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Household Wellbeing in Rural Papua New Guinea

Poverty Analysis from the 2023 PNG Rural Household Survey

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Abstract

This analysis provides the first poverty assessment using the cost of basic needs approach in Papua New Guinea in 1.5 decades. The cost of basic needs poverty methodology is the standard approach to estimating poverty in low- and middle-income countries. It aims to reflect the cost of a food basket and non-food needs to secure a healthy life and minimum standard of living. Using the cost of basic needs approach, we calculate and compare two poverty measurements. First, we compute a standard (traditional) cost of basic needs poverty line where the food poverty line is defined by a dietary energy (calorie) threshold. Second, we extend the standard cost of basic needs approach to calculate a healthy diet food poverty line that meets both the dietary energy threshold, as well as recommended nutrition targets.

Results suggest that 43 percent of sample individuals live below the standard cost of basic needs poverty line. When recalculating the poverty line to account for a healthy diet threshold (a mix of food groups set at quantities consistent with dietary guidelines), we find that 64 percent of the sample is below the healthy diet poverty line. On average, households within the survey sample over-consume the recommended daily quantity of staples and fats, however daily consumption of vegetables, fruits, and protein-rich foods (e.g., fish, meat, nuts) fall short of recommended targets.

The above poverty analysis begs the question of what characteristics are associated with higher income earning households (we use per capita consumption-expenditure as the rural income proxy). Regression analysis suggests that greater production assets (land and labor), education, market access, and income diversification (via non-farm businesses and migrant remittances) are associated with higher household incomes. While we hypothesized that households engaged in cash crop sales (i.e. cocoa, coffee, betelnut, horticulture) would be significantly better off, we find that only cocoa farming households have significantly higher incomes.

The regression analysis reveals that facilitated access to a market is one of the most important indicators explaining per capita consumption-expenditure (i.e. income per person). Households that are more than 4 hours from a market have about 25 percent less income compared to households that are within 2 hours from a market. Conversely, households that report owning a small business (non-farm enterprise) are associated with approximately 25 percent greater consumption-expenditure per capita. While market access and income diversification are important to household incomes, weather shocks such as floods are associated with significant declines (8 percent) in per capita consumption-expenditure.

Given the above results, a pilot social safety net program in more remote (greater than 4 hours from a market) and flood prone areas, where household incomes are significantly lower, may provide important insights on the most efficient mechanisms to build resilience among PNG's vulnerable population. Including a community asset building component (e.g., building and maintenance of rural feeder roads and bridges) in the social safety net program could be tested to understand how best to support rural-urban market linkages and incentivize off-farm employment.

Understanding that a social safety net program requires significant resourcing (including financial, logistics and time), there are other opportunities to improve rural welfare within the country. Facilitating remittance transfers from migrants to rural households via electronic banking services and easing banking

costs for rural households may increase remittance payments. In addition, facilitating access to primary education via reduced school fees and increasing school attendance via school feeding programs could provide greater income earning opportunities for better educated households, as well as (if designed properly) fill some of the nutrition gaps demonstrated by the large share of individuals that live under the healthy diet poverty line presented in this paper.

Key words: Poverty, Papua New Guinea, nutrition, income, expenditure, rural household survey

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1. Introduction

Nutrition shortcomings in lower middle-income countries (LMICs) across the globe have redirected attention toward monitoring households ability to acquire diets that meet nutrition guidelines (Dizon, Herforth, and Wang, 2019; FAO et al. 2020, 2021, 2022, 2023; Herforth et al., 2020, 2024; Hirvonen et al., 2020; Mekonnen et al., 2021, 2023; Mwambi, 2023; Raghunathan, Headey, and Herforth, 2021; Van, 2023). This recent focus is particularly relevant for Papua New Guinea which relies on domestically produced food sources (that are facing mounting climate change risks), and reliable and affordable food imports (that are vulnerable to adverse trade policies and price fluctuations) to meet dietary needs.

Given the lack of data and analysis on food security and the prevalence of child undernutrition in Papua New Guinea (PNG), the International Food Policy Research Institute (IFPRI) designed a comprehensive Rural Household Survey (PNG-RHS) that collected detailed food and non-food consumption and expenditure data from 2,699 rural households across 14 provinces. Prior to this survey, the most recent consumption and expenditure survey was conducted in 2009/10, leaving policymakers with little evidence on poverty incidence and nutrition indicators to make informed investment decisions. The PNG-RHS aimed to inform key indicators including poverty incidence, off-farm employment opportunities, and associated household and community characteristics that shape welfare outcomes in rural areas of the highland, lowland and island areas of the country.

The analysis presented in this paper uses the cost of basic needs approach to calculate and compare two poverty measurements. First, we compute a standard cost of basic needs poverty line where the food poverty line is tied to a dietary energy (calorie) threshold. Second, we extend the standard cost of basic needs approach to calculate a healthy diet food poverty line that is tied to recommended nutrition targets while also meeting energy adequacy (put forth by Mahrt et al., 2022). While the PNG-RHS is not statistically representative of all rural areas of PNG, it provides the most expansive quantitative update to rural welfare measurements in PNG in nearly 1.5 decades.[1]

Results suggest that 43 percent of sample individuals live below the standard cost of basic needs poverty line. When recalculating the poverty line to account for a healthy diet threshold (a mix of food groups set at quantities consistent with dietary guidelines), our analysis reveals that almost 2/3 of the sample is below the healthy diet poverty line. We find that, on average, households within the survey sample overconsume the recommended daily quantity of staples and fats, however daily consumption of vegetables, fruits, and protein-rich foods (e.g., fish, meat, nuts) fall short of recommended targets.

[1] Papua New Guinea implemented their last nationally representative Household Income Expenditure Survey in 2009/10 (HIES 2009/10).

Finally, we evaluate the correlates of total household consumption-expenditure to identify investment opportunities for improving welfare outcomes across the PNG rural landscape. We test 3 hypotheses following previous literature: 1) greater production assets (land and labor) and engagement in specific cash crop sales (coffee, cocoa, betelnut, and horticulture), 2) income diversification, and 3) households with greater income earning potential or whose household members hold official positions in the community are associated with higher consumption-expenditure per capita (which we use as an income proxy). Regression results suggest that households with greater land holdings and a larger ratio of working adults to total household members are associated with greater per capita income. While cash crop (e.g., coffee, cocoa, betelnut, and horticulture) production has been lauded as the key to rural poverty alleviation, the analysis finds that only households that cultivate cocoa enjoy statistically significant higher household incomes. Focusing on off-farm employment, results suggest that non-farm enterprise (small business) ownership is associated with the largest positive (25 percent) difference in per capita consumption-expenditure compared to households that do not own an NFE. However, wage labor does not have a significant effect on consumption-expenditure outcomes. Finally, households that experienced a flood during the last five years have significantly lower per capita incomes, ceteris parabis, compared to households that did not report flooding. However, households that experienced drought conditions are not associated with significant income differences.

The remainder of the paper is organized as such: the following section reviews the available literature on poverty analysis in PNG. Section 3 describes the methodology used to calculate agroecological zone (AEZ) specific poverty lines and poverty prevalence. In doing so, we provide the empirical specification that we extend to calculate healthy diet poverty lines. Section 4 describes the data and discusses the reference dietary guideline used to inform the food basket targets for the healthy diet poverty lines. Section 5 provides results of the analysis, comparing differences in the costs and associated poverty prevalence of the standard poverty lines and the healthy diet poverty lines. In addition, we evaluate the correlates of improved welfare outcomes using an ordinary least squares regression (OLS). Section 6 concludes by focusing on policy implications and opportunities for poverty reduction in PNG.

2. Recent poverty estimation in Papua New Guinea

Discussions of household welfare and poverty in PNG centers around whether rural livelihoods provide sufficient resources for households to maintain a minimum standard of living including sufficient dietary energy (Bourke, 2005; Gibson, 2012; Gibson and Rozelle, 1998; Gibson and Rozelle, 2003; Rogers, 2011; Schmidt et al., 2021). However, there is no empirical evidence assessing whether rural households in PNG have the means to acquire a diet consistent with nutrition guidelines while also meeting other basic needs. Previous PNG policy documents (UNDP, 2014; National Department of Health, 2014) have stated the need to better assess the gaps and challenges in ensuring healthy diets to PNG rural and urban households. Schmidt et al. (2021) argue that the absence of updated and representative consumption and expenditure data is a barrier to conducting analyses needed to design, adapt and improve nutrition and poverty alleviation programs.

The 2009/10 Household Income Expenditure Survey (HIES 2009/10) and the 1996 Papua New Guinea Household Survey (PNGHS) are the two most recent nationally representative surveys with detailed consumption and expenditure data needed for monetary poverty analysis. Gibson and Rozelle (1998,

2003) and Gibson (2012) estimated regional standard costs of basic needs poverty lines to calculate national poverty headcount rates from each survey. Despite efforts to maintain consistency in the poverty estimation methodology, differences in survey design between the 1996 PNGHS and the 2019/10 HIES result in imperfect comparability between the methods (Gibson, 2012). In 1996, an estimated 37.7 percent of the population was poor compared to 39.9 percent in 2009/10, a statistically insignificant difference (Gibson, 2012; Gibson and Rozelle, 1998).

