Economia agro-alimentare /
Food Economy
An International Journal on Agricultural and Food Systems
Vol. 26, Iss. 1, Art. 5, pp. 109-135 - ISSNe 1972-4802
DOI: 10.3280/ecag2024oa16358

Access to Technology to Increase Food Resilience in Rural Households in Indonesia

Thomas Soseco[*,a], **Isnawati Hidayah**[b], **Nila Cahayati**[c], **Fajar Try Leksono**[d]

[a] Universitas Negeri Malang, Indonesia
[b] Sapienza University or Rome, Italy
[c] Universitas Brawijaya, Indonesia
[d] Institute for Rural Development and Sustainability, Indonesia

Abstract

Food resilience is intricately linked to household standard of living, human development, and economic growth. Higher food expenditure not only signifies improved living standards but also provides households with the necessary energy and nutrition for daily activities. The integration of technology holds promise for bolstering food resilience among households. However, there exists a gap in understanding how technology can enhance household food resilience across different socio-economic classes, considering the diverse food expenditure patterns observed. This paper employs quantile regressions to examine the impact of technology on food resilience, accounting for heterogeneity across socio-economic classes. Utilizing data from the Indonesia Family Life Survey (IFLS) wave 5 dataset, our findings reveal varying effects of certain variables across different classes. Key contributors to food expenditure identified include income, household size, education, and engagement in agriculture as the primary source of employment. Consequently, policy interventions should prioritize expanding internet access for low-decile households residing in rural areas to effectively enhance food resilience.

Article info

Type:
Article
Submitted:
13/08/2023
Accepted:
10/03/2024
Available online:
14/06/2024

JEL codes:
C21, E21, J10, Q12

Keywords:
Food expenditure
Households
Indonesia
Quantile regression

Managing Editor:
Alessio Cavicchi

* *Corresponding author*: Thomas Soseco - Faculty of Economics and Business, Universitas Negeri Malang, Indonesia. E-mail: thomas.soseco.fe@um.ac.id.

Introduction

Household food expenditure is associated with the living standard, allowing household members to have sufficient energy and nutrition to work, learn, and positively contribute to society (Kousar *et al*., 2017; Soseco *et al*., 2022). It is also assumed that a higher food budget can be associated with better access and more options for nutritious food at home (Beydoun *et al*., 2009).

Households can achieve food security through their ability to fulfil the nutritional needs of family members. Food security contributes to increasing labour productivity by allowing individuals to work for longer hours and in productive ways (Alderman *et al*., 2005; Huffman & Orazem, 2007; Wang & Taniguchi, 2003). Rising nutrition improves a population's skill level and reflects increased living standards, improving health standards, and altering time allocation decisions (Fogel, 2004; Huffman & Orazem, 2007). Further, food security is also an important aspect of poverty measurement because of its significant proportion, particularly in the poorest households, where expenditures on food contribute 73.6% to the poverty line value and the increase in food prices contributes 57.8% to the inflation rate (McCulloch & Timmer, 2008).

The issue of food security in Indonesia is important considering the stark difference between population groups, e.g., urban and rural, or by household quantiles (Badan Pusat Statistik, 2021). In March 2021, Indonesia's average monthly food expenditure per capita was about Rp.622,845 (US$43.65). Comparison between urban and rural shows household expenditure in urban areas that reached Rp.681,278 (US$47.74) per month, higher than in rural areas (Rp.545,942 or US$38.26 per month) (Badan Pusat Statistik, 2021). A comparison of food expenditure across classes shows that the poorest households, i.e., those in quantile 1, have the highest shares of food expenditure in March 2021, reaching 64.15%. Lower percentages were found in the next quantiles, where households in quantile 2 had 60.88%, households in quantile 3 had 57.85%, and those in quantile 4 had 54.05%. Lastly, the smallest proportion of food expenditure was in quantile 5, reaching 39.33% (Badan Pusat Statistik, 2021). Another finding shows the importance of rice as the main food commodity for most of the Indonesian population. In contrast, food expenditure is about 67%-72% for low-income households, 16%-26% of which is spent on rice (McCulloch & Timmer, 2008).

Using technology to improve food security gives many benefits, such as reducing associated costs related to nutrition education and knowledge sharing (Anerua & Azonuche, 2010; Brug *et al*., 2005; Neuenschwander *et al*., 2012). Another study shows that internet affects saving behaviour and households' expenditure patterns (Thaariq *et al*., 2012). Technology adoption can also improve the welfare of households in rural areas through increased

agricultural income and diversity of household diets (Muhaimin *et al.*, 2020). Further, the transformation of technological innovations will continue to be an essential driver of future agricultural growth, including greater use of crop varieties, machinery, and land/institutional reforms (Sutardi *et al.*, 2022).

Considering the need to integrate technology into the households' agriculture-related activities, further examination is needed to observe the impact of technology on different household classes. As found by some researchers, the heterogeneity across classes potentially gives variation in food expenditure, hence bringing different levels in diet quality, food diversity, nutrition access, and food security across classes (Bernstein *et al.*, 2002; Darmon & Drewnowski, 2008; Kant *et al.*, 1993; Pampel *et al.*, 2010; Wahlqvist & Specht, 1998).

This paper contributes to the literature investigating the role of technology in increasing nutrition levels, measured from food expenditure across household classes focusing on households in rural areas in Indonesia. We focus on some aspects contributing to households' food resilience in Indonesia, including technology, income, household size, education, and agriculture as main employment. To achieve the above purpose, we used quantile regression to determine the contributors to food expenditure across classes, shown by the relationship pattern between food expenditure as the dependent variable and its covariates. This approach can overcome the standard regression estimation limitations involving average values as it will not capture the possibility of controlling variables varying across classes and misinterpret the results.

The rest of this paper is structured as follows: section 2 presents a literature review of the potential determinants of differences in food resilience, and section 3 describes the methodology and data. Section 4 presents the result of the estimation and policy implications. Then, section 5 presents the conclusion and recommendations for future studies.

1. Literature review

A) Households' Food Expenditure

Neoclassical demand theory suggests that households attempt to maximise their consumption choices subject to preferences and resource constraints, where prices, income, and time constraints affect a household's decision on food expenditure (Fan *et al.*, 2007). Engel's Law, a 19th-century observation, states that as household incomes rise, the percentage of income spent on food decreases, and more money goes to other goods or services. This Law has been widely used to understand the global relationship between household income and food expenditure(Mulamba, 2022).

Additionally, studies have shown that household income, household size, and the age of the household head significantly affect food expenditure. These theories and findings provide valuable insights into the dynamics of household food expenditure patterns and their determinants (Ab *et al*., 2022; Yovo & Gnedeka, 2023).

Another study shows that food resilience refers to the ability of individuals, households, and communities to withstand and recover from shocks and stresses to their food security. It involves measuring and understanding the capacity to consistently access and utilise sufficient, safe, and nutritious food over time. Determinants of food resilience include factors such as socioeconomic status, access to resources, availability of infrastructure, and exposure to shocks (Upton *et al*., 2016).

As a composite index, the resilience index of households includes stability, social safety nets, access to public services, assets, income and food access, and an adaptive capacity. This conceptual framework treats resilience as latent and multidimensional, showing the ability of households to maintain their wellbeing in the face of shocks (Alinovi *et al*., 2010; Ronalia *et al*., 2023).

B) The Determinants of Food Resilience

Previous studies have identified some determinants of food resilience. Technology plays an important role in enhancing the resilience of food supply chains, where digital twin technology, in particular, has been identified as a key factor in improving the resilience and sustainability of food supply chains (Singh *et al*., 2023). In the context of short food supply chains (SFSCs), low-cost digital technologies have been found to support flexibility, collaboration, visibility, and agility, which are important resilience capabilities (Sun *et al*., 2022).

Adopting modern technology in agriculture can lead to high production rates and long-range food resilience in Indonesia(Widodo, 2007). Mobile phone use in the agricultural sector in Indonesia varies depending on farmers' location in their professional network, with conversion factors playing a significant role in achieving food resilience (Wahid & Furuholt, 2012). Mobile phone data-derived indicators also show high correlations (> .8) with food security variables like food or vegetable consumption expenditure in Indonesia (Decuyper *et al*., 2014). Mobile phone use and higher frequency of use are significantly and positively correlated with food access in Indonesia (Wantchekon & Riaz, 2019). Lastly, internet use has a negative effect on agricultural household food insecurity in Indonesia (Ardianti & Hartono, 2022).

