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Food Access, Spatial Differences, and Social Protection Targeting: Evidence from Central Java

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Abstract

Social protection programs are important policy instruments for addressing food insecurity. This study examines the statistical relationships between food access, area of residence, and social protection participation in Central Java using quantitative and qualitative data. A Partial Least Squares Structural Equation Modeling (PLS-SEM) approach is applied to explore structural associations among these variables. The results indicate that food access is positively associated with social protection participation, suggesting that households experiencing food access constraints are more likely to be linked with such programs. Spatial differences are also observed: urban households appear to face greater food access challenges, while rural households are statistically more likely to be associated with social protection participation. Area of residence further shows a significant indirect association in the relationship between food access and social protection. These findings highlight the importance of improving the alignment between social protection targeting and evolving food access vulnerabilities, particularly in urban areas.

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Introduction

Food represents a fundamental human necessity; therefore, reinforcing the pillars of food security must become a key policy priority. To support this objective, the Indonesian government has long implemented various social protection initiatives, delivered through both direct cash transfers and indirect forms of assistance (Iping, 2020). Empirical studies indicate that social protection programs contribute significantly and positively to improving household food security (Amrullah *et al.*, 2020; Devereux *et al.*, 2012; Osabohien *et al.*, 2023). Efforts to strengthen food security pillars are closely aligned with the broader goal of eradicating hunger (Sinha & Chattopadhyay, 2024).

The hunger situation in Indonesia can be illustrated by FAO (2023), which reports an upward trend in the prevalence of undernourishment between 2011 and 2021. Meanwhile, The Global Food Security Index (2022) ranks Indonesia 63rd out of 113 countries in terms of overall food security performance. Although several dimensions of food security in Indonesia – such as affordability, availability, sustainability, and adaptation – show an improving trend, the availability pillar has recently weakened. This decline is accompanied by reduced agricultural production stability and a decrease in the sufficiency of food supply.

At the subnational level, Central Java Province is considered more vulnerable to natural hazards than other provinces on Java Island, raising concerns about the resilience of its food security pillars (Pratiwi *et al.*, 2020). Recurrent flooding in the province has led to crop failures and disruptions in food supply. Between 2014 and 2018, floods affected approximately 3.35% of the total cultivated land area, resulting in estimated rice production losses equivalent to 5.24% of actual output (Susanty *et al.*, 2022). Despite the increasing frequency and intensity of such disasters, a comprehensive and specific mitigation framework – particularly one addressing household food security coping strategies – has not yet been fully developed.

Given the persistence of food insecurity risks and the importance of accurate targeting in social protection delivery (Amrullah *et al.*, 2020; Devereux *et al.*, 2012), understanding how observable household conditions are associated with program participation becomes increasingly relevant. Although social protection is widely recognized as a key policy instrument for reducing vulnerability (Iping, 2020; Mehta *et al.*, 2018), evidence also shows that exclusion errors and governance challenges may limit its reach among near-poor and vulnerable groups (Luthfiah *et al.*, 2015). In this context, examining the statistical associations between household food access and social protection participation can provide insights into how program outreach aligns with observable indicators of need, particularly in areas exposed to food security pressures.

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Spatial disparities further complicate this relationship. Rural populations, often characterized by higher dependence on agriculture and greater exposure to livelihood shocks, are frequently identified as more vulnerable to food insecurity (Sibhatu & Qaim, 2017). At the same time, regional differences in infrastructure, service access, and administrative capacity may shape the distribution of social assistance. This study analyzes the structural associations between household food access, area of residence, and participation in social protection schemes in Central Java Province. By identifying these relationships, the study contributes empirical evidence on observable characteristics linked to program participation and highlights potential spatial patterns relevant to improving the inclusiveness and targeting orientation of social protection policies.

1. Background

Food security continues to pose a serious challenge for many nations, including those with substantial natural resource endowments. Efforts to strengthen food security systems have become increasingly complex due to climate change and rapid population growth, both of which intensify pressures on food supply and demand. Recent studies emphasize that climate change, economic instability, and global crises simultaneously exacerbate food insecurity, particularly in developing countries, by disrupting agricultural productivity and food access systems (Abdullahi *et al*., 2024). In addition, climate change is projected to significantly reduce crop yields and increase the risk of global food insecurity in the absence of effective adaptation strategies (Regmi & Paudel, 2024). Recent evidence further suggests that climate change may substantially reduce global agricultural productivity and food production, potentially lowering output by up to 14% by 2050 without adequate mitigation and adaptation measures (Farah *et al*., 2025; Li *et al*., 2025). Moreover, the agricultural sector itself contributes considerably to greenhouse gas emissions, highlighting the reciprocal relationship between climate change and food security (Ringeisen *et al*., 2024).

