error and bias if survey implementation lacked important measures to ensure safety and confidentiality of survey respondents.

positively associated with being adequate on asset ownership and consumption control (Table 6). This is consistent with wives reporting greater control over household purchasing decisions and asset ownership when they are engaged in a sales job compared to when they are not. Similarly, a greater share of wives engaged in commercial farming have decision-making autonomy on household purchases compared to women who do not engage in commercial farming.

However, wives having a sales job (compared to not having a sales job) are less likely to be adequate in the freedom from domestic violence domain. That is, wives having a sales job predicts them being more permissive rather than less permissive of domestic violence towards wives in some circumstances. Thus, there may be some need for programming offering protection or support to women who work in sales. Given cultural norms indicating that women are still expected to perform their unpaid domestic responsibilities while working in sales (Kosec *et al.* 2021), the increased workload may expose them to retributive violence if household work is incomplete.

Table 6: Share of wives that are adequate on each empowerment indicator according to whether the wife engages in sales job and commercial farming

	Wife engages in sales job			**Wife engages in commercial farming**		
	No	Yes	t-test	No	Yes	t-test
Asset ownership	66%	75%	***	68%	69%	
Credit decision	50%	49%		50%	51%	
Consumption control	49%	53%	*	49%	56%	**
Freedom from domestic violence	35%	29%	***	33%	33%	

Notes: *** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$. See Appendix 3 for the definitions of adequacy for each empowerment indicator.

Source: HIES (2009-10).

We further compare women's decision-making authority depending on employment in a disaggregated set of purchase data. Panel A of Table 7 shows that women that are active in sales jobs also have greater agency in household decisions about purchases on clothing, medication, and child education compared to women who are not engaged in a sales job (Table 7). We find a similar pattern when comparing women who engage in commercial farming with those who do not.

Panel B of Table 7 focuses on household asset ownership. We perform a similar exercise to evaluate whether wives' engagement in sales jobs and in commercial farming is associated with owning key assets, including livestock, poultry, agricultural equipment, fishing equipment, a house or apartment, and furniture and household goods. Women having a sales job is significantly associated with a greater likelihood of the household owning poultry, agricultural equipment, fishing equipment, a house or apartment, and furniture or household goods. Further analysis should evaluate what specific types of sales and commercial farming activities are associated with greater women's agency. Given limited data, we are unable to assess the scale of sales or commercial farming enterprises and activities that are reported.

Table 7: Share of wives involved in making various decisions in the home according to wife's employment activities

	Wife engages in sales job			**Wife engages in commercial farming**		
	No	Yes	t-test	No	Yes	t-test
Panel A: Decisions on purchases						
Purchase of food for the household	89%	91%		89%	93%	***
Purchase of clothing for you	93%	95%	**	93%	95%	
Purchase of clothing for children	83%	87%	***	83%	91%	***
Spending on medicine for you	89%	90%		89%	95%	***
Spending on medicine for children	81%	85%	***	81%	88%	***
Education for boys in household	64%	70%	***	64%	71%	**
Education for girls in household	61%	70%	***	63%	67%	
All of the above at the same time	49%	53%	*	49%	56%	**
Sample size (Number of wives)	*2,125*	*957*		*2,787*	*295*	
Panel B: Household ownership[2]						
Livestock	37%	39%		38%	35%	
Poultry	17%	26%	***	20%	16%	
Agricultural equipment	56%	67%	***	58%	61%	
Fishing equipment	15%	21%	***	17%	13%	
House/apartment	26%	32%	**	28%	23%	*
Furniture and household goods	33%	42%	***	36%	33%	
Number of rural households	*1,429*	*476*		*1,621*	*284*	

Notes: 1) *** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$. 2) The sample includes all households—regardless of whether the household owns the asset.

Source: HIES (2009-10).

CORRELATION BETWEEN WOMEN'S ECONOMIC PARTICIPATION AND HOUSEHOLD WELFARE

While the previous section showed greater household asset ownership and women's decision-making roles in households with a wife participating in a sales or commercial farming job, we acknowledge that other household differences may be driving some of these results. This section goes further to isolate different measures of women's economic participation and how well they predict household welfare, while also controlling for other geographic, household, and individual characteristics. Given that household welfare can be measured in a variety of ways, we construct six outcome indicators to investigate how women's off-farm employment participation is associated with household consumption, expenditure, nutrition, and asset ownership.

Specifically, we estimate the following empirical specification using Ordinary Least Squares (OLS):

$$Y_i = \beta_0 + \beta_1 R_i + \beta_2 X_i + \varepsilon_i \quad (1)$$

where i indexes households. The outcome Y_i, represents one of six outcomes related to household welfare including: daily calories per capita (edible portion), daily expenditure on food away from home, household dietary diversity score (HDDS) over 16 food categories, Principal Component Analysis (PCA) for livestock wealth, PCA score for production assets, and PCA score for durable assets (all three PCAs' construction is detailed in Appendix 3). R_i represents a set of independent variables that capture women's economic activities.

We use five different models of women's economic participation with different sets of variables (descriptive statistics of these variables are presented in Appendix 4). These include: an indicator for at least one woman being employed (Table 8, Panel A); the percentage of women in the household who are employed (Table 8, Panel B); a vector of dummies for NFE ownership by gender of the owner (Table 8, Panel C); indicators for at least one woman working in each of a vector of sectors (Table 9, Panel A); and a vector of variables indicating the percentage of women in the household working in each economic sector (Table 9, Panel B). X_i is a set of control variables including a dummy for a household with a female head; dummy for a married household head; dummy for polygamous household head; dummy for a household head older than 35; dummies for education levels of the head of household; dummies for languages that the household head speaks; number of adult women in the household; number of adult men in the household; and household size.