Other determinants of household food expenditure in Indonesia are related to income, where higher-income households will have higher food consumption, which leads to higher food expenditure than households with lower incomes (Hafizah *et al*., 2021; Soseco, 2021; Syamola & Nurwahyuni,

2019). Moreover, in the agricultural sector, different land typologies will cause different farmland productivity, impacting household income and consumption(Ariani & Saliem, 2015). On the other hand, Faharuddin *et al*. (2019) observed that agricultural households in Indonesia spent more on buying rice than vegetables and fish, meaning that the consumption of carbohydrates and calories is dominated by less fat and protein, which is inverse to non-agricultural households. Another study by Irawan *et al*. (2006) found that the share of food expenditure to total household expenditure ranges from 61%-65%; the lowest expenditure came from the cocoa-based commodity agro-ecosystem, and the highest was in the rubber agro-ecosystem.

Some studies found the importance of women's role in managing the family's budget. Belotti *et al*. (2017) found that expenditure, age, and education will influence food budget management by women. A similar finding is found in Bertham *et al*. (2011), where women's participation in decision-making is important for the household. Moreover, Mulugeta (2009) found that women with higher education and better financial knowledge will participate in food budget management. Thus, women's involvement leads to higher nutrition consumption for family members to reduce the possibility of stunting (Belotti *et al*., 2017; Islam & Sim, 2021).

2. Method and data

2.1. *Method*

The method used in this paper is quantile regressions that can capture the interaction between variables across household classes that cannot be attained by using the standard regression model. The quantile regression model, first introduced in the seminal contribution by Koenker and Bassett Jr (1978) can be written as:

$$y_{it} = x'_{it}\beta_\theta + u_{\theta it} \text{ with} Quant_\theta(y_{it}|x_{it}) = x'_{it}\beta_\theta$$

where y_{it} is the dependent variable, x is a vector of regressors, β is the vector of parameters to be estimated, and u is a vector of residuals. $Q_\theta(y_{it}|x_{it})$ identifies the θ^{th} conditional quantile of y_{it} given x_{it}.

Using quantile regression offers resilience against outliers, comprehensively depicts the inherent connection, and delineates the entire conditional distribution (Koenker & Bassett Jr, 1978; Abrevaya & Dahl, 2008; Coad & Rao, 2011). Quantile regression serves as a remedy for the shortcomings of ordinary regression models. Unlike the average term provided by conventional

regression, quantile regression avoids offering an incomplete overview of distributions and concealing the fundamental relationship between independent and dependent variables (Abrevaya & Dahl, 2008).

Our analysis contrasted the outcomes with a linear regression model that neglects class heterogeneity. Additionally, we tested intra-cluster correlation to explore whether household food expenditure might be affected by existing correlations, with clusters defined as regions or islands.

2.2. *Data*

Data is obtained from the latest Indonesian Family Life Survey (IFLS) of wave 5 in 2014. The IFLS is the largest and longest ongoing longitudinal dataset that contains rich information regarding households' socioeconomic and health data that covers 21 years of observation (1993 to 2013) and interviewed 15,921 households living in 13 provinces in Indonesia. The IFLS 5 distinguishes respondents' location status, either urban or rural, which is beneficial for our study. In this research, the author(s) define rural and urban areas based on population density, economic activities (particularly agriculture), and geographical characteristics.

The dependent variable is household food expenditure, categorised as an expenditure from food bought by the family, equivalent expenditure from own food production, and total food expenditure. Food expenditure in this research is aimed at measuring food availability in the family, instead of commodities' quantity, to anticipate food prices in Indonesia that are relatively fluctuating and high or unaffordable for some household groups (McCulloch & Timmer, 2008).

The independent variables relate to household characteristics that potentially influence food expenditure. The first aspect is related to the household economy, which is measured by income and employability. The second aspect is demography, which covers information on household size. A household head's education is defined as the accumulation of length of study from school grades, where a household head who has elementary schools (SD) as their highest education is appointed has six years education, junior high school (SMP) is equivalent to 9 years of education, senior high school (SMA) is 12 years of education, college/bachelor is 16 years of education, master degree is 18 years of education, and a doctoral degree is 22 years of education), and household's decision-maker. The third aspect is location, observed whether the household lives in urban or rural, the household has safe drinking water sources (obtained from pipe water, well/pump, well water, and spring water, and the household has electricity). The fourth aspect is related to technology, measured by internet penetration. Table 1 shows the descriptive statistics of variables.

Table 1 - Descriptive Statistics

Variable	Mean	Std. Dev.
Households' food expenditure (Rp)(per week)	356,320.50	311,399.00
Households' production food expenditure (Rp) (per week)	65,917.45	94,732.63
Households' total food expenditure (Rp) (per week)	422,238.00	337,317.60
Households' income (Rp.×1,000,000)(per year)	26,30	48,80
Households size	3.68	1.80
	Freq.	**Per cent**
Households live in rural	6,339	39.82
Household heads sex is male	11,227	70.52
Household heads have no education	5,590	35.11
Household heads' education is elementary (SD)	3,645	22.89
Household heads' education is in junior high school (SMP)	1,912	12.01
Household heads' education is senior high school (SMA)	3,136	19.7
Household heads' education is college/undergraduate	1,543	9.69
Household heads' education is post-graduate	95	0.6
Household heads' primary activity is working	9,992	62.76
Households have safe drinking water sources	14,772	92.78
Households have electricity	15,058	94.58
Households head employment in agriculture	2,676	16.81
Decision-maker is husband	1,325	8.32
Decision-maker is wife	4,440	27.89
Internet availability	3,187	29.31

Source: Analysed by authors.

The average total food expenditure for households in Indonesia in 2014 was Rp.422,238.00, or about US$ 29.59 per week. There was a large gap between food expenditure bought and own produced, where the food expenditure bought (Rp.356,320.50 or US$ 24.97 per week) was far above the food expenditure own produced by the households (Rp.65,917.45 or US$4.61 per week) (see Table 1). The slight variation in food causes this large gap in production, where households commonly plant staple foods, e.g., rice, vegetables, and fruits, which have low prices, and consume processed food with higher prices.

Based on demographic characteristics, the average household size in Indonesia in 2014 was 3.68. Less than half of the population lives in rural areas (39.82%), while the rest live in urban areas. Approximately 16.81% of households have agriculture as their primary source of income, and only 29.41% of households can access the internet (Table 1).

3. Results

3.1. *Food Expenditure Across Classes*

The distribution of food expenditure across classes shows household food expenditure has a positive association with their classes, where the higher the classes (the more income or wealthier the household is), the more their food expenditure. Comparison across classes shows households in the lowest percentiles (percentiles 1-10) in rural areas have Rp.43,180.71per week of food expenditure (about US$2.87), and the wealthiest households (who are in percentiles 90-100) spent Rp.1,032,212.00(US$68.81) per week for food expenditure.

Table 2 - Food Expenditure Across Classes, 2014

Percentiles	Food Expenditure		Own Production Food Expenditure		Total Food Expenditure	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Urban						
1-10	17,945.47	1,781.72	0.00	(omitted)	37,277.45	2,796.73
10-20	112,466.70	2,553.07	0.00	(omitted)	159,191.90	2,645.75
20-30	176,076.50	2,469.77	1,341.68	223.37	226,534.20	2,557.12
30-40	231,460.60	2,508.28	9,062.41	423.64	280,795.20	2,457.68
40-50	285,195.30	2,627.35	19,357.65	541.72	336,767.50	2,897.01
50-60	344,226.40	3,308.92	33,712.38	858.10	401,435.70	3,459.02
60-70	416,882.80	3,698.26	53,049.40	1,051.55	480,825.60	4,308.82
70-80	512,439.80	4,719.38	79,931.43	1,402.98	583,833.60	4,897.86
80-90	657,265.30	6,592.11	123,127.90	1,973.17	739,823.30	7,079.99
90-100	1,121,623.00	17,836.38	282,186.90	5,974.25	1,230,867.00	18,839.13
Rural						
1-10	18,554.90	1,721.21	0.00	(omitted)	43,180.71	2,864.92
10-20	88,161.30	2,345.77	2,786.17	308.25	142,452.30	2,744.36
20-30	139,984.60	2,539.60	12,200.58	572.20	198,124.40	2,616.20
30-40	183,907.50	2,294.55	24,496.49	780.99	247,084.20	2,737.44
40-50	227,257.10	2,848.83	39,378.17	995.82	293,638.30	2,932.18
50-60	275,408.30	3,017.49	56,345.51	1,026.47	346,519.60	3,369.91
60-70	333,129.20	3,830.70	75,853.72	1,267.11	408,905.70	4,256.92
70-80	408,273.30	4,613.75	101,509.00	1,557.76	495,488.70	5,242.38
80-90	527,110.00	6,659.02	144,237.20	2,584.40	629,361.10	7,257.79
90-100	889,233.20	17,068.78	289,140.50	6,614.96	1,032,212.00	19,304.54

Food expenditure has a larger proportion than own production food expenditure in urban and rural areas. In urban areas, households in percentiles 1-10 and 10-20 have zero value in their food production while

still maintaining the consumption of food bought by the household. This condition reflects limited resources for the poorest households to produce food, e.g., limited land area, limited capital, or knowledge, resulting in the inability to grow staple foods like fruits and vegetables. Hence, buying food products is the only way to solve the family's food demand. In contrast, only percentiles 1-10 in rural areas cannot grow their food production, resulting in zero value in their food expenditure. This condition indicates the benefits of living in rural areas, as relatively abundant land allows most households to produce food than their counterparts in a similar class in urban areas.