The World Bank's international poverty line (currently set at $2.15 (2017 PPP) per person per day) is designed to allow for poverty comparisons across countries.[2] Using the 2009/10 HIES, the World Bank estimated poverty in PNG to be 39.7 percent of the population. In 2009, poverty in PNG (39.7 percent) was considerably higher than the 2009 global average (17.9 percent) and the 2009 lower-middle income country average (25.5 percent) (World Bank 2023). While useful for cross-country comparisons, the international poverty line lacks specificity to local conditions that are incorporated when calculating a given country's cost of basic needs poverty lines –notably, local norms, relative prices, and the composition of essential nonfood needs.

The Multidimensional Poverty Index (MPI) has also been calculated for PNG, which estimates non-monetary poverty in the form of household deprivations in health, education, and living standards (OPHI, 2022). The MPI and national and international monetary poverty indicators are complementary as they assess different aspects of household poverty and thus triangulate poverty outcomes. PNG's MPI was calculated using data from the 2016/18 Demographic and Health Survey (OPHI, 2022). Overall, 57 percent of the PNG population was considered MPI poor. More than 60 percent of the MPI index was attributed to poor living standards.

The 2022 Socio-Demographic and Economic Survey implemented by the National Statistical Office is the most recent nationally representative survey aimed at generating key data indicators by understanding labor portfolios, education rate and household characteristics across the country. While the survey collects information on asset ownership by households and housing quality, a detailed consumption and expenditure module was beyond the scope of the survey, making it difficult to leverage the data for monetary poverty estimation. However, the Socio-Demographic and Economic Survey would be useful to estimate multidimensional poverty.

Recognizing the lack of updated monetary poverty estimates to inform key policy dialogue on poverty reduction and opportunities to improve household wellbeing, we estimate poverty headcounts using the detailed consumption and expenditure data collected in the 2023 PNG-RHS. In doing so, we calculate both standard cost of basic needs poverty lines and healthy diet poverty lines by AEZ.

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2 The World Bank's international poverty line is the median national poverty line in 28 low-income countries, adjusted for differences in purchasing power (Jolliffe et al., 2022).

3. Methodology

The cost of basic needs poverty methodology is the standard approach to estimating poverty in low- and middle-income countries. It aims to reflect the cost of a food basket associated with achieving good health (defined by a nutrition standard), along with the cost of other essential non-food needs required to attain a minimum standard of living (Ravallion, 1994, 1998, 2020; Ravallion and Sen, 1996). The cost of basic needs food poverty line is defined by the cost of a food basket that reflects the consumption patterns of poor and near poor reference households while also aligning with a nutrition standard. Conventionally, the nutrition standard is limited to dietary-energy (calorie) needs. Mahrt et al. (2022) developed a healthy diet approach which extends the cost of basic needs food poverty line to align with dietary guidelines. For purposes of comparison, we estimate poverty prevalence by imputing both the standard cost of basic needs poverty lines and the healthy diet poverty lines.

Consistent with previous poverty estimations in PNG, we reflect local conditions such as relative prices, availability, and food norms by producing sub-national (by defined agro-ecological zone - AEZ) poverty lines (Gibson and Rozelle, 2003; Gibson, 2012; Schmidt et al., 2021). However, calculating different poverty lines across geographic areas likely results in poverty lines that represent varying utility levels. When poverty lines are utility inconsistent – intuitively they represent different levels of quality – it is possible that households with a given real consumption-expenditure level could be deemed poor in one AEZ, yet non-poor in another AEZ, which would render poverty rates noncomparable.

Revealed preference theory provides a method for testing whether AEZ food poverty lines are utility-consistent, without requiring specification of an explicit utility function (Gibson and Rozelle, 2003; Ravallion and Lokshin, 2006). To ensure that AEZ food poverty lines represent a similar level of utility, we estimate utility-consistent food poverty lines for both the standard and the healthy diet food poverty lines by adopting an information-theoretic approach to resolving utility inconsistency by imposing revealed preference constraints (Arndt and Simler, 2005, 2007, 2010; Mahrt et al., 2022). [3]

[3] The information theoretic approach for resolving utility inconsistency applies a cross-entropy criterion that minimizes the directed distance between food quantities in original food baskets and estimated quantities that satisfy revealed preference conditions, respectively. This approach to ensuring utility consistency in standard food poverty lines is standardized in a combination of STATA and Gams code called Poverty Line Estimation Analytical Software (PLEASe), (Arndt and Mahrt 2017).

3.1. Standard poverty lines

Regional standard food poverty lines are specified as:

$$z_r = \sum_i p_{ir} * \ q'_{ir} \qquad \forall r \qquad [1]$$

where:

$$k_r = \sum_i c_i * q_{ir} \qquad \forall\, r \qquad [1a]$$

$$q'_{ir} = \frac{k^T}{k_r} * q_{ir} \qquad \forall\, i, r \qquad [1b]$$

i is an index of foods in the consumption basket;

r is an index of agroecological zones across space;

q_{ir} represents quantities in grams of food i consumed by reference poor households;

c_i represents calories per gram;

p_{ir} represents price per gram paid by reference poor households; and

k^T represents the dietary energy target of a reference adult measured in calories.

Thus, the standard food poverty line (z in Equation 1) is the sum of the price per gram in reference households (p) of a basket of food items indexed by i, times the quantity (q') of each food item, by agroecological zone (r). The variable q' represents reported food quantities (q) scaled such that the total energy content of the food basket, measured in calories per gram (c), meets the dietary energy target (k^T) of a reference adult across all AEZs.[4]

We estimate non-food allowances as the average of what may be considered the upper and lower bounds on the level of non-food expenditure needed to meet basic, non-food needs in each AEZ (Ravallion, 1994; Arndt and Mahrt, 2017).

1. Households with *total consumption-expenditure* within 20 percent of the standard food poverty line – households that may need to forego food expenditure to meet essential non-food needs

[4] We eliminate from the basket any food consumed away from home such as at restaurants, etc. (which lacks the details necessary to assess its dietary energy content). Food consumed away from home accounts for 0.8 percent of total household food expenditure in the survey sample areas (most likely due to the rural nature of the survey).

2. Households with *food consumption-expenditure* within 20 percent of the standard food poverty line – households that can meet dietary energy requirements and thus are assumed to have also met essential non-food needs.

By averaging the non-food expenditure in the two sets of households described above we arrive at a non-food allowance falling between these upper and lower bounds.

The total standard poverty line at agro-ecological zone is the sum of the standard food poverty line and the non-food allowance. Households with daily per adult equivalent consumption-expenditure below the relevant AEZ defined poverty line are deemed poor.[5]

To ensure that poverty lines reflect the consumption patterns of households near the poverty line, we implement an iterative procedure (Ravallion 1994) whereby reference households (20 percent of the population weighted consumption-expenditure distribution just above and below the standard poverty line) are updated after each iteration until AEZ poverty rates converge. Food poverty lines in the final iteration are adjusted to ensure utility consistency using the information theoretic approach developed by Arndt and Simler 2005, 2007, 2010). Finally, the non-food allowance is recalculated using the utility-consistent, regional standard food poverty lines to obtain the final standard poverty lines and final poverty headcounts.

3.2. Healthy diet poverty lines

We adopt the healthy diet poverty line methodology developed by Mahrt et al. (2022) which expands upon the standard food poverty line specified in Equation 1 by incorporating a set of food group (e.g., staples, vegetables, fruits, etc.) specific calorie thresholds. Consumption patterns of reference households are specified in terms of dietary energy, which allows the food basket to align with food group targets and the dietary-energy target. AEZ defined healthy diet food poverty lines are specified as:

$$h_r = \sum_f \sum_{i_f} p_{i_f r} * s_{i_f r} * d_f \qquad \forall\, r \qquad [2]$$

where:

$$s_{i_f r} = \frac{k_{i_f r}}{\sum_{j_f} k_{j_f r}} \qquad \forall\, i_f, r \qquad [2a]$$

$$k_{i_f r} = \mathrm{c}_i * q_{ir} \qquad \forall\, i_f, r \qquad [2b]$$

$$k^T = \sum_f d_f \qquad [2c]$$

[5] Total consumption-expenditure serves as the welfare standard. Consumption-expenditure is a more appropriate welfare standard than income in LMICs like PNG that are characterized by a large share of subsistence agriculture, informal labor markets, and income seasonality, which is typically at least partially offset by consumption smoothing.

f is an index of food groups;

i_f, j_f are indices of foods in food group f;

r is an index of AEZs across space;

q_{ir} represents quantities in grams of food i consumed by reference poor households;

c_i represents calories per gram;

p_{ir} represents price per calorie paid by reference poor households;

d_f represents healthy diet food group targets in calories; and

k^T represents the dietary energy target of the reference adult measured in calories.