Regression results suggest that there is no association between women's employment and our key household welfare measures. Having at least one woman employed actually predicts fewer daily calories consumed per capita (Table 8, Panel A). However, when we disaggregate women's employment by activity (analysis reported in Table 9), regression results suggest that reductions in daily calories per capita predicted by women's employment come entirely from women being employed in domestic work. The percentage of women employed is also not significantly associated with any household welfare measures of interest (Table 8, Panel B). It may be the case that women's involvement in outside employment is a strategy of risk diversification (particularly for vulnerable households) rather than income generation. Further research should evaluate risk diversification and household employment strategies to understand the costs and benefits of such decisions on women's own as well as overall household welfare.

One factor that is predictive of greater household welfare is the household owning a NFE, compared to not owning one. The type of NFE least predictive of household welfare gains is a NFE owned only by women. These results echo similar work by Schmidt, et al. (2020). A household having a woman-owned NFE does predict higher household production asset wealth (however, only at the 10 percent significance level). Having a NFE owned only by men predicts higher household production asset wealth, durable asset wealth, HDDS, and daily calories per capita. However, having a NFE jointly owned by women and men predicts higher values of five of the six household welfare outcomes we consider (all but daily expenditure on food away from home per capita). This suggests major household welfare gains from joint ownership of NFEs, and thus the benefits of policy and programming promoting this type of economic involvement of women.

Table 8: Women's value chain participation and household welfare – Part I

	Daily calories (kcal) per capita	Daily expenditure (PGK) on food away from home per capita	HDDS (out of 16 food categories)	PCA score - Livestock wealth	PCA score - asset wealth (production assets)	PCA score - asset wealth (durables)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
At least one employed woman in HH	-216.18**	-6.20	-0.12	-0.10	0.11	0.11
	(102.59)	(4.15)	(0.21)	(0.10)	(0.12)	(0.15)
Constant	1,506.04***	33.97*	2.00**	0.06	-1.20**	-1.20*
	(430.50)	(17.40)	(0.87)	(0.43)	(0.49)	(0.62)
Observations	989	989	1,026	1,026	1,026	1,026
R-squared	0.15	0.08	0.11	0.08	0.14	0.16
Panel B						
% of women employed (over adult women 16-64)	-41.18	-6.57	-0.01	-0.03	-0.00	0.03
	(110.38)	(4.35)	(0.23)	(0.11)	(0.13)	(0.16)
Constant	1,169.00**	13.03	1.85**	-0.09	-1.17**	-1.33**
	(454.29)	(17.90)	(0.92)	(0.46)	(0.52)	(0.67)
Observations	951	951	987	987	987	987
R-squared	0.15	0.08	0.11	0.08	0.14	0.17
Panel C						
Has NFE owned by only men	319.49***	3.10	0.49**	0.07	0.46***	1.07***
	(112.12)	(4.55)	(0.23)	(0.11)	(0.13)	(0.16)
Has NFE owned by only women	195.33	0.54	-0.02	0.06	0.24*	0.22
	(120.69)	(4.90)	(0.25)	(0.12)	(0.14)	(0.17)
Has NFE owned by both women and men	262.76**	6.90	0.76***	0.25**	0.83***	1.15***
	(103.53)	(4.20)	(0.21)	(0.11)	(0.12)	(0.15)
Constant	1,364.36***	32.44*	1.99**	0.02	-1.22**	-1.26**
	(431.18)	(17.50)	(0.87)	(0.43)	(0.48)	(0.60)
Observations	989	989	1,026	1,026	1,026	1,026
R-squared	0.16	0.08	0.12	0.08	0.18	0.23

Notes: 1) Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. 2)The sample for analysis includes all households. 3) The control variables used for this analysis include all of the geographic and household-level controls detailed in section 8.

Source: RSFS (2018).

Table 9 further disaggregates our analysis to evaluate whether women's employment in a set of specific sectors impacts household welfare. As mentioned earlier, a household having women employed in domestic work is associated with consuming less daily calories per capita. Other forms of employment, including in agriculture, do not predict any differences in calorie consumption per capita. This suggests the limited value of women's involvement in domestic work for improved household welfare –

and possible detrimental impact on calorie consumption. Similarly, daily expenditure on food away from home per capita is also lower if women engage in domestic work.

Women's employment in sales, trained work, and other services is associated with improvements in household durable asset wealth and – for the case of women's involvement in sales and other services – a higher HDDS. However, for no sector do we find women's employment contributing to greater production asset wealth. Interestingly, women's employment in agriculture predicts neither improvements nor declines in any of the six household welfare measures. Overall, we conclude that there are some benefits and few costs to households in which women are economically active—with the possible exception of women's participation in domestic work, which is associated with poorer household welfare indicators.