Table 3 shows the differences in food expenditure between urban and rural Indonesia. In 2014, households in rural areas had lower total food expenditure than urban households except for percentiles 1-10. This condition is shown by the ratio of total food expenditure in rural households in Table 3 Column 6, which is approximately 15% lower than in urban households. Low-income rural households might influence this condition, which limits their ability to buy food as much as urban households.

A comparison of bought and own-produced food in Table 3 shows contrary findings where rural households in all classes except the poorest class have lower food expenditure than urban households. At the same time, rural households in all classes except the highest class consume own-produced food more than urban households. This condition might be relevant to sources abundant in rural areas that allow most households to produce food.

Table 3 - The Difference in Total Food Expenditure between Urban and Rural

Percentiles	Food Expenditure		Own Production Food Expenditure		Total Food Expenditure	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
0-10	1.034	0.140	1.213	0.062	1.158	0.116
10-20	0.784	0.027	1.265	0.053	0.895	0.023
20-30	0.795	0.018	1.335	0.046	0.875	0.015
30-40	0.795	0.013	1.317	0.042	0.880	0.012
40-50	0.797	0.012	1.260	0.035	0.872	0.011
50-60	0.800	0.012	1.200	0.028	0.863	0.011
60-70	0.799	0.012	1.137	0.027	0.850	0.012
70-80	0.797	0.012	1.080	0.022	0.849	0.011
80-90	0.802	0.013	1.048	0.026	0.851	0.013
90-100	0.793	0.020	0.953	0.031	0.839	0.020

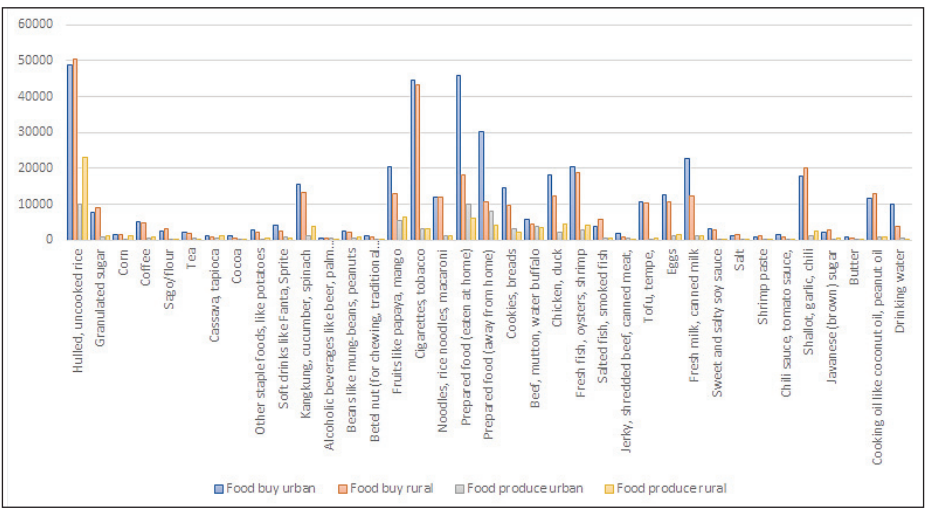
Note: This contrasts with respect to households in urban areas.

Source: analysed by authors

However, attention should be focused on the poorest households (percentiles 1-10) as even though they have higher food expenditure than urban households, this does not necessarily mean high quality of food as they tend to consume more staple foods mainly consisting of carbohydrates and less diverse food as well as increased consumption on tobacco. While the wealthiest households tend to consume more meat, snacks, and dried food (Pangaribowo & Tsegai, 2011).

Looking at the differences in the expenditure on food bought and own food production between rural and urban households, the higher the classes, the lower the differences (See Table 3). This condition might be caused by different food consumption patterns where low-class households prioritise food purchases over non-food expenses like education, health, or entertainment (Crotty *et al.*, 1992; Hymans & Shapiro, 1976). Besides, it is also associated with a high proportion of food expenditure relative to their low income, where food costs account for 60-80% of low-income households' entire income (Maxwell *et al.*, 2000; Ruel *et al.*, 1998). This condition is also supported by government subsidies mainly for low-income families, e.g., a cash transfer program/ BLT or rice for poor households/ Raskin, which can increase households' income but is mainly allocated to buy food (Rinukti, 2018; Satriawan & Shrestha, 2018).

Figure 1 - Food Commodities Urban and Rural, 2014



Source: Analysed by authors.

Our findings also show the variety of own-produced food products consumed by rural households are stapled food (rice, sugar, corn, coffee, cassava, potato), vegetables (kangkong, cucumber, mung-beans, betel nut), fruits (papaya, mango, banana), poultry (chicken, duck), eggs, spices (shallot, garlic, chili, candle nuts). Since those products require a large land area to grow, FAO (2018) explained that land area is one beneficial factor that allows rural households to improve access to a greater food supply, bringing increased quantity and variety of food for family members.

On the other hand, households in urban areas consume bought food more than rural households, mainly processed food commodities, e.g., tea, cocoa, cigarettes, tobacco, noodles, cookies, bread, meat from cattle (beef, mutton, water buffalo, jerk, shredded beef, canned beef), milk (fresh milk, canned milk), and butter (see Figure 1).

3.2. *The Determinants of Food Expenditure in Households in Rural Areas*

Table 4 shows the linear regression to find the determinants of food expenditure, own production food expenditure, and total food expenditure that ignores the heterogeneity across classes. From the base model (columns 2-4), some significant contributors to food expenditures are income, household size, rural living, and education. When we add variables of agriculture as the main employment sector and internet access, those variables significantly affect food expenditure components (see Table 4).

The role of agriculture and internet access on households' food expenditure is relevant to previous studies that show agricultural households who have internet access have better living conditions, e.g., in income terms than other households who lack internet access (Khanal & Mishra, 2013).

Since the results from Columns 2-10 in Table 4 show the effect of the determinants on households' food expenditure, lacking information on the impact of variables on different classes, either in low, middle, or high classes, the findings potentially hide the influence variables in each class.

We then test for the existence of intra-cluster correlation as it might influence the variations in the variables by using a procedure by Parente and Santos Silva (2016) and using provinces as clusters. The null hypothesis is that there is no intra-cluster correlation. Table 5 shows that each decile has a probability of 0.000. Hence, we cannot reject the null hypothesis of no intra-cluster correlation. Therefore, there is no intra-cluster correlation.