Thus, for each AEZ (r), the total value of the healthy diet food poverty line (h in Equation 2), equals the sum of the costs of the healthy diet food groups. Food group costs equal the sum across foods in the food group (i_f) of the price per calorie of food i multiplied by the food group calorie target (d) weighted by within-food group calorie-shares (s_i). Unlike the standard food poverty line, d need not be scaled as food group calorie guidelines sum to the energy requirements of a reference adult (k^T).[6] Reference households are those identified in the final iteration of the standard poverty calculations.

In addition to the standard non-food allowance, the healthy diet poverty line also incorporates an allowance for culturally important foods, such as spices, seasonings, coffee, and tea. These foods are not included in dietary guidelines but are included in standard food poverty line baskets. The total healthy diet poverty line is the sum of the healthy diet food poverty line, the standard non-food allowance, and the seasonings allowance (by agroecological zone).

[6] Unlike standard food baskets, healthy diet baskets are restricted to foods that can be clearly classified into food groups specified in dietary guidelines. Consequently, in addition to food away from home, foods such as spices and alcoholic beverages are excluded from the healthy diet food poverty line.

4. Empirical application

4.1. PNG Rural Household Survey 2023

No nationally representative consumption and expenditure data have been collected in PNG since the 2009/10 HIES.[7] The 2016–2018 PNG Demographic and Health Survey (DHS, 2016-18) collected important indicators on individual nutritional status, however detailed household food consumption and expenditure data used for monetary poverty analysis were not collected.

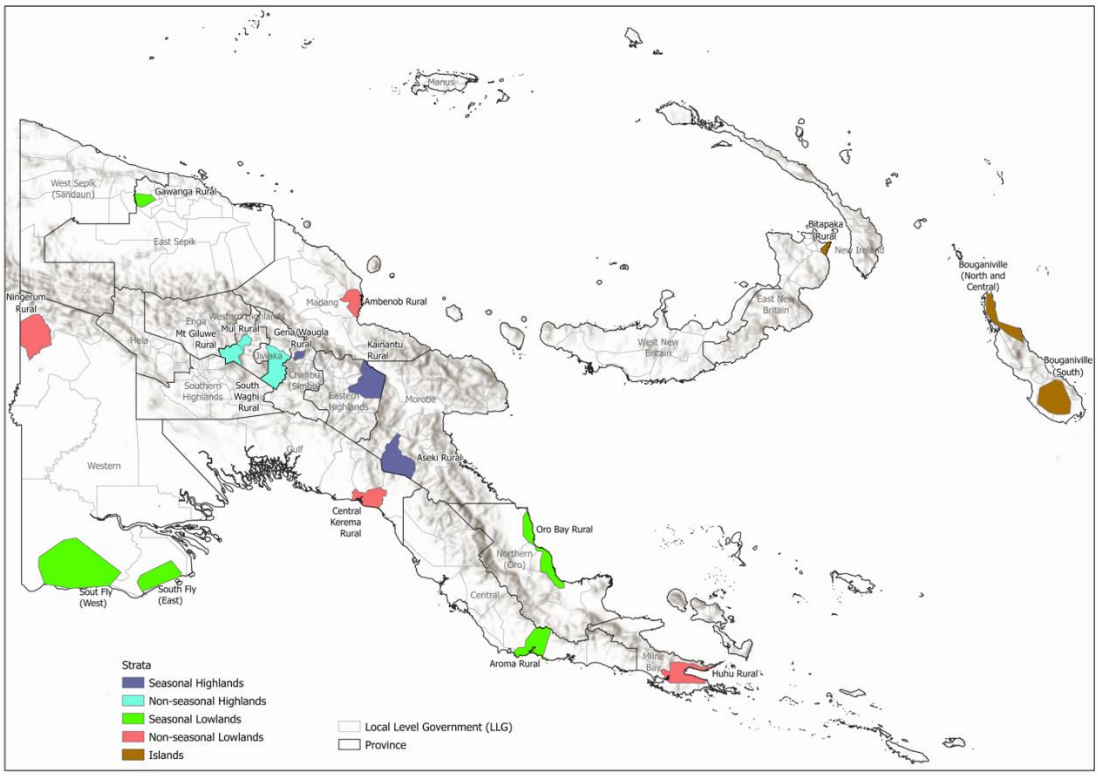
It is within this context that the research team implemented the 2023 PNG-RHS between May and December 2023. The survey collected detailed household-level data on agricultural production, food and non-food consumption and expenditure, and livelihood strategies across 14 provinces, including communities in the highlands, lowlands, and islands of PNG (Figure 1). It is important to note, however, that the PNG-RHS survey is not nationally representative. Instead, a purposive sample was chosen using criteria that enable analysis of the key factors that interact within rural households and communities to result in more resilient local food systems, more diversified employment profiles, and improved household wellbeing. The cluster sample of this survey, carefully designed to evaluate rural livelihood profiles that are shaped by agroecological potential allows for robust comparison between highland and lowland households, as well as between rainfall (seasonal vs. non-seasonal) patterns within the highland and lowland areas of the country. Similarly, it provides a detailed picture of the diverse livelihood patterns between island and mainland communities.

Given that agricultural livelihood representativeness was an important consideration in selecting survey sample areas, we used agroecological criteria – elevation and rainfall seasonality – from both mainland PNG and island locations to ensure that analyses using the survey data could be generalizable and broadly applicable beyond the survey areas. Given PNG's wide-ranging elevation (0 – 4,500 meters above sea level) and associated variation in rainfall due to topographic differences, rural household livelihood is shaped around agroecological patterns and opportunities. Within the five agroecological classifications, the subdistrict local-level government (LLG) areas of rural PNG were used as the administrative area for randomly selecting survey areas. Within the randomly selected LLGs, communities were randomly chosen as lower-level clusters. Within these communities, the research team compiled and updated a comprehensive listing of households in each of the selected communities prior to randomly selecting ten households to interview per community.[8]

[7] While the 2018 State of Food Security and Nutrition in the World report (FAO, 2018) provides analysis on child nutrition status, it uses the 2009/10 HIES data to compute key indicators.

[8] For greater detail on survey sampling and methodological concerns, please refer to Schmidt et al. (2024).

Figure 1: 2023 PNG Rural Household Survey sample selection



Note: Administrative boundaries from National Statistical Office, Papua New Guinea; and hill shade from Environment System Research Institute (ESRI). Source: Created by authors.

4.2. Household consumption and expenditure data

We use the PNG-RHS to calculate AEZ specific poverty lines. The survey is comprised of 2,699 households in 270 communities across 5 agroecological zones (Table 1). The questionnaire asks respondents to report the quantity of each of 75 different food items that the household consumed during the previous week; its source (own-produced, purchased, or received as a gift); and the amount paid for purchased food items. In addition, respondents were asked to report non-food and durable expenditures of 47 different items. These items were disaggregated into monthly and yearly expenditures depending on expenditure type (e.g., detergent and other household goods were reported as monthly expenditures, while less frequent expenditures such as furniture or clothing were reported as yearly expenditures).

Table 1. Agroecological zones used in poverty line estimations

Agroecological zone	Number of households	Number of reference households	Districts
Seasonal highlands	451	187	Kainanatu, Kerowagi, and Menyamya
Non-Seasonal highlands	450	170	Anglimp/South Waghi, Tambul, and Mul/Baiyer
Seasonal lowlands	748	291	Abau, Ambunti/Drekikier, South Fly, and Popondetta
Non-seasonal lowlands	600	205	Madang, North Fly, Kerema, and Alotau
Islands	450	169	Central Bougainville, Kokopo, North Bougainville, and South Bougainville

Note: Number of reference households in the final iteration of the pre-entropy standard poverty estimates. Source: PNG-RHS (2023)

From this consumption and expenditure data we calculate the indicators required for poverty measurement including: 1) unit values (prices) of each food item faced by reference poor households; 2) food consumption quantities per adult equivalent of reference poor households; and 3) food, non-food, and total consumption-expenditure per adult equivalent of all households.[9] All monetary values are adjusted for differences in living costs across survey areas. In particular, a survey specific price index is calculated using the relative cost of a fixed food basket across 18 sentinel survey sites.

All food quantities and prices are calculated accounting for only the edible portion of each food item.[10] To facilitate comparison across varying household demographic compositions, household food consumption quantities and household expenditure are reported per adult equivalent. We compute equivalency scales for each household member based on age and sex-specific daily energy requirements relative to a reference adult (the average of moderately active 30-year-old males and females – 2,432 calories).[11]

[9] The PNG-RHS contains insufficient data to calculate the value of services from dwellings, which is typically a component of a consumption aggregate (Deaton and Zaidi, 2002).