Table 9: Women's value chain participation and household welfare – Part II

	Daily calories (kcal) per capita	Daily expenditure (PGK) on food away from home per capita	HDDS (out of 16 food categories)	PCA score - Livestock wealth	PCA score - asset wealth (production assets)	PCA score - asset wealth (durables)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
At least one woman is working in agriculture (dummy)	-76.97	-5.42	-0.05	-0.05	-0.02	-0.04
	(96.76)	(3.90)	(0.20)	(0.10)	(0.11)	(0.14)
At least one woman is working in manual work (dummy)	-79.70	-13.42	0.23	-0.03	-0.89	0.84
	(652.60)	(26.30)	(1.36)	(0.67)	(0.76)	(0.96)
At least one woman is working in sales (dummy)	154.53	-5.09	1.74***	0.06	0.43	1.08***
	(251.13)	(10.12)	(0.51)	(0.25)	(0.29)	(0.36)
At least one woman is working in other services (dummy)	35.15	15.18	1.26*	-0.62*	0.43	1.80***
	(347.65)	(14.01)	(0.72)	(0.36)	(0.41)	(0.51)
At least one woman is working in handicraft work (dummy)	-558.52	-17.88	0.49	0.71	0.38	0.16
	(473.43)	(19.08)	(0.99)	(0.49)	(0.55)	(0.69)
At least one woman is working in domestic work (dummy)	-288.97**	-13.20***	-0.20	0.17	0.01	0.05
	(112.59)	(4.54)	(0.23)	(0.11)	(0.13)	(0.16)
At least one woman is working in trained work (dummy)	-14.99	1.15	0.49	-0.04	0.18	1.13***
	(200.76)	(8.09)	(0.42)	(0.21)	(0.23)	(0.29)
At least one woman is working in other work (dummy)	480.61	45.83	-1.71	-0.74	-0.46	-0.24
	(805.49)	(32.46)	(1.68)	(0.83)	(0.94)	(1.18)
Constant	1,455.05***	34.13**	1.73**	0.02	-1.22**	-1.32**
	(431.36)	(17.38)	(0.87)	(0.43)	(0.49)	(0.61)
Observations	989	989	1,026	1,026	1,026	1,026
R-squared	0.16	0.10	0.13	0.09	0.14	0.20
Panel B						
% of women working in agriculture (over adult women 16-64)	16.51	-5.26	-0.03	-0.06	-0.02	-0.06
	(113.79)	(4.46)	(0.23)	(0.12)	(0.13)	(0.17)
% of women working in manual work (over adult women 16-64)	159.44	-34.24	-0.26	-0.64	-0.97	2.63*
	(1,011.82)	(39.65)	(2.12)	(1.06)	(1.21)	(1.51)

% of women working in sales (over adult women 16-64)	208.51 (345.97)	-2.63 (13.56)	2.12*** (0.72)	0.06 (0.36)	0.90** (0.41)	1.63*** (0.51)
% of women working in other services (over adult women 16-64)	-321.97 (535.57)	50.49** (20.99)	2.30** (1.12)	-0.87 (0.56)	0.43 (0.64)	3.19*** (0.80)
% of women working in handicraft (over adult women 16-64)	-711.02 (551.56)	-22.25 (21.62)	-0.46 (1.16)	0.82 (0.58)	0.33 (0.66)	-0.28 (0.82)
% of women working in domestic work (over adult women 16-64)	-246.04* (137.66)	-14.17*** (5.40)	-0.26 (0.29)	0.10 (0.14)	-0.03 (0.16)	-0.08 (0.20)
% of women working in trained work (over adult women 16-64)	59.24 (271.35)	0.22 (10.63)	0.73 (0.57)	-0.43 (0.28)	-0.08 (0.32)	1.43*** (0.40)
% of women working in other work (over adult women 16-64)	-716.48 (1,101.87)	94.19** (43.18)	-1.04 (2.31)	-0.73 (1.16)	-0.80 (1.32)	0.21 (1.65)
Constant	1,139.11** (454.17)	13.02 (17.80)	1.74* (0.92)	-0.07 (0.46)	-1.20** (0.52)	-1.44** (0.65)
Observations	951	951	987	987	987	987
R-squared	0.16	0.10	0.12	0.08	0.14	0.21

Notes: 1) The sample for analysis includes all households. 2) The control variables used for this analysis include all of the geographic and household-level controls detailed in section 8.

Source: RSFS (2018).

RELATIONSHIP BETWEEN GENDER ATTITUDES AND WOMEN'S ECONOMIC PARTICIPATION

Given that the econometric analysis suggests potential gains from women's participation in mid- and downstream value chain employment, we next investigate what may be keeping women from engaging more fully in these value chain nodes. We analyze the extent to which households that are otherwise similar but differ only in the gender norms prevailing among both the head and their spouse differ in terms of women's economic participation. That is, is there evidence consistent with women's economic participation being lower due to regressive gender norms keeping women from participating economically in similar ways as do men? Results suggest that both women's and men's gender attitudes have some predictive power for women's economic participation, though not all gender attitudes matter. Specifically, when men oppose the notion that jobs should be reserved for men (and thus support more egalitarian labor participation), we find some evidence that their wives are more likely to be employed. For women, those that oppose the notion that jobs should be reserved for men are significantly more likely to be part of a household that owns a NFE co-owned with women. Particularly for women, the belief that their working does not harm men (by crowding men out for jobs) predicts that they are much more likely to be employed. Thus, programming designed to promote greater economic inclusiveness via behavior change communication must include both men and women, as convincing women that their working will not crowd out jobs for men could actually increase their willingness to work.

To disaggregate men and women's views of gender norms, we analyze data collected from both husbands and wives as part of the RSFS (2018) on their attitudes towards seven statements related to women's roles in society (Our sample for analysis is comprised of 1,589 individuals). The specific questions were as follows, where answer choices were on a Likert scale ranging from 1 to 5 and reverse coded as necessary to ensure that higher values indicate more egalitarian gender attitudes (i.e., attitudes more supportive of women having agency and opportunities equal to those of men): 1) In your opinion, when money is scarce, to what extent should boys have more education than girls? (i.e., prioritize boys for education); 2) In your opinion, if jobs are scarce, to what extent should they be reserved for men rather than women? (i.e., reserve jobs for men); 3) In your opinion, to what extent should men have the final word about decisions affecting the community? (i.e., men should make community decisions); 4) In your opinion, to what extent should a husband make all the decisions in the household about how to manage assets like farm equipment? (i.e., husband should manage household assets); 5) If a woman earns money outside the home, a man somewhere will be less able to provide for his own family (i.e., women crowd out men for jobs); 6) When a wife earns money through work outside the home, her children are negatively affected (i.e., women's work harms children); and 7) A good woman always supports her husband's opinions. We then standardized the 5-point scale measures using the mean and standard deviation of the whole group of individuals (including women and men) to facilitate interpretation of the effects.