Table 4 - The Influence of Variables on Households'Food Expenditure in Rural Areas

	Food Exp.	**Own Production Food Exp.**	**Total Food Exp.**	**Food Exp.**	**Own Production Food Exp.**	**Total Food Exp.**	**Food Exp.**	**Own Production Food Exp.**	**Total Food Exp.**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ln income	0.059***	0.042**	0.05***	0.056***	0.045**	0.048***	0.055***	0.044**	0.047***
	(0.011)	(0.019)	(0.009)	(0.011)	(0.019)	(0.009)	(0.011)	(0.019)	(0.009)
Households size	0.177***	0.056***	0.151***	0.176***	0.055***	0.151***	0.178***	0.057***	0.153***
	(0.008)	(0.013)	(0.006)	(0.008)	(0.013)	(0.006)	(0.008)	(0.013)	(0.006)
Household heads' s ex is male	–0.014	–0.041	–0.027	–0.003	–0.054	–0.021	0	–0.052	–0.018
	(0.044)	(0.074)	(0.035)	(0.044)	(0.074)	(0.035)	(0.044)	(0.074)	(0.035)
Household head's years of schooling	0.028***	0.013***	0.026***	0.03***	0.011**	0.027***	0.026***	0.008	0.023***
	(0.003)	(0.005)	(0.002)	(0.003)	(0.005)	(0.002)	(0.003)	(0.005)	(0.003)
Household heads' primary activity is working	0.023	0.012	0.004	0.029	0.004	0.007	0.029	0.004	0.008
	(0.044)	(0.073)	(0.036)	(0.044)	(0.073)	(0.036)	(0.044)	(0.073)	(0.036)
Households have safe drinking water sources	0.143**	–0.068	0.062	0.13**	–0.054	0.054	0.128**	–0.055	0.052
	(0.058)	(0.094)	(0.047)	(0.057)	(0.094)	(0.047)	(0.057)	(0.094)	(0.046)
Households have electricity	–0.173*	–0.094	–0.095	–0.191*	–0.077	–0.104	–0.19*	–0.076	–0.103
	(0.101)	(0.167)	(0.08)	(0.101)	(0.167)	(0.08)	(0.101)	(0.167)	(0.08)
Decision-maker is wife	0.037	–0.056	0.009	0.07**	–0.096*	0.028	0.073**	–0.095*	0.031
	(0.029)	(0.049)	(0.023)	(0.03)	(0.05)	(0.024)	(0.03)	(0.05)	(0.024)
Household heads' employment in agriculture				–0.145***	0.163***	–0.082***	–0.13***	0.176***	–0.065***
				(0.028)	(0.046)	(0.022)	(0.028)	(0.047)	(0.023)
Households can access internet							0.114**	0.093	0.131***
							(0.045)	(0.077)	(0.037)
Constant	10.653***	10.041***	11.233***	10.736***	9.951***	11.279***	10.745***	9.957***	11.29***
	(0.206)	(0.34)	(0.165)	(0.206)	(0.341)	(0.166)	(0.206)	(0.341)	(0.165)
R-squared	0.166	0.010	0.183	0.173	0.014	0.186	0.174	0.015	0.189
Number of observations	3,507	3,192	3,523	3,507	3,192	3,523	3,507	3,192	3,523
F-statistics	87.19	4.22	98.35	81.11	5.17	89.21	73.74	4.80	81.84

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Parentheses refer to robust standard error. Estimated using standard regression model.

Source: Analysed by authors.

Table 5 - Parente-Santos Silva test for intra-cluster correlation

Deciles	**T**	**P > T**
1	16.461	0.000
2	30.191	0.000
3	40.956	0.000
4	45.853	0.000
5	43.568	0.000
6	34.431	0.000
7	34.059	0.000
8	27.997	0.000
9	13.229	0.000

Source: Analysed by authors.

Tables 6-8 show estimations from quantile regressions for households' food expenditure in rural areas to show the effect of variables on different percentiles or classes. Results in Tables 6-8 show that some variables have a different effect for low, middle, or higher classes that cannot be obtained from regression, which ignores heterogeneity across classes in Table 4.

Table 6 - Quantile Regression for Household Food Expenditure in Rural Areas

	Deciles								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Ln income	0.058**	0.075***	0.072***	0.074***	0.064***	0.061***	0.044***	0.042***	0.029**
	(0.023)	(0.016)	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.013)	(0.012)
Households size	0.227***	0.194***	0.18***	0.172***	0.158***	0.154***	0.146***	0.137***	0.119***
	(0.015)	(0.009)	(0.008)	(0.007)	(0.008)	(0.007)	(0.009)	(0.007)	(0.006)
Household heads' sex is male	0.219	–0.031	–0.005	–0.027	–0.06	–0.035	–0.043	–0.117**	–0.071**
	(0.143)	(0.072)	(0.052)	(0.058)	(0.05)	(0.037)	(0.058)	(0.06)	(0.031)
Household head's years of schooling	0.033***	0.036***	0.031***	0.024***	0.024***	0.019***	0.019***	0.023***	0.018***
	(0.006)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
Household heads' primary activity is working	0.123	0.019	0.014	0.012	–0.014	0	0.054	0.092**	0.095*
	(0.084)	(0.076)	(0.061)	(0.052)	(0.043)	(0.04)	(0.048)	(0.043)	(0.054)
Households have safe drinking water sources	0.318	0.186**	0.154	0.067	0.039	0.077	0.064	0.029	–0.007
	(0.2)	(0.088)	(0.116)	(0.077)	(0.065)	(0.055)	(0.072)	(0.097)	(0.08)
Households have electricity	–0.138	–0.159	–0.187	–0.161*	–0.078	–0.222	–0.159	–0.148	–0.09
	(0.206)	(0.191)	(0.148)	(0.097)	(0.093)	(0.158)	(0.141)	(0.133)	(0.065)
Decision-maker is wife	–0.194***	–0.156***	–0.099***	–0.094***	–0.101***	–0.105***	–0.136***	–0.152***	–0.152***
	(0.059)	(0.038)	(0.033)	(0.03)	(0.028)	(0.029)	(0.031)	(0.031)	(0.032)
Household heads'' employment in agriculture	0.157**	0.083**	0.058*	0.072**	0.028	0.013	0.015	0.035	0.004
	(0.062)	(0.039)	(0.034)	(0.03)	(0.029)	(0.03)	(0.034)	(0.032)	(0.033)
Household can access internet	0.086	0.023	0.089	0.11***	0.114**	0.132***	0.166**	0.155***	0.195***
	(0.086)	(0.063)	(0.054)	(0.042)	(0.048)	(0.044)	(0.067)	(0.05)	(0.06)
Constant	9.071***	9.745***	10.117***	10.426***	10.832***	11.146***	11.551***	11.868***	12.384***
	(0.455)	(0.324)	(0.27)	(0.231)	(0.219)	(0.246)	(0.255)	(0.253)	(0.212)
R-squared	0.118	0.113	0.101	0.093	0.086	0.083	0.079	0.076	0.075
Number of observations	3,507	3,507	3,507	3,507	3,507	3,507	3,507	3,507	3,507

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Parentheses refer to robust standard error.

Source: Analysed by authors.

Table 7 - Quantile Regression for Household Food Production in Rural Areas

	Deciles								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Ln income	0.047	0.047	0.05*	0.033	0.02	0.013	0.035**	0.045**	0.058***
	(0.036)	(0.037)	(0.03)	(0.025)	(0.021)	(0.016)	(0.017)	(0.019)	(0.021)
Households size	0.007	–0.01	0.014	0.075***	0.075***	0.095***	0.094***	0.098***	0.075***
	(0.018)	(0.022)	(0.024)	(0.018)	(0.015)	(0.012)	(0.011)	(0.014)	(0.012)
Household heads' sex is male	–0.051	–0.026	–0.037	–0.046	0.022	–0.031	–0.087	–0.047	–0.03
	(0.159)	(0.109)	(0.119)	(0.094)	(0.075)	(0.078)	(0.073)	(0.08)	(0.069)
Household head's years of schooling	0.021**	0.007	0.014	0.008	0.002	0.005	0.009*	0.009*	0.006
	(0.01)	(0.01)	(0.009)	(0.007)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
Household heads' primary activity is working	0.06	0.234*	0.069	0.035	–0.026	–0.034	–0.029	–0.119	–0.055
	(0.108)	(0.139)	(0.142)	(0.104)	(0.084)	(0.079)	(0.07)	(0.079)	(0.105)
Households have safe drinking water sources	–0.039	–0.069	0.16	–0.053	–0.034	–0.013	0.014	–0.143	–0.119
	(0.251)	(0.108)	(0.12)	(0.161)	(0.117)	(0.073)	(0.094)	(0.136)	(0.103)
Households have electricity	0.059	–0.192	–0.104	0.124	0.156	0.062	0.035	–0.124	0.07
	(0.289)	(0.231)	(0.159)	(0.143)	(0.24)	(0.262)	(0.124)	(0.277)	(0.412)
Decision-maker is wife	0.312***	0.356***	0.309***	0.228***	0.136***	0.106***	0.083*	0.033	0.015
	(0.092)	(0.089)	(0.075)	(0.06)	(0.051)	(0.041)	(0.043)	(0.044)	(0.053)
Household heads' employment in agriculture	–0.143	–0.166*	–0.191**	–0.119*	–0.078	–0.064	–0.047	–0.048	–0.067
	(0.089)	(0.094)	(0.085)	(0.065)	(0.055)	(0.043)	(0.047)	(0.045)	(0.054)
Household can access internet	–0.328**	0.056	0.045	0.147	0.154*	0.128*	0.102	0.135	0.296***
	(0.141)	(0.176)	(0.128)	(0.108)	(0.082)	(0.069)	(0.069)	(0.11)	(0.082)
Constant	8.165***	9.04***	9.271***	9.754***	10.24***	10.646***	10.546***	11.014***	11.004***
	(0.62)	(0.627)	(0.499)	(0.445)	(0.419)	(0.366)	(0.294)	(0.418)	(0.533)
R-squared	0.012	0.01	0.008	0.008	0.01	0.015	0.017	0.018	0.015
Number of observations	3,192	3,192	3,192	3,192	3,192	3,192	3,192	3,192	3,192

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Parentheses refer to robust standard error.