[10] The data on edible portions, energy content, and nutrient composition of foods are primarily sourced from USDA Food Composition Database (2016), with additional information supplemented by the Indonesia Food Composition Table (TKPI, 2019), the Bangladesh Food Composition Database (Shaheen et al., 2013), a WorldFish database (Scott, 2019) and Pacific Islands Food Composition Tables (Dignan et al., 2004) for select items.

[11] We adopt the daily energy needs by sex and age described in Mahrt et al. (2019) for Myanmar given similarities in BMI, weight and height data reported for PNG (Benjamin et al., 2007).

4.3. Reference diet

A reference diet for PNG with quantified consumption guidelines by food group provides the nutrition standard for calculating healthy diet food poverty lines. Incorporating nutrition thresholds into the poverty analysis requires dietary parameters, often outlined in national Food Based Dietary Guidelines (FBDG), that define food group quantities associated with a nutritious and well-balanced diet. Given that PNG has yet to develop a country-specific FBDG, we reviewed the available FBDGs within the Asia Pacific region (including Indonesia, Fiji, and the Philippines) and the internationally developed Healthy Diet Basket (Herforth et al., 2022). We then developed a PNG specific reference diet by adapting the diet recommended in the Indonesia FBDG (Ministry of Health of the Republic of Indonesia 2014).

We chose to adapt the Indonesia FBDG because it has the most comprehensive quantified guidelines that are consistent with food types and consumption patterns in PNG (Table 2).[12] It provides consumption targets for starchy staples, vegetables, fruit, animal sourced foods, plant-based protein-rich foods, and added oils and fats, and also provides guidelines of upper bounds on sugar intake. The Indonesia guidelines recommend specific serving sizes and numbers of servings for several age groups by sex. For this analysis, we specify the adapted reference diet using average guidelines for male and female adults aged 30-49 (Table 2). We increase the guidelines for dietary energy from staple foods so that the reference diet aligns with the 2,432 calorie needs of an average adult in PNG.

In order to adapt the Indonesian guidelines to more appropriate food consumption patterns of PNG, we reallocate two of the three recommended servings of plant-based protein rich foods (in the Indonesian FBDG) to the Animal Source Food (ASF) group for PNG.[13] Unlike the Indonesian diet that includes a variety of plant-based protein rich foods such as nuts, pulses, tofu, and tempeh, PNG consumes more ASF compared to plant-based protein (which is limited to nuts in PNG).

[12] In addition, the Indonesia diet closely resembles the food group categories and quantities proposed as the target measures for the global Healthy Diet Basket by Herforth et al. (2022).

[13] The Indonesia guidelines use tempeh as the representative food for the plant-based food group. Based on the protein content of tempeh relative to fish, two servings of tempeh are converted to 1.25 servings of fish and added to the already recommended three servings of ASF. The third serving of plant-based proteins is converted to a serving of nuts and pulses based on the protein content of peanuts relative to tempeh.

Table 2. PNG reference diet adapted from Indonesia FBDG, calories per adult (aged 30-49 years) per day

	Staples	Vegeta-bles	Fruits	Animal source foods	Nuts and pulses	Fats	Discretionary foods (sugary foods)
Recommended calories per day	1,300	110	165	304	118	275	160

Source: Adapted from the Indonesia food-based dietary guidelines (Ministry of Health of the Republic of Indonesia 2014) and authors' calculations.

We use guidelines on sugary foods to represent discretionary food consumption.[14] Inclusion of discretionary foods is consistent with the cost of basic needs approach which stipulates that poverty lines represent diets actually consumed, including nutritionally unnecessary foods (Ravallion, 2016, 2020). Including the discretionary food group, along with the seasoning allowance, also improves comparability of the healthy diet poverty line with the standard poverty line.

4.4. Food consumption descriptive statistics

Table 3 reports average daily dietary energy consumption per adult equivalent by food group and compares these values with the PNG reference diet (Table 2). On average, households within the survey sample over-consume the recommended daily quantity of staples and fats, however daily consumption of vegetables, fruits, animal source foods, and nuts and pulses fall short of recommended targets.[15] Looking within AEZs, on average, households in the seasonal lowlands AEZ nearly consume the recommended amount of animal source foods. This is expected because an important share of the seasonal lowlands sample lives along rivers or along the coastline. The main source of animal source foods for seasonal lowland households is fish or seafood. Conversely, households in the seasonal highlands and islands AEZs consume approximately one-half of the suggested daily animal source foods recommendation (143 and 144 calories per day, respectively). While one may suspect that households in the islands would benefit from greater fish and seafood consumption, two-thirds of the islands survey sample is composed of north and south Bougainville, where communities living in the interior of the island have limited access to marine fish and seafood.

[14] Sugary foods in the survey include sugar, honey and other sweeteners; Milo or 3-in-1 instant coffee; soda and soft drinks, and sugar cane.

[15] A predominant source of fat in PNG cuisine derives from coconut milk. Coconut milk is used for flavor and texture throughout PNG cuisine and has important cultural and ceremonial value as well.

Table 3. Recommended and consumed calories of each food group, per adult equivalent/day, by agroecological zone

	Staples	Vegetables	Fruits	Animal source foods	Nuts and pulses	Fats	Discretionary foods
Recommended diet	1300	110	165	304	118	275	160
Survey sample	1339	69	93	204	53	323	61
	(14.7)	(1.3)	(1.9)	(4.9)	(2.0)	(5.7)	(1.4)
Seasonal highlands	1278	89	108	143	91	118	45
	(30.0)	(3.0)	(5.7)	(8.7)	(6.8)	(4.8)	(2.5)
Non-seasonal highlands	1265	105	87	230	95	186	61
	(29.6)	(3.2)	(4.6)	(11.6)	(5.8)	(7.7)	(2.9)
Seasonal lowlands	1169	60	99	284	29	452	74
	(27.4)	(2.8)	(3.8)	(12.4)	(2.7)	(12.0)	(3.7)
Non-seasonal lowlands	1478	54	83	167	35	325	65
	(27.9)	(2.1)	(3.4)	(7.0)	(4.0)	(10.7)	(2.5)
Islands	1594	52	83	144	45	412	46
	(45.8)	(2.9)	(3.8)	(7.1)	(3.8)	(15.6)	(2.4)

Note: Standard errors in brackets.
Source: Authors' calculations using the PNG-RHS (2023).

Households across the survey sample substantially under-consume vegetables and fruits. For subsistence farmers and lower income households, this may be due to a variety of factors including: limited physical capital (land or labor) to produce sufficient food quantities; poor land endowments/land fertility or ongoing land degradation; lack of access to inputs (seed and fertilizer) and technology to produce and store more perishable fruits and vegetables; climate variability; and/or higher levels of production risk. Lower-income households may also face food security tradeoffs, substituting fruits and vegetables for less expensive, energy-dense staples to ensure that energy (calorie) needs are met.

5. Results

5.1. Poverty line costs and composition and household poverty prevalence

Table 4 presents utility consistent food poverty lines, the non-food expenditure allowance, the healthy diet seasoning allowance and the total poverty lines for the standard and healthy diet. Both food poverty lines are based on the same reported consumption patterns and meet the specified energy target of 2,432 calories per adult-equivalent per day. The difference between the standard and the healthy diet food poverty line baskets is that the healthy diet basket defines food quantity thresholds within food groups scaled to meet the reference healthy diet (reported in Table 2), while the standard poverty line defines food quantity thresholds to solely meet an energy (calorie) threshold. Thus, the higher cost of the healthy diet food basket is driven by cost differences in meeting within food group thresholds to ensure key nutrients are included in the food basket requirements. The total standard poverty line for each of the AEZs

varies between 7.43 PGK (non-seasonal lowlands) and 8.26 (seasonal highlands) PGK per adult-equivalent per day. The total healthy diet poverty line varies between 9.35 (seasonal lowlands) and 11.06 (non-seasonal lowlands) PGK per adult-equivalent per day.

Table 4: Utility-consistent absolute poverty lines, by agroecological zone (PGK/adult-equivalent/day)

	Standard food poverty line	Healthy diet food poverty line	Non-food expenditure allowance	Healthy diet seasonings allowance	Standard total poverty line	Healthy diet total poverty line
Seasonal highlands	6.96	8.87	1.30	0.19	8.26	10.36
Non-seasonal highlands	6.69	8.62	1.31	0.16	7.99	10.09
Seasonal lowlands	5.90	8.00	1.09	0.26	6.99	9.35
Non-seasonal lowlands	6.23	9.46	1.19	0.41	7.43	11.06
Islands	6.32	9.09	1.53	0.31	7.85	10.93

Note: Pre- and post- entropy poverty lines are reported in Appendix Table A1. 1.00 US dollar = 3.60 PGK in August 2024 (IMF 2024). Source: Authors' calculations using PNG-RHS (2023).