Empirical evidence from Indonesia demonstrates that food security is influenced by various structural and economic factors, including population density, land availability, staple food production, and food price fluctuations. Widada *et al*. (2017) found that food security conditions are strongly associated with the production of key food commodities – such as rice, maize, soybeans, poultry, and beef – as well as consumer price indices in essential sectors including housing, energy, healthcare, transportation, and financial services. Furthermore, multidimensional approaches, such as the

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Food Insecurity Multidimensional Index, indicate that food insecurity extends beyond caloric adequacy and also encompasses dimensions related to food access, utilization, and stability.

In addition to macro-level and production-related determinants, an expanding body of literature underscores the importance of household-level socioeconomic characteristics in shaping food security outcomes. Research consistently demonstrates that factors such as household income, mothers' educational attainment, family size, the gender and age of the household head, employment status, access to information, participation in social networks, and patterns of food and non-food expenditures significantly affect food security status (Akbar, 2018; Khan *et al*., 2012; Muhammad & Sidique, 2019; Umaroh & Pangaribowo, 2020). Food price fluctuations are also crucial, as increases in food prices have been shown to raise the prevalence of undernourishment, particularly among low-income households (Warr, 2014). Similarly, Omotesho *et al*. (2006) identify farm size, agricultural income, non-farm income, and household size as major determinants of food security among rural households, with patterns broadly consistent with those observed across households in general.

Given the diverse drivers of food insecurity, social protection has become a key policy tool for reducing vulnerability, especially among disadvantaged groups. Many countries have adopted social protection measures aimed at reinforcing food security systems by assisting poor and food-insecure households, as well as those affected by economic disruptions and environmental shocks. While short-term coping mechanisms such as emergency aid play an important role, the long-term effectiveness of social protection depends on its alignment with sustainable strategies that strengthen the core pillars of food security: availability, affordability, stability, and food quality.

A growing body of empirical evidence confirms the positive contribution of social protection programs to household food security. Lavers (2013) and Hidrobo *et al*. (2018) find that such interventions significantly enhance both the quantity and diversity of food consumption, including higher spending on nutrient-dense foods such as animal-source products. Social protection has also been shown to mitigate food insecurity linked to labor market shocks, including job loss and wage reductions (Loopstra *et al*., 2016). Moreover, in contexts experiencing rapid urban expansion, social protection policies remain vital for addressing food insecurity and nutritional challenges, while still complementing efforts to strengthen rural food systems (Brzeska *et al*., 2015).

Beyond supporting consumption, social protection interventions can produce wider economic benefits by promoting agricultural production and contributing to poverty alleviation. Evidence indicates that transfers and related programs can ease liquidity constraints, encourage farm investment, and enhance the productive capacity of beneficiary households (Dyngeland

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et al., 2020; Tirivayi *et al.*, 2016). Nevertheless, program effectiveness is highly dependent on accurate targeting and suitability to local conditions, particularly in areas vulnerable to climate-related risks.

To strengthen the conceptual foundation of this study, the analysis integrates the food security framework, vulnerability theory, and targeting theory in social protection. The food security framework conceptualizes food security as a multidimensional construct encompassing availability, access, utilization, and stability, with household-level outcomes primarily shaped by economic access and livelihood conditions. Vulnerability theory further emphasizes that food insecurity arises not only from current deprivation but also from exposure to risks and limited coping capacity. Residential location, particularly the rural–urban divide, may influence vulnerability through differences in labor markets, infrastructure, market access, and public services, thereby shaping both food access and household risk profiles.

Targeting theory provides an additional lens for understanding social protection participation. Social protection programs are designed to prioritize vulnerable households using observable indicators of deprivation; however, program receipt is also influenced by administrative capacity, eligibility criteria, and geographic targeting mechanisms. Therefore, the relationship between food access, residential location, and social protection participation reflects both household vulnerability and institutional processes. This study does not seek to establish causality but instead models the structural associations among these variables within a unified analytical framework.

2. Methods

Research Design and Data Sources

This study applies a quantitative approach supported by qualitative insights from a literature review. The quantitative analysis uses secondary data from the 2021 National Socioeconomic Survey (Susenas) conducted by Statistics Indonesia (BPS), covering 29,497 households in Central Java Province. The survey provides nationally representative household-level information on socio-economic conditions, including indicators related to food access, demographic characteristics, and participation in social protection programs.