Source: Analysed by authors.

Table 8 - Quantile Regression for Household Total Food Expenditure in Rural Areas

	Deciles								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Ln income	0.05***	0.053***	0.064***	0.05***	0.049***	0.048***	0.041***	0.044***	0.037***
	(0.016)	(0.012)	(0.011)	(0.011)	(0.01)	(0.011)	(0.012)	(0.012)	(0.014)
Households size	0.172***	0.164***	0.157***	0.15***	0.148***	0.142***	0.142***	0.138***	0.115***
	(0.012)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)	(0.009)
Household heads' sex is male	0.043	–0.029	–0.015	0.003	–0.018	–0.012	–0.026	–0.106*	–0.073
	(0.071)	(0.044)	(0.044)	(0.047)	(0.04)	(0.039)	(0.065)	(0.055)	(0.078)
Household head's years of schooling	0.028***	0.028***	0.025***	0.022***	0.021***	0.021***	0.017***	0.015***	0.015***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Household heads' primary activity is working	–0.007	0.024	–0.013	–0.017	0.006	0.026	0.042	0.035	0.081
	(0.071)	(0.043)	(0.048)	(0.039)	(0.036)	(0.042)	(0.05)	(0.038)	(0.064)
Households have safe drinking water sources	0.212*	0.084	0.04	0.046	0.071	–0.007	–0.014	–0.027	–0.056
	(0.109)	(0.087)	(0.067)	(0.048)	(0.058)	(0.071)	(0.062)	(0.055)	(0.08)
Households have electricity	0.031	–0.034	–0.012	–0.099	–0.07	–0.102	–0.091	–0.169***	–0.006
	(0.222)	(0.149)	(0.099)	(0.137)	(0.098)	(0.074)	(0.157)	(0.054)	(0.192)
Decision-maker is wife	–0.066	–0.055*	–0.028	–0.06**	–0.053**	–0.061**	–0.06**	–0.053*	–0.118***
	(0.042)	(0.029)	(0.027)	(0.026)	(0.026)	(0.026)	(0.03)	(0.03)	(0.036)
Household heads' employment in agriculture	0.049	0.016	0.035	0.025	0.01	0.004	0.008	0.011	–0.004
	(0.042)	(0.032)	(0.027)	(0.027)	(0.027)	(0.027)	(0.032)	(0.031)	(0.039)
Household can access internet	0.097*	0.069	0.087**	0.099**	0.113***	0.104**	0.17***	0.22***	0.207***
	(0.057)	(0.054)	(0.039)	(0.046)	(0.042)	(0.044)	(0.053)	(0.054)	(0.064)
Constant	10.09***	10.56***	10.617***	11.127***	11.249***	11.505***	11.806***	12.127***	12.419***
	(0.342)	(0.245)	(0.207)	(0.227)	(0.187)	(0.194)	(0.257)	(0.201)	(0.301)
R-squared	0.135	0.124	0.11	0.101	0.096	0.091	0.085	0.08	0.073
Number of observations	3,523	3,523	3,523	3,523	3,523	3,523	3,523	3,523	3,523

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Parentheses refer to robust standard error.

Source: Analysed by authors.

Table 6 shows that variables of income, household size, education, household head's employment in agriculture, and internet access are the significant contributors to food-bought expenditure in all classes, with a decreasing effect for higher classes. A possible explanation for this decreasing effect is the higher the household classes and the demand shift from quantity-oriented to quality-oriented food. Since the food budget consumes the most significant proportion of Indonesian households' budgets, poorer families tend to consume low-quality food to maintain food sufficiency. In contrast, upper classes households tend to maximise their utility by buying less food with higher quality and variety.

Table 7 shows that variables of households living in rural areas are the only significant contributors to own production expenditure for all classes. On the other hand, variables of income and agriculture employment are significant for the low and middle classes. At the same time, household size and internet access variables are significant for the middle and upper classes.

These findings indicate that living in rural areas allows households to produce their food largely due to sufficient resources available in rural areas that are not always easily found in urban, e.g., land areas, access to water, and direct sunlight exposure, which are important for crop growth. Further, the benefits of having agriculture as the main employment sector, which is only owned by 16.81% of Indonesian households, allow them to have flexible working hours and higher knowledge to produce their food. Smallholder farmers and their families produce food to fulfill their necessities and cope during drought and adverse times (FAO, 2018). According to FAO (2018), 93% of Indonesian farmers are classified as small farmers who live in subsistence farming. The farmer's family consumes nearly all the crops or livestock raised, leaving little, if any, surplus for sale or trade. Hence, the combination of irregular income received from trade and the inability to buy food forced them to produce their food (Faharuddin *et al*., 2017; Priyanti *et al*., 2007).

Findings in Tables 6-8 show that only households in the middle and upper classes can benefit from internet access, which positively impacts their food self-reliance. In Tables 6-8, households in the low deciles have a positive but insignificant impact on internet access, which indicates the disproportionate benefit of the internet for household classes, as the World Bank (2021) found. Further, the World Bank (2021) shows that highly educated populations, commonly occupying the middle and upper classes, are five times more likely to be connected to the internet than those with lower educational levels. At the same time, individuals from lower-income families are three times less likely to connect to the internet than those from top-income families. This digital divide can result in a food consumption gap, leading to decreased human resources and a loss of economic potential. Hence, increasing access to the internet for the poorest households is important to ensure households

have the knowledge to improve their food self-reliance and can raise their standard of living,

The above findings also imply that producing one's food is not significantly influenced by household income. Instead, households that rely on high-value assets like land area and water access can fulfill their food production, as found in the agriculture employment sector. The significance of agriculture in Indonesia's economy is shown by its contribution to more than 14% of GDP in 2017, which is generated from 32% of the nation's total land area used for agricultural production. Further, the agricultural sector serves as the second-biggest job absorption, especially for those living in rural areas where 33% of Indonesia's labour force is employed in the agricultural sector (FAO, 2018). Another study found that farmers act as producers and consumers; therefore, households allocate resources to produce goods and services and use goods and services to fulfill their needs (Priyanti *et al.*, 2007).

Table 8 shows that income, household size, education, and internet access significantly contribute to total food expenditure in all deciles. At the same time, variables of households living in rural areas and agriculture employment are significant for middle and upper deciles. Findings in Table 8 show that internet access can benefit households as it allows households to have higher knowledge of food nutrition, an active lifestyle, and great deals to save on food expenses, which then leads to wiser decisions on food expenditure (Ezeoha *et al.*, 2020; Liang *et al.*, 2020; Mwalupaso *et al.*, 2020). In addition, having a mobile phone and access to the internet increases household income, which indirectly increases food security (Liang *et al.*, 2020; Xue *et al.*, 2021).

To check the robustness of quantile regression, we reviewed the results with the robust-to-outliers method, as Verardi and Croux (2009) proposed in Table 9. This estimator provides similar median results of quantile regression in Tables 6-8; hence, we can accept that estimations from quantile regression are robust to explain the relationship between technology and food expenditure in Indonesia.

Considering findings from quantile estimations in Tables 6-8, the focus of development should be aimed at households living in rural areas as it consistently contributes significantly to supporting households' food resilience. Further, intervention in households in the lowest classes should be done as any financial support from external resources like the government will significantly help them increase their food resilience, as Maipita *et al.* (2011).