First, we analyzed responses to test for any significant differences in attitudes toward each statement across genders (Table 10). Given the normalization procedure already described above, our effect sizes can be interpreted in terms of the result of a 1 standard deviation increase in the extent to which gender attitudes are egalitarian (i.e., supporting equal treatment of women and men). We find that for all seven statements, men had more egalitarian gender attitudes than did women, and for four of them, these differences were statistically significant: 1) prioritization of boys' education over girls; 2) a belief that men should make community decisions; 3) a belief that the husband should manage household assets; and 4) a belief that women should always support their husband's opinions. Further research is needed to understand whether men are seeking to supply acceptable answers to survey enumerators regarding women's civic and economic participation, and/or whether women feel their disenfranchisement is acceptable given different social and economic conditions that we are unable to control for in regression analysis.

Table 10: Gender attitudes balance table

Variable	**Men (1)**		**Women (2)**		**T-test Difference**
	N	Mean/SE	N	Mean/SE	(1)-(2)
Extent of disagreement - Prioritize boys for education (normalized)	658	0.057 [0.040]	868	-0.043 [0.033]	0.100*
Extent of disagreement - Reserve jobs for men (normalized)	656	0.038 [0.038]	855	-0.029 [0.035]	0.067
Extent of disagreement - Men should make community decisions (normalized)	682	0.104 [0.041]	891	-0.08 [0.032]	0.184***
Extent of disagreement - Husband should manage household assets (normalized)	678	0.079 [0.040]	875	-0.061 [0.033]	0.139***
Extent of disagreement - Women crowd out men for jobs (normalized)	655	0.026 [0.037]	837	-0.02 [0.036]	0.046
Extent of disagreement - Women's work harms children (normalized)	658	0.015 [0.037]	782	-0.012 [0.037]	0.027
Extent of disagreement - Women should support husband's opinions (normalized)	697	0.112 [0.041]	892	-0.088 [0.031]	0.200***

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Source: RSFS (2018).

Second, we carried out econometric analysis to consider how well gender attitudes of husbands and of wives (controlling for each simultaneously) are associated with outcomes related to women's economic participation. We perform two types of estimations: one at the household level and one at the individual level. Our empirical specification for the *household*-level analysis is as follows:

$$Y_j = \beta_0 + \beta_1 FG_j + \beta_2 MG_j + \beta_3 X_j + \varepsilon_{ij} \quad (2)$$

where j indexes households, the outcome, Y_j, is a dummy for the household having a NFE owned by women or both women and men jointly, FG_j and Mj capture gender attitudes of the woman respondent (male respondent) in each household, and X_j represents a set of control variables including: dummy for a household with a female head; dummy for a married household head; dummy for polygamous household head; dummy for a household head older than 35; dummies for province, dummies for education levels of the head of household; dummies for languages that the household head speaks; number of adult women in the household; number of adult men in the household; and household size.

Our empirical specification for the *individual*-level analysis is as follows:

$$Y_{ij} = \beta_0 + \beta_1 FG_j + \beta_2 MG_j + \beta_3 X_j + \beta_4 Z_i + \varepsilon_{ij} \quad (3)$$

where i indexes households and j indexes wives that lived in households where there were two respondents (i.e., a male and a female) of the gender attitudes module of RSFS (2018). Y_i, is a dummy for the wife being employed, and FG_i and MG_i capture gender attitudes of the woman respondent (male respondent) in each household (the woman respondent is the woman herself, while the male respondent is most typically but not exclusively her husband). X_j is as defined before while Z_i is a set of control variables for individual characteristics including dummies for the individual's age range, a dummy for marital status, and dummies for level of education.

Table 11 summarizes these results. We estimate regressions that include both women's and men's attitudes simultaneously (columns 1 and 4), those which include only men's attitudes (columns 2 and 5), and those which include only women's attitudes (columns 3 and 6). Results suggest that both women's and men's gender attitudes have some predictive power for women's economic participation, though not all gender attitudes matter. Specifically, when men oppose the notion that jobs should be reserved for men (and thus support more egalitarian labor participation), we find some evidence that their wives are more likely to be employed. However, men's gender attitudes do not significantly influence the likelihood that their household has a co-owned (man and woman) NFE. For women, in contrast, those that oppose the notion that jobs should be reserved for men are significantly more likely to be part of a household that owns a NFE co-owned with women. That is, when women feel increasingly like they deserve jobs, they are more entrepreneurial. We find no evidence that attitudes regarding whether or not boys should be prioritized for education influence women's participation in a NFE or their employment more generally. This may reflect that in PNG, many of the jobs women take do not require substantial formal education. Thus, programming that addresses regressive gender attitudes about women's right to and benefits from off-farm employment, targeted at both women and men, may be one promising avenue for increasing women's economic participation.

Thus far, we have considered whether attitudes about reserving jobs for men (i.e., supporting men's employment over women's) predict differences in women's empowerment and NFE ownership outcomes. It is also interesting to examine whether attitudes toward how women working *affects others* (specifically, men and children) predict differences in women's employment and NFE ownership outcomes. That is, when husbands feel (or wives feel) that women's working will harm others, do these feelings actually predict a lower likelihood of women working, or of women owning a NFE? We find no evidence that men's attitudes about how women's working affects others influence actual employment and NFE ownership outcomes for women. However, for women, the belief that their working does not harm men (by crowding them out for jobs) predicts that they are much more likely to be employed. Thus, programming convincing women that their working will not crowd out jobs for men could actually increase their willingness to work.