The literature review complements the quantitative findings by providing contextual understanding and supporting the interpretation of empirical results, particularly in relation to social protection targeting and food security vulnerability. Building on this analytical framework, the study employs a structured empirical approach to ensure data quality and robustness prior to estimation. Accordingly, data cleaning procedures were conducted prior to

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analysis, including the removal of incomplete observations and consistency checks across key variables to ensure data reliability.

Variables and Measurement

The main variables included in the model are household food access, area of residence (urban-rural classification), number of household members, and participation in social protection programs. These variables are selected to represent observable household characteristics and spatial context that may be statistically associated with program participation.

Food access is used as an indicator reflecting household-level conditions related to food security, while area of residence captures spatial differences that may influence both vulnerability and access to social assistance. Social protection participation serves as the key endogenous variable in the structural model.

The indicators of food access are based on the Food Insecurity Experience Scale (FIES), an internationally recognized framework developed by the Food and Agriculture Organization (FAO) for measuring household-level food insecurity. All variables were operationalized according to the coding framework provided by Statistics Indonesia (BPS), ensuring consistency with national statistical standards.

Analytical Approach

To examine the structural associations among variables, this study employs Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM is an exploratory, prediction-oriented technique suitable for analyzing complex relationships among multiple variables, particularly when the objective is to identify statistically significant associations rather than to test well-established causal theories. The large sample size (29,497 households) exceeds the minimum recommended thresholds for PLS-SEM applications (Hair *et al*., 2014), thereby ensuring sufficient statistical power for model estimation.

The analysis follows a two-step approach, consisting of the evaluation of the measurement model (outer model) and the structural model (inner model). The measurement model is assessed through indicator loadings, composite reliability, and average variance extracted (AVE) to ensure reliability and convergent validity, while discriminant validity is evaluated using the Fornell-Larcker criterion.

The structural model is examined using path coefficients and the coefficient of determination (R^e). Statistical significance is assessed through bootstrapping with 5,000 resamples, following Hair *et al*. (2014), to obtain

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robust and stable estimates. Given the cross-sectional nature of the data, the analysis focuses on statistical associations rather than causal inference, and this limitation is explicitly considered in the interpretation of the results.

Given the cross-sectional nature of the data, the model seeks to identify structural patterns linking household food access, spatial characteristics, and participation in social protection programs. This approach is considered appropriate for social policy contexts where outcomes are influenced by multiple observed and unobserved factors.

Social protection programs are frequently linked to efforts to reduce food insecurity and vulnerability. The literature suggests that food-related deprivation is often used as an observable indicator to identify households in need of assistance (Devereux *et al.*, 2012). Inadequate food access is also associated with broader welfare disadvantages, which may shape the likelihood of households being included in social protection schemes (Ullmann *et al.*, 2019). Therefore, examining the statistical association between food access and participation in social protection programs can provide insights into how observable household conditions align with program outreach.

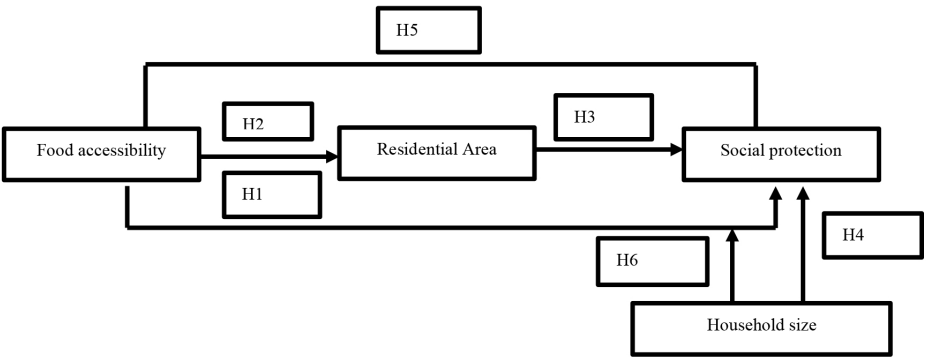
Spatial context represents another important dimension. Rural households are often characterized by higher exposure to livelihood risks, limited infrastructure, and greater vulnerability to food insecurity (Fintel & Pienaar, 2016; Garrett & Ruel, 1999). However, variations in administrative capacity and service delivery between rural and urban areas may also influence access to social assistance (Stavropoulou *et al.*, 2017). Household demographic characteristics, particularly family size, are likewise associated with economic pressure and food needs (Rahman, 2013; Sabates-Wheeler & Devereux, 2018). All constructs in the model are treated as reflective constructs in the PLS-SEM framework. These factors may be statistically related to the likelihood of participating in social protection programs. Based on the literature review, the hypotheses to be built in this study are:

H1: *Household food access is significantly associated with participation in social protection programs.*
H2: *Household food access is significantly associated with area of residence (urban-rural).*
H3: *Area of residence is significantly associated with participation in social protection programs.*
H4: *Household size is significantly associated with participation in social protection programs.*
H5: *Area of residence is associated with the relationship between food access and social protection participation.*
H6: *Household size is associated with the relationship between food access and social protection participation.*

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Figure 1 is the model to be analyzed using PLS-SEM. The research model has four constructs, each with indicators are listed in Table 1.