We also should increase internet access for rural households as it lacks significance on own food production for low deciles but is significant for food-bought expenditure for the same deciles. Internet use among low-decile rural households increases knowledge and productivity, especially when agriculture is their primary employment, contributing significantly to food

Table 9 - Estimation of Robust Regression

	Robust Regression			Ordinary Least Square		
	Food Exp.	**Own Production Food Exp.**	**Total Food Exp.**	**Food Exp.**	**Own Production Food Exp.**	**Total Food Exp.**
Ln income	0.067***	0.016	0.054***	0.055***	0.044**	0.047***
	(0.014)	(0.019)	(0.012)	(0.011)	(0.019)	(0.009)
Households size	0.152***	0.09***	0.146***	0.178***	0.057***	0.153***
	(0.008)	(0.014)	(0.007)	(0.008)	(0.013)	(0.006)
Household heads' sex is male	–0.067	–0.037	–0.02	0	–0.052	–0.018
	(0.05)	(0.079)	(0.043)	(0.044)	(0.074)	(0.035)
Household head's years of schooling	0.023***	0.006	0.02***	0.026***	0.008	0.023***
	(0.003)	(0.006)	(0.003)	(0.003)	(0.005)	(0.003)
Household heads' primary activity is working	0.005	–0.042	0.006	0.029	0.004	0.008
	(0.046)	(0.085)	(0.04)	(0.044)	(0.073)	(0.036)
Households have safe drinking water sources	0.006	0.006	0	0.128**	–0.055	0.052
	(0.073)	(0.107)	(0.062)	(0.057)	(0.094)	(0.046)
Households have electricity	–0.079	0.093	–0.085	–0.19*	–0.076	–0.103
	(0.133)	(0.17)	(0.114)	(0.101)	(0.167)	(0.08)
Decision-maker is wife	–0.106***	0.122**	–0.045*	–0.13***	0.176***	–0.065***
	(0.028)	(0.051)	(0.025)	(0.028)	(0.047)	(0.023)
Household heads' employment in agriculture	0.015	–0.082	0.006	0.073**	–0.095*	0.031
	(0.028)	(0.051)	(0.025)	(0.03)	(0.05)	(0.024)
Household can access internet	0.118***	0.166*	0.112***	0.114**	0.093	0.131***
	(0.047)	(0.089)	(0.042)	(0.045)	(0.077)	(0.037)
Constant	10.856***	10.38***	11.269***	10.745***	9.957***	11.29***
	(0.252)	(0.36)	(0.222)	(0.206)	(0.341)	(0.165)

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Parentheses refer to standard error. Robust regression is estimated using Verardi and Croux (2009) estimator.

Source: Analysed by authors.

production. Hence, breaking down barriers to mobile internet connectivity in Indonesia will be critical to delivering better economic benefits, for example, by providing affordable internet-capable phones for low-income households living in rural and remote areas households, as they need to spend at least one-fifth of their monthly expenses to buy a phone (Setiawan *et al*., 2022). Expanding internet coverage should also be encouraged. Hence, infrastructure development is needed to increase internet adoption in the population (Ariansyah, 2018). Moreover, the government should upgrade households' internet-related skills to allow them to use the internet effectively (Makun & Jayaraman, 2012; Rath & Hermawan, 2020).

The positive but decreasing impact of household size on food expenditure in classes shows that the larger household size variable positively impacts food expenditure but with a decreasing effect for higher deciles. Since higher food expenditure for the poorest households does not necessarily mean better

food variety or quality, the government needs to increase households' income to ensure their ability to support themselves when they face additional household members.

3.3. *Policy Implication*

Several strategies can be implemented to enhance food security by targeting key determinants such as household size, income, education, and agricultural practices, as identified in the preceding sections. Policy implications stemming from this research are delineated below.

Firstly, bridging the technology gap across communities is imperative, particularly for low-income households. This can be achieved by expanding internet accessibility in remote regions, reducing internet expenses for educational purposes, and enhancing digital literacy among individuals. Improved internet access can empower households with valuable knowledge and skills, thereby enhancing productivity and contributing to overall food security.

Secondly, promoting the adoption of advanced agricultural technologies and eco-friendly farming practices through dissemination efforts, pilot projects, and financial incentives is crucial. These initiatives can enable households to reduce farming costs, lessen reliance on chemical inputs, and bolster food security levels.

Thirdly, advocating for family planning programs can enhance dietary outcomes for household members. With similar expenditure levels, smaller households can prioritize the quality of food consumption over larger households. This underscores the importance of addressing household size dynamics in fostering better nutritional outcomes.

In summary, interventions aimed at reducing disparities, fostering agricultural development, and promoting smaller household sizes are essential for creating a more inclusive and sustainable environment. These measures will not only improve dietary diversity but also enhance food security among households, ultimately contributing to broader socio-economic development.

Conclusions

This paper investigates technology's contribution to the increase of households' standard of living measured by food expenditure among households in rural areas in Indonesia. Observation of different households' classes shows the importance of technology in supporting nutrition

sufficiency. Other important contributors to food expenditure for different household classes are income, household size, education, and agriculture as main employment. The focus should be on widening internet access for low-decile households as it can help them increase knowledge in selecting food commodities and increase productivity in food production.

While this research can achieve the determinants of household food expenditure across classes, some limitations exist. First, using food expenditure as a monetary proxy for household food sufficiency potentially hides the variety and quality of household food consumed, providing a more accurate measurement of household food sufficiency. Second, this study focuses only on internet availability and does not cover the differences in intensity and scope of internet use, which may lead to different results on food security levels. Future research can use panel data to examine the trend of the relationship between the internet and nutrition sufficiency over time. The differences in the pattern of internet use in households and the contribution of spatial aspects are also interesting to find.

References

Ab, O., Aj, A., Ma, A., & Om, P. (2022). Rural Households Food Expenditure Pattern and Food Security Status in Nigeria. *Biomedical Journal of Scientific & Technical Research*, 43(4), 34900-34909. Doi: 10.26717/BJSTR.2022.43.006946.

Alderman, H., Behrman, J.R., & Hoddinott, J. (2005). Nutrition, malnutrition and economic growth. *Health and economic growth: Findings and policy implications*, 169-194. Doi: 10.7551/mitpress/3451.003.0012.

Alinovi, L., Mane, E., & Romano, D. (2010). Measuring household resilience to food insecurity: application to Palestinian households. *Agricultural survey methods*, 341-368. Doi: 10.1002/9780470665480.ch21.

Anerua, F., & Azonuche, D. (2010). Information and communication technology (ict): a necessary tool for food and nutrition education issues and challenges. Multidisciplinary *Journal of Research Development*, 14(4). -- Retrieve from: www.globalacademicgroup.com/journals/multidisciplinary%20journal%20of%20research%20development/INFORMATION%20AND%20COMMUNICATION%20TECHNOLOGY.pdf.

Ardianti, D.M., & Hartono, D. (2022). Internet Use and Agricultural Household Food Insecurity in Indonesia. *Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi dan Pembangunan*, 23(2), 179-191. Doi: 10.23917/jep.v23i2.18077.

Ariani, M., & Saliem, H.P. (2015). Pola Pengeluaran dan Konsumsi Rumah Tangga Perdesaan: Komparasi Antartipe Agroekosistem. Indonesian Agency for Agricultural Research and Development. Book Chapter: Konsumsi Pangan Rumah Tangga: Antara Harapan dan Kenyataan. -- Retrieve from: www.neliti.com/publications/716/pola-pengeluaran-dan-konsumsi-rumah-tangga-perdesaan-komparasi-antartipe-agroeko#cite.

Ariansyah, K. (2018). The Importance of the internet on improving economic welfare: An empirical evidence from Indonesian rural household. Paper presented at the 2018 *International Conference on ICT for Rural Development (IC-ICTRuDev)*. Doi: 10.1109/ICICTR.2018.8706868.

Badan Pusat Statistik (2021). *Pengeluaran untuk Konsumsi Penduduk Indonesia, Maret 2021*. -- Retrieved from www.bps.go.id/publication/2021/10/29/b4d4f654fc44dee98f389171/pengeluaran-untuk-konsumsi-penduduk-indonesia-maret-2021.html.

Belotti, F., Hughes, G., & Mortari, A.P. (2017). Spatial panel-data models using Stata. The *Stata Journal*, 17(1), 139-180. Doi: 10.1177/1536867X1701700109.

Bernstein, M.A., Tucker, K.L., Ryan, N.D., O'Neill, E.F., Clements, K.M., Nelson, M.E., … Singh, M.A.F. (2002). Higher dietary variety is associated with better nutritional status in frail elderly people. *Journal of the American Dietetic Association*, 102(8), 1096-1104. Doi: 10.1016/S0002-8223(02)90246-4.