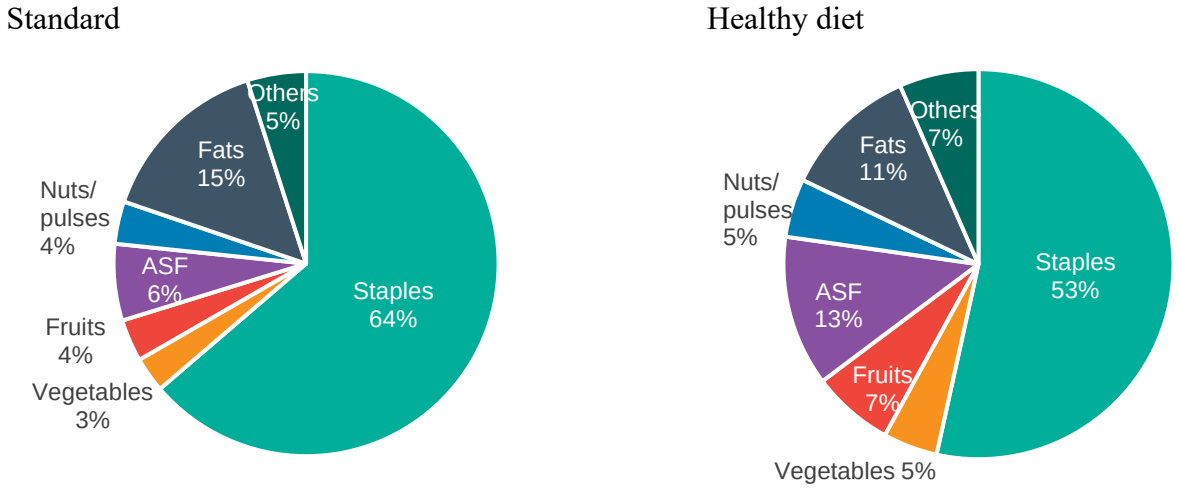
Comparing cost shares by food group of the standard and healthy diet food baskets reveals that a greater share of the food basket cost in the standard diet is derived from staples (Appendix Figure A1). The cost share of starchy staples in the standard basket is 50 percent more than that of the healthy diet basket (36 percent versus 24 percent, respectively). In contrast, nutrient-rich food groups (vegetables, fruits, and protein-rich foods) together account for over two-thirds (64 percent) of the total healthy diet basket cost, compared to only 46 percent of the standard basket (Appendix Figure A1). However, differences in costs exist across AEZs for both the standard and healthy diet food baskets (Appendix Figure A2 and A3). For example, fruits, vegetables and animal source foods are more costly in the non-seasonal lowlands and islands, which have the highest healthy diet food poverty line compared to other AEZs (Appendix Figure A3).

Figure 2 compares energy shares by food group for the standard and healthy diet food baskets.[16] Similar to the cost share comparison above, the energy shares of staples in the standard food basket are 20 percent greater than the healthy diet basket staple energy shares. While staple foods have important nutrients beyond carbohydrates, eating a disproportionate share of staples crowds out food groups rich in other essential nutrients. Conversely, in the healthy diet basket, nearly double the share of dietary energy

[16] The standard diet incorporates 'Other foods' which include discretionary foods that are not categorized into any healthy diet food group.

is dedicated to nutrient-rich food groups (30 percent) including fruits, vegetables, animal source foods and nuts/pulses compared to the nutrient-rich food groups in the standard basket (17 percent) (Figure 2).

Figure 2: Energy shares by food group of standard and healthy diet food basket



Note: Figure displays sample population weighted averages of regional food group energy shares.
Source: Authors' calculations using the 2023 PNG-RHS and food composition tables (Dignan et al. (2004), Scott (2019), Shaheen et al. (2013), TKPI (2019), and USDA (2016)).

Finally, we assess whether the two food baskets defined by the respective poverty lines effectively meet the estimated average requirements (EAR) for an average 30-year-old adult (Table 5).[17] [18] The diet defined by the standard poverty line consumption basket does not meet the EARs for calcium (65 percent), zinc (90 percent), riboflavin (85 percent), and vitamin A (81 percent). The healthy diet food basket is only deficient in calcium (84 percent of the EAR). For ease of interpretation, we shade cells in Table 5 light grey to indicate shortfalls in the range of 86-99 percent of EARs, and dark grey to indicate shortfalls 85 percent or less of EARs.

[17] EARs are intake levels estimated to meet the nutrient requirements of half the healthy individuals in a gender-age group, while recommended daily allowances (RDA) are estimated to meet the nutrient requirements of nearly all healthy individuals in the gender-age group.

[18] The nutrient values used in this analysis are based on raw foods and are not adjusted for nutrient retention factors associated with different cooking methods or differences in bioavailability and cultivar.

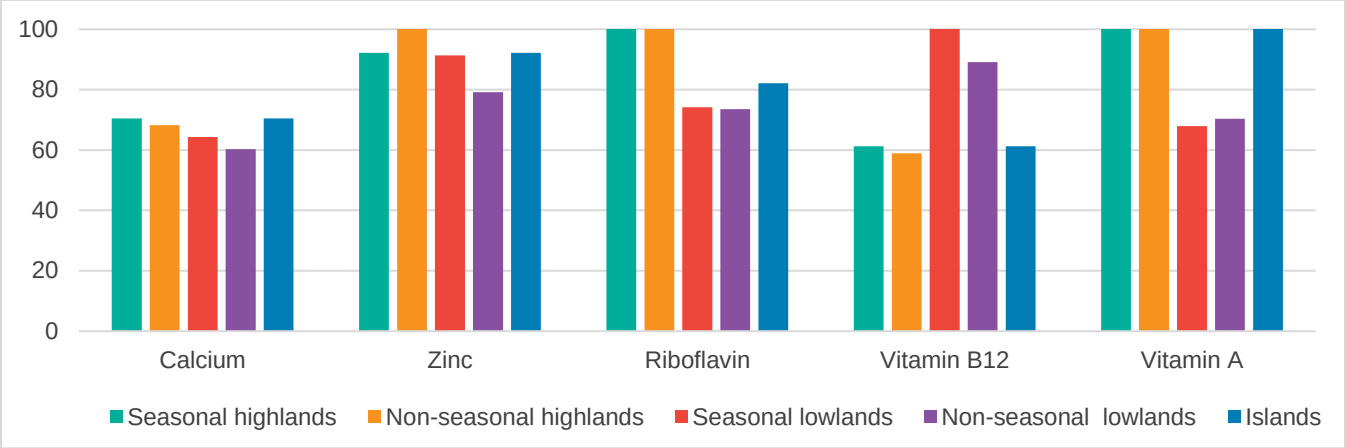
Table 5: Nutrient adequacy of the standard and healthy diet food baskets for a 30-year-old adult woman

		Percentage of EAR for a 30-year-old adult woman	
	EAR	Standard diet	Healthy diet
Protein, g	39	126	166
Calcium, mg	750	65	84
Iron, mg	11	163	164
Magnesium, mg	265	166	175
Phosphorous, mg	580	160	183
Zinc, mg	7.60	90	103
Copper, mg	0.7	262	261
Vitamin C, mg	80	306	326
Thiamin, mg	0.9	235	249
Riboflavin, mg	1.3	85	105
Niacin, mg	11	202	240
Vitamin B6, mg	1.3	158	183
Folate, µg DFE	250	231	252
Vitamin B12, µg	2.0	105	181
Vitamin A, µg RAE	490	81	123

Notes: The table displays average regional food basket nutrient composition. Data shown are adequacy levels by nutrient in the food baskets shown for a moderately active 30-year-old adult woman, with a 2,195 calorie diet. Nutrient composition of food baskets is based on the nutrient content of raw foods. Estimated average requirements (EARs) are taken from Allen et al. 2020 with the following assumptions: 1) The protein EAR is calculated based on .66 g/kg/day and weight for attained height with a BMI of 24.9 – 58.7 kg (Mahrt 2019); 2) Iron assumes a moderate-absorption diet; 3) Zinc assumes a semi-refined diet. Light grey shading indicates shortfalls in the range of 86-99 percent of EARs, and dark grey indicates 85 percent or less of EARs.
Source: Allen et al. 2020 and authors' calculations based on the 2023 PNG-RHS and various food composition tables (Dignan et al. (2004), Scott (2019), Shaheen et al. (2013), TKPI (2019), and USDA (2016)).

The nutrient adequacy of the standard food basket varies considerably by AEZ (Figure 4). Compared to other zones, the standard food baskets in the seasonal and non-seasonal lowlands have the greatest inadequacies in calcium, zinc, riboflavin, and vitamin A. While vitamin B12 is adequate on average across the survey sample (Table 5), it is inadequate in all standard food baskets except that of seasonal lowlands. This underlines the importance of evaluating not only a food poverty line that meets energy (calorie) thresholds (standard food poverty line), but also a food poverty line that requires that within- food group thresholds are met to ensure recommended intake of nutrients.

Figure 4: Nutrient adequacy of the standard diet food basket for a 30-year-old adult woman, by agroecological zone



Notes: See Table 5
Source: Allen et al. 2020 and authors' calculations based on the 2023 PNG-RHS and various food composition tables (Dignan et al. (2004), Scott (2019), Shaheen et al. (2013), TKPI (2019), and USDA (2016)).