Table 11: Gender attitudes and women's labor participation

VARIABLES	(1) HH has NFE owned by women or both (women and men)	(2) HH has NFE owned by women or both (women and men)	(3) HH has NFE owned by women or both (women and men)	(4) Wife is employed	(5) Wife is employed	(6) Wife is employed
Ext. of disagreement N(0 1) - Prioritize boys for education (M)	-0.00	0.00		-0.03	-0.03	
	(0.03)	(0.02)		(0.02)	(0.02)	
Ext. of disagreement N(0 1)- Reserve jobs for men (M)	-0.02	-0.02		0.03	0.04*	
	(0.03)	(0.02)		(0.02)	(0.02)	
Ext. of disagreement N(0 1)- Women crowd out men for jobs (M)	-0.01	-0.01		0.02	0.02	
	(0.02)	(0.02)		(0.02)	(0.02)	
Ext. of disagreement N(0 1)- Women's work harms children (M)	0.02	0.02		-0.02	-0.02	
	(0.02)	(0.02)		(0.02)	(0.02)	
Ext. of disagreement N(0 1)- Prioritize boys for education (F)	-0.02		-0.02	-0.00		-0.00
	(0.03)		(0.02)	(0.02)		(0.02)
Ext. of disagreement N(0 1)- Reserve jobs for men (F)	0.04*		0.04	0.01		0.01
	(0.03)		(0.02)	(0.02)		(0.02)
Ext. of disagreement N(0 1)- Women crowd out men for jobs (F)	0.00		0.00	0.03		0.04*
	(0.02)		(0.02)	(0.02)		(0.02)
Ext. of disagreement N(0 1)- Women's work harms children (F)	0.01		0.02	0.01		0.01
	(0.02)		(0.02)	(0.02)		(0.02)
Constant	-0.39	-0.34	-0.38	0.20	0.24	0.23
	(0.44)	(0.43)	(0.43)	(0.39)	(0.39)	(0.39)
Observations	411	411	411	411	411	411
R-squared	0.05	0.04	0.04	0.31	0.31	0.30

Notes: (1) Standard errors in parentheses. (2) *** p<0.01, ** p<0.05, * p<0.1. (3) HH has NFE owned by women, or both (women and men) is a dummy for households that reported that in the household women owned or shared ownership with any men of a non-farm enterprise. (4)'Women is employed' is a dummy for women older than 16 years old that reported having an employment as a main occupation (if the individual reported being a student or domestic work/housewife they are considered as unemployed). (5) For columns (1)-(3), the sample for analysis includes all households. Column (4)-(6) provides information of individual level analysis for wives in households where 2 respondents (head of household and wife) answered the gender attitudes module. (6) The control variables include geographic and household-level controls.

Source: RSFS (2018).

CONCLUSION

Papua New Guinea is endowed with comparatively good agricultural potential for surplus production capacity. In addition, PNG benefits from a variety of topographical terrain that allows for diverse agricultural production output, and important land and human capital resources to transform agriculture into an important economic growth engine for the country. However, this analysis of three key agricultural value chains (poultry, sweet potato, and fresh vegetables) suggests that PNG will need to significantly improve efficiency throughout the entire agri-food value chain to remain domestically and globally competitive. Not only support to increase agricultural productivity is needed, but investments and capacity strengthening in mid-stream value chain operations such as product aggregation, transport logistics, packaging and processing, and handling are crucial to supporting a globally competitive agriculture sector.

Beyond supporting economic growth, the agriculture sector (throughout the entire agricultural value chain) in PNG will continue to be the most important sector for job creation, employment diversification, and household welfare. The analysis presented in this report suggests that supporting more efficient value chain nodes and linkages, as well as promoting inclusive participation within each value chain node (via supporting women's empowerment and decision making within the workplace and at home) could significantly improve human development indicators across the country. Our PNG-specific regression results echo earlier analysis demonstrating that where women are economically empowered and have access to decent jobs in higher-value nodes of value chains, households have higher incomes and, in some cases, improved food security outcomes (FAO, 2011). The analysis also shows that regressive gender norms (of both men and women) are, at times, limiting the potential for women to engage in different nodes of value chains. This underscores the need for policies and programming that can boost support for women taking on roles and decision-making authority that is more traditionally male.

Evaluating function and efficiency across the three study value chains suggests some overarching investments and policies that should be prioritized regardless of agricultural commodity. While policy has focused on the need to increase agricultural production capacity at the farm level, this analysis suggests that a concerted effort to increase efficiency and support infrastructure in the midstream segment (e.g., packaging, processing, handling, and systems to support real-time market price information) of the value chain is needed. Mid-stream investments may also incentivize farmers to invest in higher yielding crop technology and inputs (fertilizers, improved seed, mechanization, etc.) if they perceive a larger market for higher quality output. For the poultry value chain, investments in upstream value chain function and geographic reach are necessary, including expanding branch locations of poultry feed and day-old-chick supply. In addition, agricultural extension focused on improving handling, healthcare, and transport of chicken will be necessary to meet urban demand for poultry products.

Programs and policies aimed at strengthening midstream value chain nodes, and respective forward and backward linkages, should place an emphasis on incorporating women into leadership and off-farm employment roles within each node. Our analysis using the PNG Rural Household Survey of Food Systems (IFPRI, 2018) data suggests that women's employment in sales, trained work, and other services are associated with improvements in their decision-making in the household and further in household durable asset wealth and – for the case of women's involvement in sales and other services – a higher Household Dietary Diversity Score. Conversely, households with women employed in domestic work are associated with consuming less daily calories per capita. Reaping the benefits of these large household welfare improvements stemming from women's economic involvement in key value chains is critical for economic growth as well as ensuring that that growth is inclusive.