Bertham, Y.H., Ganefianti, D.W., & Andani, A. (2011). Peranan Perempuan dalam Perekonomian Keluarga dengan Memanfaatkan Sumberdaya Pertanian. *AGRISEP,* 10(1), 138-153. Doi: 10.31186/jagrisep.10.1.138-153.

Beydoun, M.A., Powell, L.M., & Wang, Y. (2009). Reduced away-from-home food expenditure and better nutrition knowledge and belief can improve quality of dietary intake among US adults. *Public health nutrition*, 12(3), 369-381. Doi: 10.1017/S1368980008002140.

Brug, J., Oenema, A., Kroeze, W., & Raat, H. (2005). The internet and nutrition education: challenges and opportunities. *European Journal of Clinical Nutrition*, 59(1), S130-S139. Doi: 10.1038/sj.ejcn.1602186.

Crotty, P.A., Rutishauser, I.H., & Cahill, M. (1992). Food in low-income families. *Australian Journal of Public Health*, 16(2), 168-174. Doi: https://doi.org/10.1111/j.1753-6405.1992.tb00047.x.

Darmon, N., & Drewnowski, A. (2008). Does social class predict diet quality? The American *Journal of Clinical Nutrition*, 87(5), 1107-1117. Doi: 10.1093/ajcn/87.5.1107.

Decuyper, A., Rutherford, A., Wadhwa, A., Bauer, J.-M., Krings, G., Gutierrez, T., … Luengo-Oroz, M.A. (2014). Estimating food consumption and poverty indices with mobile phone data. *arXiv* preprint arXiv,1412.2595. Doi: 10.48550/arXiv.1412.2595.

Ezeoha, A.E., Obi, A., Igwe, A., & Ezeruigbo, C. (2020). The mobile phone revolution, the Internet and rural electricity: What are the implications for food security in Africa? *Information Development*, 36(4), 603-622. Doi: 10.1177/0266666919884991.

Faharuddin, Yunita, Mulyana, A., & Yamin, M. (2019). Agricultural households' food demand: Evidence from Indonesia. *Asian Journal of Agriculture and Development*, 16(1362-2019-4203), 45-60. Doi: 10.37801/ajad2019.16.2.3.

Faharuddin, F., Mulyana, A., Yamin, M., & Yunita, Y. (2017). Nutrient elasticities of food consumption: the case of Indonesia. *Journal of Agribusiness in Developing and Emerging Economies*, 7(3), 198-217. Doi: 10.1108/JADEE-02-2016-0008.

Fan, J.X., Brown, B.B., Kowaleski-Jones, L., & Smith, K.R. (2007). Household food expenditure patterns: a cluster analysis. *Monthly Lab. Rev.*, 130, 38. -- Retrieved from: www.bls.gov/opub/mlr/2007/04/art3full.pdf.

FAO (2018). *Country factsheet on small family farms - Indonesia*. -- Retrieved from www.fao.org/agrifood-economics/publications/detail/en/c/1132206/.

Fogel, R.W. (2004). Health, nutrition, and economic growth. *Economic Development and Cultural Change*, 52(3), 643-658. Doi: 10.1086/383450.

Hafizah, D., Hakim, D.B., Harianto, H., & Nurmalina, R. (2021). Analisis Elastisitas Pendapatan Rumah Tangga di Indonesia. *Jurnal Ilmu Pertanian Indonesia*, 26(3), 428-435. Doi: 10.18343/jipi.26.3.428.

Huffman, W.E., & Orazem, P.F. (2007). Agriculture and Human Capital in Economic Growth: Farmers, Schooling and Nutrition. In: R. Evenson & P. Pingali (Eds.). *Handbook of Agricultural Economics* (vol. 3, pp. 2281-2341): Elsevier. Doi: 10.1016/S1574-0072(06)03043-X.

Hymans, S.H., & Shapiro, H.T. (1976). The allocation of household income to food consumption. *Journal of Econometrics*, 4(2), 167-188. Doi: 10.1016/0304-4076(76)90011-7.

Irawan, B., Simatupang, P., Sugiarto, S., Agustin, N., & Sinuraya, J. (2006). Panel Petani Nasional (PATANAS): analisis indikator pembangunan pertanian dan pedesaan. *Laporan Akhir Penelitian*.

Islam, D.M.R., & Sim, D.N. (2021). *Education and Food Consumption Patterns: Quasi-Experimental Evidence from Indonesia*. Cornell University. Doi: 10.2139/ssrn.3925151.

Kant, A.K., Schatzkin, A., Harris, T.B., Ziegler, R.G., & Block, G. (1993). Dietary diversity and subsequent mortality in the first national health and nutrition examination survey epidemiologic follow-up study. *The American journal of clinical nutrition*, 57(3), 434-440. Doi: 10.1093/ajcn/57.3.434.

Khanal, A.R., & Mishra, A.K. (2013). Assessing the impact of internet access on household income and financial performance of small farms. *Research in Agricultural & Applied Economics*. Doi: 10.22004/ag.econ.143019.

Koenker, R., & Bassett Jr, G. (1978). Regression quantiles. *Econometrica*, 46(1), 33-50. Doi: 10.2307/1913643.

Kousar, R., Sadaf, T., Makhdum, M.S.A., & Ijaz, A. (2017). Determinants of household's education and nutrition spending: A gender-based empirical analysis. *Humanomics*. Doi: 10.1108/H-06-2016-0050.

Liang, L., Shrestha, R., Ghosh, S., & Webb, P. (2020). Using mobile phone data helps estimate community-level food insecurity: Findings from a multi-year panel study in Nepal. *PLoS One*, 15(11), e0241791. Doi: 10.1371/journal.pone.0241791.

Maipita, I., Jantan, D., & Razak, N.A.A. (2011). The impact of fiscal policy toward economic performance and poverty rate in Indonesia. *Bulletin of Monetary Economics and Banking*, 12(4), 391-424. Doi: 10.21098/bemp.v12i4.378.

Makun, K.K., & Jayaraman, T. (2012). Spread of ICT and Economic Growth in Pacific Island Countries: A Panel Study. *Bulletin of Monetary Economics and Banking*, 23, 109-128. Doi: 10.21098/bemp.v23i0.1178.

Maxwell, D., Levin, C., Armar-Klemesu, M., Ruel, M., Morris, S., & Ahiadeke, C. (2000). *Urban Livelihoods and Food and Nutrition Security in Greater Accra, Ghana*. -- Retrieved from: Urban Livelihoods and Food and Nutrition Security in Greater Accra, Ghana - Google Books.

McCulloch, N., & Timmer, C. (2008). Rice policy in Indonesia: a special issue. *Bulletin of Indonesian Economic Studies*, 44(1), 33-44. Doi: 10.1080/00074910802001561.

Mulamba, K.C. (2022). Relationship between households' share of food expenditure and income across South African districts: a multilevel regression analysis.

Humanities and Social Sciences Communications, 9(1), 1-11. Doi: 10.1057/s41599-022-01454-4.

Mulugeta, M.S. (2009). Determinants of livelihood strategies of urban women: The case of female household heads in Wolenchiti Town, Ethiopia. *Research and Perspectives on Development Practice*, 6. -- Retrieved from: https://mural.maynoothuniversity.ie/9964/1/Metasebia-Solomon-Mulugetasmallpdf.com_.pdf.

Mwalupaso, G.E., Wang, S., Eshetie, A.M., & Tian, X. (2020). Ameliorating food and nutrition security in farm households: Does informatization matter?. *Sustainability*, 12(2), 522. Doi: 10.3390/su12020522.

Neuenschwander, L.M., Abbott, A., & Mobley, A.R. (2012). Assessment of Low-Income Adults' Access to Technology: Implications for Nutrition Education. *Journal of Nutrition Education and Behavior*, 44(1), 60-65. Doi: 10.1016/j.jneb.2011.01.004.

Pampel, F.C., Krueger, P.M., & Denney, J.T. (2010). Socioeconomic disparities in health behaviors. *Annual Review of Sociology*, 36, 349. Doi: 10.1146/annurev.soc.012809.102529.

Pangaribowo, E.H., & Tsegai, D.W., Food Demand Analysis of Indonesian Households with Particular Attention to the Poorest (August 1, 2011). *ZEF-Discussion Papers on Development Policy No. 151*, -- Available at SSRN:https://ssrn.com/abstract=1945226.