We now move on to evaluate the share of the sample that is poor based on the food and non-food thresholds that comprise the different poverty lines (standard and healthy diet) described above. We compare the value of total household consumption-expenditure per adult equivalent per day with the standard poverty line and the healthy diet poverty line, respectively. Approximately 43 and 64 percent of the survey sample lives in households with consumption-expenditure below the standard and healthy diet poverty lines, respectively (Table 6). Approximately 21 percent of the survey sample falls between the two poverty lines – the share of the sample population that are not poor according to the standard poverty line but are lacking resources to secure a healthy diet without sacrificing basic non-food needs (Figure 3).

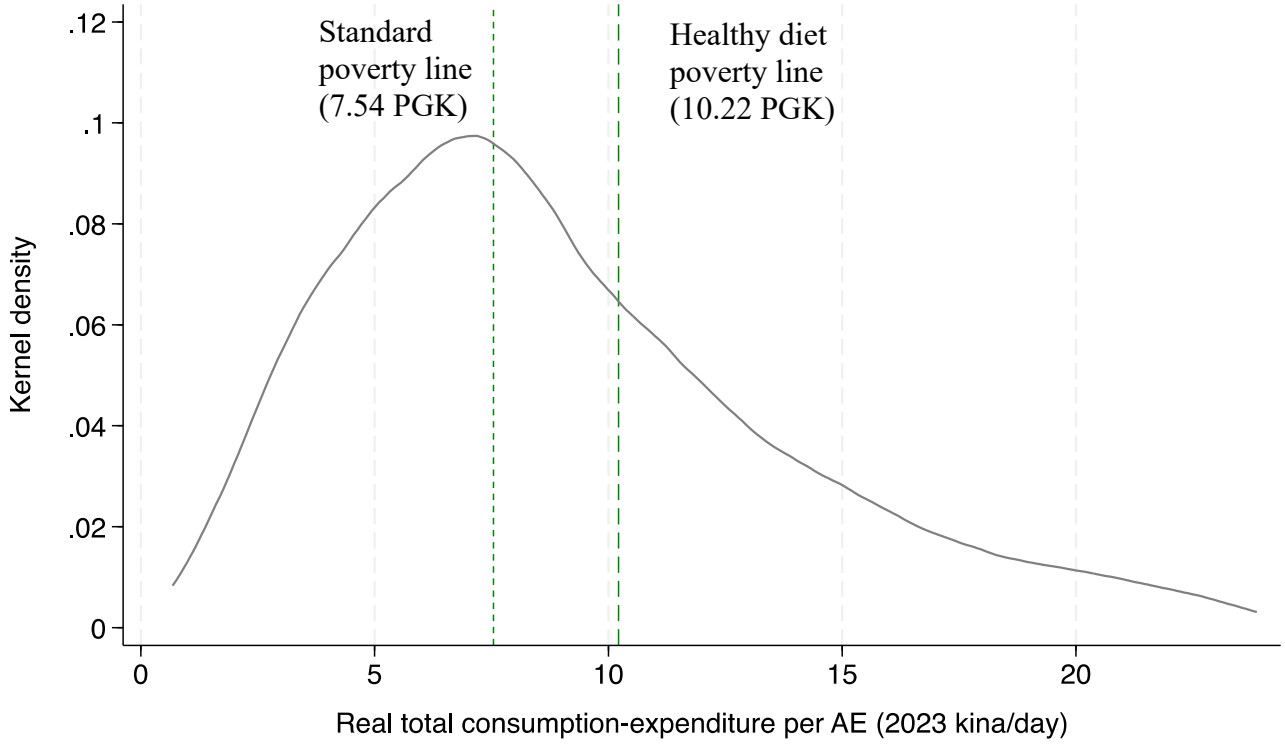
Table 6 also reports the poverty gap, or depth of poverty, measured as the percentage shortfall in household consumption-expenditure in poor households relative to the cost of meeting basic needs. The poverty gap increases from 15 percent to 25 percent relative to the standard versus the healthy diet poverty line.

Table 6: Poverty headcounts and gaps, by agroecological zone

	Poverty headcount (% of sample population)		Poverty gap (%)	
	Standard poverty line	Healthy diet poverty line	Standard poverty line	Healthy diet poverty line
All households	43	64	15	25
Seasonal highlands	63	76	27	36
Non-seasonal highlands	40	57	12	19
Seasonal lowlands	39	58	13	22
Non-seasonal lowlands	39	67	11	25
Islands	42	69	13	25

Source: Authors' calculations using 2023 PNG-RHS.

Figure 3: Distribution of real total consumption-expenditure compared to the standard and healthy diet poverty lines (spatially adjusted PGK)



Note: A spatial price deflator is derived from regional standard poverty lines. Real poverty lines equal the sample population weighted mean spatially adjusted regional poverty lines.
Source: Authors' calculations using 2023 PNG-RHS

5.2. Factors associated with total consumption-expenditure

A variety of factors may be associated with household consumption-expenditure (income proxy) among rural households in PNG. We use an ordinary least squares (OLS) regression to evaluate hypothesized factors associated with household per capita consumption-expenditure outcomes. The OLS analysis is

defined on three main hypotheses. First, considering that the household survey focused on rural households, we assume that greater agricultural production assets (land and labor), engagement in higher value agricultural production and sales opportunities, and better market access are correlated with greater consumption-expenditure. Second, previous literature has demonstrated that diversification of income sources into off-farm sectors is correlated with greater consumption-expenditure (Schmidt et al., 2019). We assume households where members are engaged in wage labor or own a small business (non-farm enterprise) are relatively better off. Finally, we assume that households where the household head or spouse hold and official position (e.g., councilor, head of community organization, church elder or pastor, etc.) are correlated with greater consumption-expenditure given that these households may have better access to knowledge or opportunity for improved income earning potential. Finally, we control for differences across geographic areas (provinces), rainfall, and elevation, as well as experiencing a past shock (agriculture production or violence) that affected household livelihood. In addition, we control for individual characteristics that may shape income earning opportunities such as age, sex, birth lineage, and education.

Evaluating our first hypothesis, we find that larger agricultural landholdings and a higher ratio of working age individuals within the household are correlated with significantly higher per capita consumption-expenditure per person. The survey data demonstrate wide distribution of household landholding sizes (from 0.23 – 21.9 hectares), however a limited number of households own over 4 hectares of land. Thus, we create land ownership quartiles (minimum and maximum landholding sizes per quartile are reported in the regression output) to evaluate the relationship to land size and consumption-expenditure. Compared to households with the lowest reported land holding (quartile 1, omitted), households that have land areas in the 3rd and 4th quartile of landholdings are associated with 12.3 and 21.9 percent greater incomes, respectively.

A greater share of working age individuals within the household is associated with greater per capita consumption-expenditure. For example, those that have greater than the median share of working age adults are associated with a 14.6 percent greater per capita consumption-expenditure. However, a larger household size (regardless of age) is associated with decreased consumption-expenditure per person. Larger households must share their resources among more household members, and each additional member is associated with an 8.9 percent less consumption-expenditure per person (Table 7).

Table 7: Factors associated with log household per capita consumption-expenditure

Variable	Estimate	% Effect	S.E.
Age of household head (years)	-0.00182	-0.18	0.0016
Household head is male, 0/1	0.0377	3.84	0.0351
Any household member completed primary school, 0/1	0.110**	11.63	0.0397
Household size	-0.0894***	-8.55	0.00571
Household has above median share of working age adults, 0/1	0.136***	14.57	0.0261
Household has a current migrant member, 0/1	0.0325	3.30	0.0381
Household received money remittances, 0/1	0.137***	14.68	0.0435
Head or spouse holds official position in community, 0/1	0.0934***	9.79	0.031
Respondent's parents born in the same community, 0/1	-0.00937	-0.93	0.0155
Agricultural landholdings, quartile 2 (0.39 - 1.05 ha), 0/1	0.0202	2.04	0.0371
Agricultural landholdings, quartile 3 (1.05 - 2.1 ha), 0/1	0.116**	12.30	0.039
Agricultural landholdings, quartile 4 (2.11 ha - 21.9 ha), 0/1	0.198***	21.90	0.0341
Household sells cocoa, 0/1	0.0781**	8.12	0.0325
Household sells coffee, 0/1	0.0301	3.06	0.057
Household sells betelnut, 0/1	0.00378	0.38	0.049
Household sells fruits or vegetable crops, 0/1	0.00452	0.45	0.0423
Household owns NFE, 0/1	0.230***	25.86	0.0338
Household involved in wage activities, 0/1	-0.0154	-1.53	0.0487
Household experienced drought in the last 5 years, 0/1	0.0443	4.53	0.0388
Household experienced floods in the last 5 years, 0/1	-0.0839**	-8.05	0.0291
Household experienced violence in community, 0/1	0.00606	0.61	0.0328
Takes 2-4 hours to reach the nearest market, 0/1	-0.107	-10.15	0.0645
Takes more than 4 hours to reach the nearest market, 0/1	-0.301***	-25.99	0.0436
Average 30-year annual rainfall (cm)	0.000213	0.02	0.000164
Elevation (meters)	-0.000168	-0.02	0.000146
Province fixed effects	YES		
Constant	2.372***		0.0963
Observations	2,699		
R-squared	0.347		

Note: Robust standard errors (SE) in parentheses; *** p<0.01, ** p<0.05, * p<0.1; standard errors are clustered at province level; 0-2 hours travel time to market binary variable is omitted; the first quartile of agricultural land-holdings is omitted; households with above median share of working age adults are those with one working adult aged 16–64 per about 2 (1.66) household members. The % effect of a log-linear regression is evaluated by trans-forming the OLS coefficient: 100*(exp(B)-1). The effect of variables for which the squared term is also included in the regression is calculated as B1 + 2B2-x where B1 is the coefficient on linear term, B2 is the coefficient on the squared term and -x is the mean of the variable in question.
Source: Authors' calculations using PNG-RHS (2023).