APPENDICES

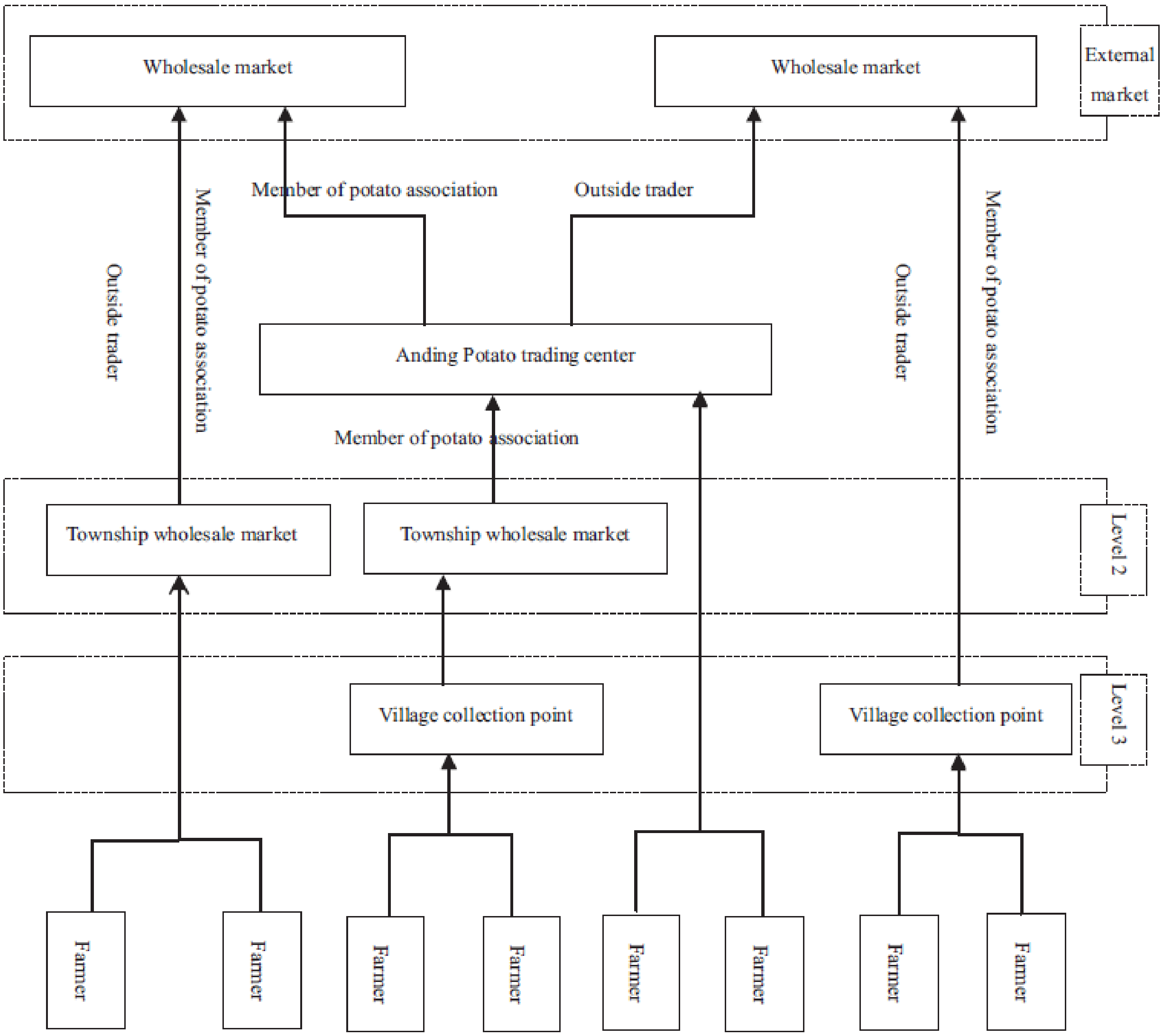
Appendix 1: Proportion of total energy and expenditure from different foods (groups) by region in urban PNG

	Metro Southern		Urban Southern		Urban Highland		Metro Momase		Urban Momase		Urban Islands	
	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.	Exp.
Sweet potato	3.5	2.0	3.3	2.4	15.6	6.7	4.4	2.6	3.3	2.2	2.5	1.8
Sago	1.5	0.2	10.2	1.8	0.2	0.0	0.8	0.1	9.4	1.8	4.4	0.8
Cassava	1.4	0.2	2.4	0.3	0.6	0.1	1.4	0.2	1.0	0.2	3.5	0.5
Other tubers	2.0	1.5	4.9	3.8	2.1	1.6	2.4	1.9	3.1	2.6	3.2	2.6
Rice and other cereals	56.3	23.9	46.5	23.8	41.8	22.7	50.1	22.3	49.0	24.7	51.7	24.8
Vegetables and fruits	2.1	6.5	2.6	7.3	3.5	9.5	3.2	8.7	2.2	6.3	1.6	5.6
Coconut	2.5	0.7	4.7	1.1	1.1	0.4	3.8	1.0	3.2	1.0	2.9	0.8
Other nuts	1.3	0.3	0.5	0.4	1.5	0.9	3.0	0.8	1.1	0.6	1.0	0.7
Chicken and eggs	5.1	9.6	3.5	8.6	8.4	11.5	4.4	10.3	4.2	8.7	2.1	6.0
Pork	1.6	0.8	1.9	1.1	4.1	2.2	3.5	1.0	1.9	1.5	7.7	5.1
Fish and seafood	4.4	6.1	5.2	8.8	2.4	4.3	2.4	4.1	3.6	7.0	4.1	7.7
Other animal-sourced food	5.8	9.4	2.7	6.9	7.7	7.3	5.4	8.5	3.5	6.0	3.0	7.0
Oils, fats	6.4	1.9	5.3	1.9	7.3	2.0	7.9	1.7	8.4	1.6	5.7	1.7
Other food	6.2	36.8	6.3	31.9	3.7	30.8	7.2	36.9	6.1	35.8	6.5	34.7

Source: HIES (2009-10).