Priyanti, A., Inaga, B., Syaukat, Y., & Kuntjoro, S. (2007). Model Ekonomi Rumahtangga Petani Pada Sistem Integrasi Tanaman-Ternak: Konsepsi Dan Studi Empiris. *Wartazoa*, 17(2), 61-70.

Rath, B.N., & Hermawan, D. (2020). Do information and communication technologies foster economic growth in Indonesia?. *Bulletin of Monetary Economics and Banking*, 22(1), 103-122. Doi: 10.21098/bemp.v22i1.1041.

Rinukti, N.S. (2018). *Dampak Program Bantuan Langsung Tunai (BLT) Terhadap Pengeluaran Konsumsi Rumah Tangga Indonesia Studi Kasus: BLT 2005 dan BLT 2008* (Doctoral dissertation, Universitas Gadjah Mada).

Ronalia, P., Hartono, D., & Misdawita, M. (2023). The Impact of Resilience on Household Food Insecurity in Indonesia. *Jurnal Ekonomi Pembangunan*, 21(1), 25-38. Doi: 10.29259/jep.v21i1.20864.

Ruel, M.T., Garrett, J.L., Morris, S.S., Maxwell, D.G., Oshaug, A., Engle, P.L., … Haddad, L.J. (1998). Urban challenges to food and nutrition security. *International Food Policy Research Institute* (IFPRI). -- Retrieve from: https://ideas.repec.org/s/fpr/fcnddp.html.

Satriawan, E., & Shrestha, R. (2018). Mistargeting and regressive take up of the Indonesian Rice Subsidy Program. *Asian Economic Journal*, 32(4), 387-415. Doi: 10.1111/asej.12164.

Setiawan, I., Pape, U., & Beschorner, N. (2022). How to bridge the gap in Indonesia's inequality in internet access. -- Retrieved from: https://blogs.worldbank.org/eastasiapacific/how-bridge-gap-indonesias-inequality-internet-access.

Singh, G., Rajesh, R., Daultani, Y., & Misra, S.C. (2023). Resilience and sustainability enhancements in food supply chains using Digital Twin technology: A grey causal modelling (GCM) approach. *Computers & Industrial Engineering*, 179, 109172. Doi: 10.1016/j.cie.2023.109172.

Soseco, T. (2021). Household Size, Education, and Household Wealth in Indonesia: Evidence from Quantile Regression. *Jurnal Ekonomi Indonesia*, 10(3), 281-297. Doi: 10.52813/jei.v10i3.72.

Soseco, T., Hidayah, I., & Rini, A.D. (2022). Gender Determinant on Multidimensional Poverty Index: Evidence from Indonesia. *Jurnal Ilmu Sosial dan Ilmu Politik*, 26(2), 137-151. Doi: 10.22146/jsp.69320.

Sun, H., Cao, Y., Kim, D., & Marelli, B. (2022). Biomaterials technology for agrofood resilience. *Advanced Functional Materials*, 32(30), 2201930. doi: 10.1002/adfm.202201930.

Syamola, D., & Nurwahyuni, A. (2019). Determinan Ketahanan Pangan Rumah Tangga di Daerah Pedesaan di Indonesia (Analisis Data Susenas Tahun 2017). *Media Kesehatan Masyarakat Indonesia*, 15(1), 46-54. Doi: 10.30597/mkmi.v15i1.5880.

Thaariq, R.M., Anindita, A., & Iftina, H.D. (2012). The Internet Miracle: the Impact of Internet Access on Household Saving in Indonesia. *Bulletin of Monetary Economics and Banking*, 24(2), 255-282. Doi: 10.21098/bemp.v24i2.1650.

Upton, J.B., Cissé, J.D., & Barrett, C.B. (2016). Food security as resilience: reconciling definition and measurement. *Agricultural Economics*, 47(S1), 135-147. Doi: 10.1111/agec.12305.

Verardi, V., & Croux, C. (2009). Robust regression in Stata. *The Stata Journal*, 9(3), 439-453. Doi: 10.1177/1536867X0900900306.

Wahid, F., & Furuholt, B. (2012). Understanding the use of mobile phones in the agricultural sector in rural Indonesia: using the capability approach as lens. *International Journal of Information and Communication Technology*, 4(2-4), 165-178. Doi: 10.1504/IJICT.2012.048761.

Wahlqvist, M.L., & Specht, R.L. (1998). Food variety and biodiversity: Econutrition. *Asia Pacific Journal of Clinical Nutrition*, 7, 314-319. -- Retrieve from: https://apjcn.nhri.org.tw/server/APJCN/7/3/4/314.pdf.

Wang, X., & Taniguchi, K. (2003). Does better nutrition enhance economic growth? The economic cost of hunger. Nutrition intake and economic growth. *Studies on the cost of hunger.* Doi: 10.22004/ag.econ.289103.

Wantchekon, L., & Riaz, Z. (2019). Mobile technology and food access. *World Development*, 117, 344-356. Doi: 10.1016/j.worlddev.2019.01.006.

Widodo, S. (2007). Pembangunan dan Politik Pertanian di Indonesia. *Caraka Tani: Journal of Sustainable Agriculture*, 22(1), 26-35. Doi: 10.20961/carakatani.v22i1.20534.

World Bank. (2021). *Beyond Unicorns: Harnessing Digital Technologies for Inclusion in Indonesia*: World Bank. Retrieve from: Beyond Unicorns: Harnessing Digital Technologies for Inclusion in Indonesia (worldbank.org).

Xue, P., Han, X., Elahi, E., Zhao, Y., & Wang, X. (2021). Internet access and nutritional intake: Evidence from rural China. *Nutrients*, 13(6). Doi: 10.3390/nu13062015.

Yovo, K., & Gnedeka, K.T. (2023). Assess the level and the determinants of household food security in Togo: The food expenditures approach. *Scientific African*, 20, e01685. Doi: 10.1016/j.sciaf.2023.e01685.

Thomas Soseco
Faculty of Economics and Business, Universitas Negeri Malang, Indonesia
Jl. Semarang, 5, Malang, Indonesia
E-mail: thomas.soseco.fe@um.ac.id
He holds a PhD in Economics from the University of Waikato, New Zealand (2022), an MSc in Economics from Universitas Gadjah Mada, Indonesia (2009), and a Bachelor of Economics from Universitas Andalas, Indonesia (2005). His works focus on development economics, regional economics, household welfare, poverty, and inequality studies. He is a WoS Academy Certified Peer Reviewer. His blog is thomassoseco.blogspot.com.

Isnawati Hidayah
Department of Economics and Law, Sapienza University or Rome, Italy
Department of Public Health and Primary Care, Leiden University Medical Centre (Leiden University), Netherlands
Via del Castro Laurenziano, 9, 00161 Roma, Italia
E-mail: isnawati.hidayah@uniroma1.it
Isnawati Hidayah is pursuing PhD in Economics under join supervision at Sapienza University of Rome, Italy and LUMC, Leiden University. Isnawati graduated from Master of International Development Studies program majoring Economics Development from Wageningen University and Research, the Netherlands, in 2019. Isnawati is founder and associated as a economic researcher at ROTASI Institute (Institute for Rural Development and Sustainability). For her research, she interests on economic development, food security, food system, sustainability and rural development issues.

Nila Cahayati
Department of Economics, Brawijaya University, Indonesia
MT. Haryono Street, 165, Ketawanggede, Kec. Lowokwaru, Kota Malang,
Jawa Timur, 65300
Tel. +62 8223 3722 750
E-mail: nilacahayati190@gmail.com – nilacahayati@student.ub.ac.id
Holds a bachelor degree in economics (Malang, 2022) and master degree in economics (Malang, 2024). Researcher at ROTASI Institute since 2020 and Center for Economic Development and Citizens Studies (PKEPK), Brawijaya University, since 2024. Current research interests in socio economic and the intersection between gender, poverty, digitalization, and rural development.

Fajar Try Leksono
Department of Economics, Institute for Rural Development and Sustainability, Indonesia
Dusun. Wonodadi, Ds. Wonodadi, Kec. Wonodadi, Kabupaten Blitar, 65155
Tel. +6289-6200-5689-5
E-mail: fajar.leksono@rotasi.or.id
Fajar Try Leksono is a graduate of Universitas Negeri Malang, earning his degree in Development Economics from the Faculty of Economics. Currently, he is an entrepreneur, managing a rice milling business, and working as a farmer. His research interests focus on economic development and rural economies. Fajar actively engages with ROTASI Institute, where he gains invaluable experience in economics and hones his skills alongside his peers, fostering a collaborative environment for growth and innovation.