Our first hypothesis also assumes that a diversification of cultivated crops and sales shape household earning potential. Given ongoing policy dialogue and investments in cash crop production to improve rural household wellbeing, we include a set of binary variables that describe whether a household sells

cocoa, coffee, betelnut, or any horticulture crops (fruits and vegetables).[19] Only the sale of cocoa is associated with significantly greater per capita consumption-expenditure. Survey households that sell cocoa have incomes that are 8 percent higher than those that do not sell cocoa. During the time of the survey (May through December 2023) cocoa prices increased, on average, by about 35 percent, resulting in important income gains for cocoa farmers. While results suggest that cocoa farmers may be better off compared to other cash crop producers, this survey is unable to evaluate income trends over time. It may be that price increases in 2023 (and more so in 2024) have resulted in temporary household consumption-expenditure gains that are less sustainable during average global cocoa production years.

It is not surprising that remoteness is significantly associated with lesser income. This result echoes previous work by Gibson and Rozelle (2003). We evaluate distance from a market using the reported time it takes a household to get to their market using their most common method of transportation. Households that reported being further than 4 hours from their reported market are associated with approximately 26 percent less consumption-expenditure per capita than households that report being within 0-2 hours from their identified market. However, there is no statistically significant difference in consumption-expenditure between households 2-4 hours away from a market and those within 0-2 hours from a major market. Improved transportation infrastructure is critical for rural households. This analysis suggests there may be significant welfare gains to investing in rural feeder roads that decrease rural remoteness.

Our second hypothesis posits that diversified income (e.g., wage work, non-farm enterprise ownership, migration and / or remittance payments) is associated with greater household per capita consumption-expenditure. Households that report owning at least one business (non-farm enterprise) are significantly associated with 25.8 percent greater per capita consumption-expenditure compared to those that do not own a small business. However, we cannot assign a directional relationship to this finding given the cross-sectional nature of the survey. Meaning, it may be that better-off households establish small businesses, or vice versa where households that establish small businesses reap greater incomes. Engagement in wage labor has no significant effect on sample household consumption-expenditure. Similarly, households that report at least one of the household members is currently or has recently (last 2 years) been a migrant do not have significantly different outcome from those that do not have a migrant household member. However, households that report receiving remittances from a migrant household member are associated with 14.6 percent greater consumption-expenditure.

Our final hypothesis posits that household member characteristics may improve access or agency to income sources or information that leads to greater consumption-expenditure. However, of the characteristics tested (highest education completed, age, sex and birth lineage – parent of household head being born in the community, and the community position of the head or spouse) only education and commu-

[19] We also evaluated whether production of these crops, or production and sales of these crops had any correlation with household income. Results were similar with all coefficients insignificant except cocoa (positive and significant on sales in each regression).

nity position matter. Households where any household member completed primary school are significantly associated with almost 12 percent greater consumption-expenditure compared to households that do not have at least one member that completed primary school. Similarly, households where either the head or the spouse of the household head hold an official position in the community are associated with an almost 10 percent greater consumption-expenditure.

Finally, we control for different shocks (production and community or household) that could be associated with lower household income outcomes. If households responded yes to experiencing a shock within the last 5 years, they were asked if that specific shock decreased the household's ability to produce or purchase food. Drought and flood were the most common reported production shocks. While experiencing a flood had a significantly negative (almost -8 percent) association with household per capita consumption-expenditure, reported drought had no significant relationship. About 20 percent of households reported experiencing a violent situation (e.g, disputes over land, tribal fight, community fight etc.) during the last 5 years, however we do not find a significant relationship between violence and household consumption-expenditure. Given the sensitive nature of household and community conflict, more in-depth, qualitative assessments of the effects of violence on a variety of outcome indicators may be warranted.

6. Policy Implications and Conclusions

Household welfare in rural PNG is shaped by a complex set of factors that echo other global and diverse country case-studies (Pham et al. 2021; NSO and ICF 2019; Gibson 2012). The analysis in this paper provides the first monetary poverty analysis, using detailed consumption and expenditure data from the PNG-RHS, in nearly 1.5 decades. Poverty analysis using the standard cost of basic needs poverty line reveals that 43 percent of the rural sample are still unable to meet basic food energy (calorie) and non-food needs (i.e., fall under the standard poverty line). Rural poverty is nearly 20 percentage points higher when the food poverty line is aligned with healthy diet targets (64 percent of the sample population fall under the healthy diet poverty line).

As policymakers and the international development community increasingly prioritize nutrition outcomes, incorporating healthy diets into poverty measurements has important implications as to what it means to be poor. Particularly for PNG and other nations that are dependent on subsistence, domestic agriculture and low-cost food imports, the urgency of policies aimed to make healthy diets more accessible to poor households is critical (Global Nutrition Report, 2022).

The results from this analysis illustrate the need for policy interventions to be tailored to support local conditions. For more vulnerable locations such as remote and low-income areas, a targeted safety net program that decreases agriculture productivity risk and provides agriculture extension and health and nutrition interventions is warranted. Across developed and developing countries, safety net programs currently reach more than 2 billion people worldwide (World Bank, 2018). Despite overwhelming evidence of the positive effect social protection plays in bringing poor households out of vulnerable and food insecure conditions, PNG has yet to invest in a formal social safety net program.

Our analysis suggests that facilitated access to a market is one of the most important indicator explaining greater household consumption-expenditure. Households that live in remote areas (more than 4 hours from a market) are associated with 26 percent less per capita consumption-expenditure compared to households that are within 2 hours of a market. Building and maintaining rural feeder roads and bridges that connect more remote populations to secondary and tertiary market centers would have significant impacts on rural welfare. Integrating community infrastructure (roads and bridges) building as a component to a social safety net program may provide an effective income smoothing mechanism for households that face production shocks, as well as improve overall welfare through improved rural-(semi-)urban linkages.

In remote locations such as Aseki district in the seasonal highlands AEZ, increasing production and market sales of staple crops may not reap financial gains because markets are thin and every household in the surrounding area is growing the same crops. Achieving greater income via marketed surplus may not solve the low consumption of nutrient-rich food groups suggested in this analysis (Table 3) because there are no local markets that sell diverse foods at affordable prices. Diversifying crop production from staple crops that are less expensive (and less risky) to more expensive fruit and vegetable crops that are less drought/flood resistant; more vulnerable to pests; and require more inputs (seeds and fertilizer, etc.) may be too costly of a gamble for remote areas. Similarly, regression results suggest that households that sell horticulture products (fruits and vegetables) do not have significantly higher incomes. This suggests that developing reliable demand (consumer markets) for diversified products from accessible rural areas (while building feeder roads to less accessible areas) may support higher-value, diversified crop production for both home consumption and peri-urban and urban sales.

For rural households that have feasible market outlets, a concerted effort is needed to facilitate off-farm business opportunities, especially small farm enterprises that allow households to earn additional income and reduce risk from agriculture production shocks. Investments to better develop off-farm opportunities via specialized agricultural supply chain nodes (e.g., transport, cold storage, food processing and safety guidelines) will not only improve the supply of fresh produce but may also decrease transaction costs across domestic food markets (and reduce food price volatility). Several donor-funded projects in PNG have piloted a ‘lead firm approach’ to link farmers to consumers and promote more coordinated and efficient value chain processes of fresh vegetable output. For example, the International Finance Corporation supported 30 lead and 600 other farmers to work directly with Tininga, one of largest food wholesalers in the country. Improved linkages between farmers and the Tininga wholesaler resulted in increased fresh vegetable supply to the Port Moresby market from approximately 14 to 140 tons per month (Adam Smith International, 2018).

Several avenues to diversify income sources and reduce risk are available for rural households. In addition to increasing market access and incentivizing small business start-up and ownership, regression analysis suggests that remittances are an important income source for rural households, associated with 14.6 percent greater income compared to households that don’t receive remittances. Further investigation should be undertaken to understand the most appropriate policies, and banking or financial tools to incentivize and facilitate remittances to rural areas.