Note: "Cal." stands for calorie share, and "Exp." Stands for expenditure share.

Appendix 2: Market structure of potato supply chain in Anding County (China) in 2011



Source: Drawn by (Zhang and Hu, 2014)

Appendix 3: Data construction details

a. Indicators as proximate Pro-WEAI indicators

Indicator (0/1)	Definition of adequacy
Asset ownership	Whether owns, either solely or jointly, at least ONE of the following: • Livestock, • Poultry, • Agricultural equipment, • Fishing equipment • House/apartment • Furniture and household goods
Credit decision	Whether individual can decide on taking on or paying off a debt
Consumption control	Whether individual can make decisions on ALL the following household purchase, spending, and education decisions: • Purchase of food for the household • Purchase of clothing for you • Purchase of clothing for children • Spending on medicine for you • Spending on medicine for children • Education for boys in household • Education for girls in household
Freedom from domestic violence	Believes husband is NOT justified in hitting or beating his wife in ALL 5 scenarios: • She goes out without telling him • She neglects the children • She argues with him • She refuses to have sex with him • She burns the food

Note: The indicators above are defined by following the logic of the IFPRI Pro-WEAI indicators (Quisumbing *et al.*, 2021). We cannot define the same indicators because the questions asked in HIES are different from the Pro-WEAI questions (except for the question regarding the attitudes about intermate partner violence against women).

Source: HIES (2009-10).

b. Construction of principle components analysis

PCA score for livestock wealth: We took the first principal component of the index score computed by the Principal Component Analysis (PCA) method to compute an index score using indicator variables of households' ownership of pigs, chicken or ducks, cows or bulls, goats, sheep, fishponds and/or crocodiles.

PCA score for production assets: We took the first principal component of the index score computed by the Principal Component Analysis (PCA) method to compute an index score using indicator variables of households' ownership of hoe/spade/fork/rake, bush knife, axe, copra drier, coffee pulper, sprayer, tractor, fishing nets, fishing line with hooks, wheelbarrow, cocoa fermentary, chainsaw, water tank, and secutor.

PCA score for durable assets: We took the first principal component of the index score computed by the Principal Component Analysis (PCA) method to compute an index score using indicator variables of households' ownership of chair, table, stoves, drum oven, kerosene lamp, refrigerator or freezer, sewing machine, solar panel, light for solar panel, electricity generator, lawnmower, traditional canoe, metal/fiberglass dinghy, outboard motor, bicycle, motorcycle, car or pick up car, radio, cell phone, television set, jewelry, mosquito net, or secutor (pruning scissors)/pruning tool.

Appendix 4: Summary statistics

a. Descriptive statistics table

Variable name	Additional description of the variable (if applicable)	N	Mean	SD	Variance	Min	Max
Daily expenditure (PGK) on food away from home per capita		989	11.95	46.86	2195.88	0.00	521.43
HDDS (out of 16 food categories)		1026	4.96	2.47	6.10	0.00	16.00
PCA score - Livestock wealth		1026	-0.00	1.20	1.43	-1.58	6.96
PCA score - asset wealth (production assets)		1026	-0.00	1.40	1.95	-3.62	7.26
PCA score - asset wealth (durables)		1026	-0.00	1.82	3.30	-1.71	15.89
At least one employed women in HH	Dummy variable: 1 if there is at least one woman aged 16-64 that is employed and 0, otherwise	1026	0.83	0.38	0.14	0.00	1.00
% of women employed (over adult women 16-64)	Presents the share of women employed aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.74	0.37	0.14	0.00	1.50
% of women employed (over all women)	Presents the share of women employed aged between 16-64 years old (numerator) out of the total number of women in the HH (denominator).	1018	0.42	0.31	0.09	0.00	1.00
Male only owned NFE	HH owns NFE that is owned solely by men.	1026	0.13	0.33	0.11	0.00	1.00
Female only owned NFE	HH owns NFE that is owned solely by women.	1026	0.10	0.31	0.09	0.00	1.00
Both male and female owned NFE	HH owns NFE that is owned by both men and women.	1026	0.15	0.36	0.13	0.00	1.00
At least one woman in agriculture (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in agriculture related activities, 0 otherwise.	1026	0.56	0.50	0.25	0.00	1.00
At least one woman is working in manual work (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in manual work-related activities, 0 otherwise.	1026	0.00	0.05	0.00	0.00	1.00
At least one woman is working in sales (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in sales (services) related activities, 0 otherwise.	1026	0.02	0.15	0.02	0.00	1.00
At least one woman is working in other services (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in other services, 0 otherwise.	1026	0.01	0.10	0.01	0.00	1.00

(continued)

Variable name	Additional description of the variable (if applicable)	N	Mean	SD	Variance	Min	Max
At least one woman is working in handicraft work (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in handicrafts related activities, 0 otherwise.	1026	0.01	0.08	0.01	0.00	1.00
At least one woman is working in domestic work (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in domestic work related activities, 0 otherwise.	1026	0.23	0.42	0.18	0.00	1.00
At least one women is working in trained work (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in trained work related activities, 0 otherwise.	1026	0.04	0.19	0.04	0.00	1.00
At least one women is working in other work (dummy)	Dummy variable: 1 if HH has at least one woman aged 16-64 that is working in other activities, 0 otherwise.	1026	0.00	0.04	0.00	0.00	1.00
% of women working in agriculture (over adult women 16-64)	Presents the share of women employed in agricultural activities aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.49	0.46	0.21	0.00	1.00
% of women working in manual work (over adult women 16-64)	Presents the share of women employed in manual work activities aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.00	0.04	0.00	0.00	1.00
% of women working in sales (over adult women 16-64)	Presents the share of women employed in sales activities aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.02	0.11	0.01	0.00	1.00
% of women working in other services (over adult women 16-64)	Presents the share of women employed in other services aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.01	0.07	0.00	0.00	1.00
% of women working in handicraft (over adult women 16-64)	Presents the share of women employed in handicraft activities aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.00	0.07	0.00	0.00	1.00
% of women working in domestic work (over adult women 16-64)	Presents the share of women employed in domestic work activities aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.19	0.37	0.14	0.00	1.00

(continued)

Variable name	Additional description of the variable (if applicable)	N	Mean	SD	Variance	Min	Max
% of women working in trained work (over adult women 16-64)	Presents the share of women employed in trained work activities aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.03	0.15	0.02	0.00	1.00
% of women working in other work (over adult women 16-64)	Presents the share of women employed in other activities aged between 16-64 years old (numerator) out of the total number of women between 16-64 years old (denominator).	987	0.00	0.03	0.00	0.00	1.00
HH-produces Sweet potato	Dummy variable: 1 if HH produces sweet potato, 0 if otherwise	1026	0.59	0.49	0.24	0.00	1.00
Women work the most on sweet potato production	Dummy variable: 1 if women work the most on SP production, 0 if otherwise.	603	0.29	0.45	0.21	0.00	1.00
Both work the most on sweet potato production	Dummy variable: 1 if women work the most on SP production, 0 if otherwise.	603	0.69	0.46	0.21	0.00	1.00
HH sells sweet potato	Dummy variable: if HH sells sweet potato, 0 if otherwise	1026	0.21	0.41	0.17	0.00	1.00
Only women sell sweet potato	Dummy variable: 1 is SP is sold only by women, 0 if otherwise	218	0.89	0.31	0.10	0.00	1.00
Both women and men sell sweet potato	Dummy variable: 1 is SP is sold by both women and men, 0 if otherwise	218	0.05	0.22	0.05	0.00	1.00
HH sells vegetables	Dummy variable: if HH sells vegetables, 0 if otherwise	1026	0.48	0.50	0.25	0.00	1.00
Only women sell vegetables	Dummy variable: 1 is vegetables are sold only by women, 0 if otherwise	497	0.92	0.27	0.07	0.00	1.00
Both women and men sell vegetables	Dummy variable: 1 is vegetables are sold only by both women and men, 0 if otherwise	497	0.04	0.21	0.04	0.00	1.00
Gender of household head	Dummy variable: 1 if female, 0 if male	1026	0.10	0.30	0.09	0.00	1.00
Household head marital status (1=married)	Dummy variable: 1 if married, 0 if otherwise	1026	0.92	0.26	0.07	0.00	1.00
Household head is polygamous	Dummy variable: 1 if 2 or more wives, 0 if otherwise	1026	0.03	0.18	0.03	0.00	1.00
Age of household head	Dummy variable: 1 if HHH is >=35 years old	1026	0.29	0.45	0.21	0.00	1.00
Ed level of HHH: No schooling	Dummy variable: 1 if HHH did not attend school	1026	0.11	0.31	0.10	0.00	1.00
Ed level of HHH: Primary	Dummy variable: 1 if HHH highest education level is primary	1026	0.49	0.50	0.25	0.00	1.00

(continued)

Variable name	Additional description of the variable (if applicable)	N	Mean	SD	Variance	Min	Max
Ed level of HHH: Secondary	Dummy variable: 1 if HHH highest education level is secondary	1026	0.34	0.47	0.22	0.00	1.00
Ed level of HHH: Beyond secondary	Dummy variable: 1 if HHH highest education level is beyond secondary	1026	0.07	0.25	0.06	0.00	1.00
Language:Tok Pisin	Dummy variable: 1 if HHH speaks Tok Pisin	1026	0.99	0.11	0.01	0.00	1.00
Language:Hiri Motu	Dummy variable: 1 if HHH speaks Hiri Motu	1026	0.00	0.03	0.00	0.00	1.00
Language:Unserdeutsch	Dummy variable: 1 if HHH speaks Unserdeutsch	1026	0.00	0.03	0.00	0.00	1.00
Language:English	Dummy variable: 1 if HHH speaks English	1026	0.44	0.50	0.25	0.00	1.00
Language:Local village dialect	Dummy variable: 1 if HHH speaks Local village dialect	1026	0.93	0.25	0.06	0.00	1.00
N of adult women	Number of adult women in working age (16-64 years old) in the HH	1026	1.49	0.90	0.80	0.00	6.00
N of adult men	Number of adult men in working age (16-64 years old) in the HH	1026	1.55	1.11	1.24	0.00	8.00
N. of HH members	Number of total household members	1026	5.90	2.22	4.91	1.00	17.00
Province: Autonomous Region of Bougainville		1026	0.24	0.43	0.18	0.00	1.00
Province: East Sepik		1026	0.24	0.43	0.18	0.00	1.00
Province: Madang		1026	0.28	0.45	0.20	0.00	1.00
Province: West Sepik (Sandaun)		1026	0.23	0.42	0.18	0.00	1.00

Source: RSFS (2018).

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