This study sets a benchmark for understanding poverty prevalence that accounts for basic nutrition targets. For a large share of the rural population in PNG, access and affordability of a nutritious diet may be the largest hurdle to improving household welfare objectives. Availability, accessibility, and desirability are also important driving factors of diet choices. However, if individuals are unable to afford a minimum healthy diet at local prices, it would be difficult to achieve significant change towards healthier food consumption choices.

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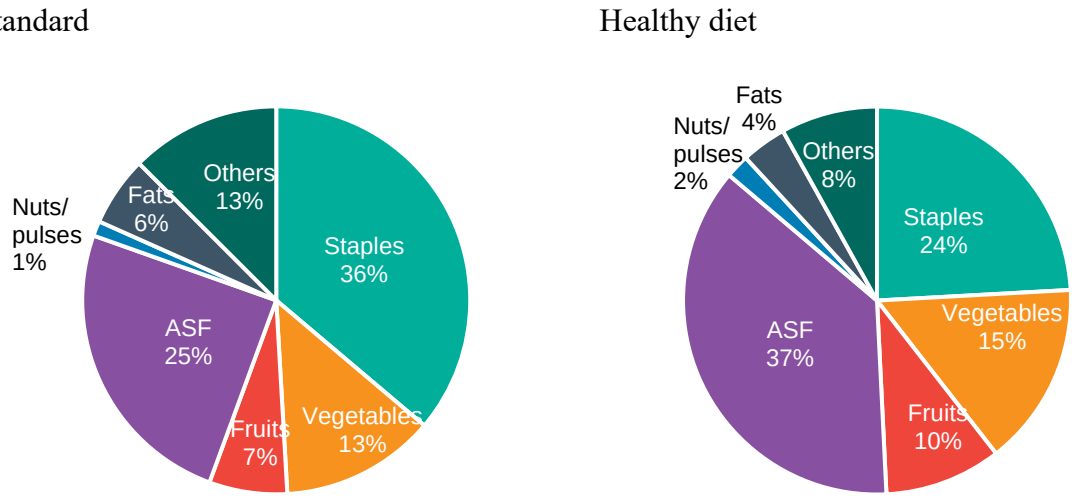
Appendix

Table A1: Cost of standard and healthy diet food poverty lines before and after entropy adjustments to ensure utility consistency, by province (PGK/adult-equivalent/day)

	Standard food poverty line		Healthy diet food poverty line	
	Pre-entropy Utility-inconsistent	Post-entropy Utility-consistent	Pre-entropy Utility-inconsistent	Post-entropy Utility-consistent
Seasonal highlands	7.00	6.96	8.81	8.87
Non-seasonal highlands	7.18	6.69	8.90	8.62
Seasonal lowlands	6.87	5.90	7.77	8.00
Non-seasonal lowlands	6.16	6.23	9.68	9.46
Islands	5.53	6.32	8.96	9.09

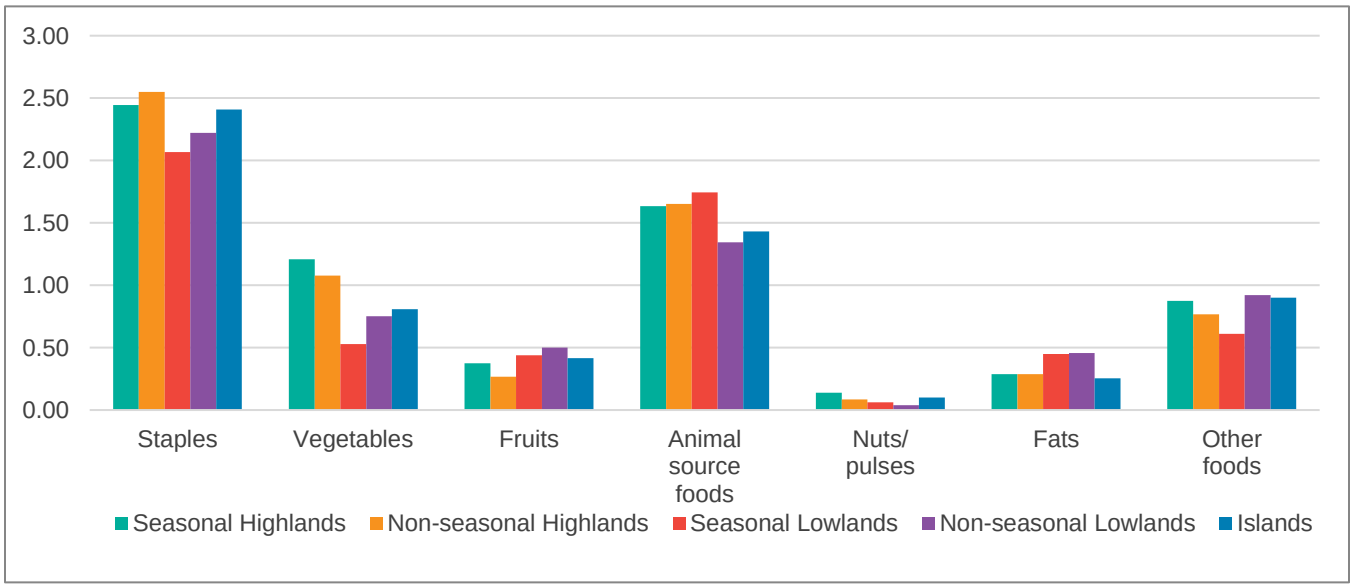
Note: 1.00 US dollar = 3.60 PGK in August 2024 (IMF 2024). Source: Authors' calculations using 2023 PNG-RHS

Figure A1: Cost shares by food group of standard and healthy diet food baskets



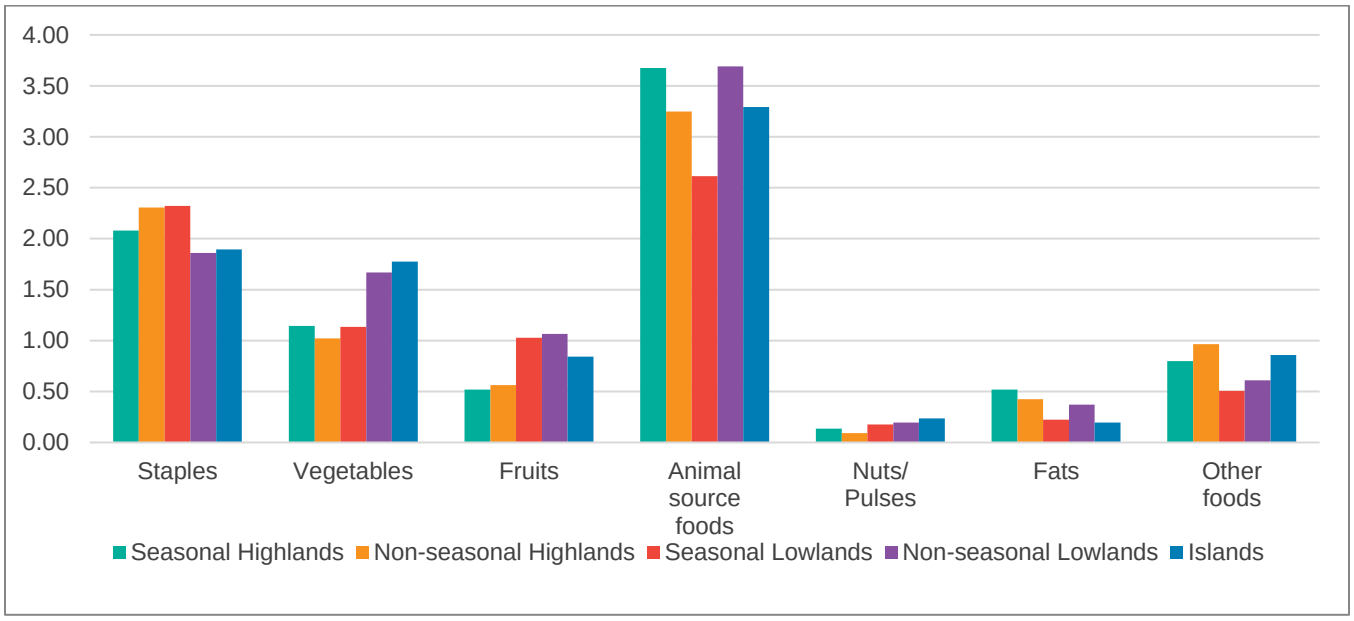
Note: Figure displays sample population weighted averages of regional food group cost shares.
Source: Authors' calculations using the 2023 PNG-RHS.

Figure A2. Standard food poverty line costs, by food group and agroecological zone (PGK/adult-equivalent/day)



Source: Authors' calculations using the 2023 PNG-RHS

Figure A3. Healthy diet food poverty line costs, by food group and agroecological zone (PGK/adult-equivalent/day)



Source: Authors' calculations using the 2023 PNG-RHS

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