Figure 1 - Research Model



3. Results

The distribution of respondents in Table 1 is presented based on constructs and indicators. The majority of respondents were not families receiving social protection programs. Furthermore, most respondents are not families vulnerable to food access. However, 11.67% of people claim to worry that they will not have enough food. The number of respondents living in urban areas is similar to rural areas, with 52.82% living in urban areas, while the rest live in rural areas. Furthermore, the maximum number of families living in one house is seven, with the majority filled with one family, 73.42%.

Table 1 - Distribution of respondents

Construct	Indicator	Symbol	Information	n	Percentage (%)
Social Protection	Do you accept Family Welfare Card (Kartu Keluarga Sejahtera/ KKS)?	A11	Did not receive	24,656	83.59
			Received	4,841	16.41
	Have you ever been a recipient of the Family Hope Program (Family Hope Program/Program Keluarga Harapan/PKH)?	A12	Did not receive	24,605	83.42
			Received	4,892	16.58
	Have you ever received Non-Cash Food Assistance (Non-Cash Food Assistance Program/Bantuan Pangan Non Tunai/BPNT)?	A14	Did not receive	21,516	72.94
			Received	7,981	27.06

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Construct	Indicator	Symbol	Information	n	Percentage (%)
Food Accessibility	Over the past year, is it worried that there will not be enough food?	A21	No	26,054	88.33
			Yes	3,443	11.67
	Over the past year, has there been a time when you have not been able to eat healthy and nutritious food?	A22	No	28,089	95.23
			Yes	1,408	4.77
	Over the past year, has it only eaten a small amount of food?	A23	No	28,127	95.36
			Yes	1,370	4.64
	Over the past year, has it eaten less than it should?	A25	No	28,585	96.91
			Yes	912	3.09
Residential Area	Urban/rural classification	X11	Urban	15,579	52.82
			Rural	13,918	47.18
Household size	How many families live in the census building/house	X21	1	21,657	73.42
			2	6,226	21.11
			3	1,021	3.46
			4	359	1.22
			5	151	0.51
			6	56	0.19
			7	27	0.09

Measurement model assessment

Evaluation of measurement models is carried out based on three criteria, namely through testing of convergent validity, testing of discriminant validity, and testing of reliability. The initial stage carried out in testing data to determine the level of accuracy with reflexive indicators can be seen from the correlation between the indicator's value and its construct. An indicator is considered reliable if it has a correlation value or loading factor above 0.7. Table 2 shows that the loading factor value of each indicator is above 0.7. In addition to the loading factor value, convergent validity is seen from the AVE value above 0.5. Likewise, Cronbach's Alpha and Composite values are each above 0.7. Furthermore, reliability indicators are also seen from the VIF value, which is below 5. Based on the test results, the model meets the criteria so that the model built is reliable or valid.

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Table 2 - Reliability and validity lower order construct of social protection

Construct	Code Indicator	Loading factor	Cronbach's Alpha	Rho A	Composite Reliability	Average Variance Extracted (AVE)	VIF
Social protection	A11	0,802	0,751	0,765	0,857	0,666	1,544
	A12	0,795					1,452
	A14	0,851					1,531
Food accessibility	A21	0,801	0,824	0,854	0,881	0,649	1,428
	A22	0,822					1,966
	A23	0,856					2,478
	A25	0,739					1,815
Region of residence	X11	1,000	1,000	1,000	1,000	1,000	1,000
Number of household members	X21	1,000	1,000	1,000	1,000	1,000	1,000
Food access * number of household members		0,985	1,000	1,000	1,000	1,000	1,000

Because there is no convergent validity problem, the next step is to test discriminant validity by comparing the cr value of the AVE square root with the correlation value between constructs. Table 3 shows that the square root value of AVE is greater than the correlation of each construct, so it can be concluded that there is no discriminant validity problem. Another method that can be used to test discriminant validity is to identify the cross-loading table. Table 4 shows that the cross-loading value is more than 0.7 in one construct, so it has no discriminant validity problems. Furthermore, Table 5 shows that the Heterotrait-Monotrait Ratio (HTMT) value is no greater than 0.9, so it can be concluded that there is no multicollinearity problem in the data.

The R^2 value reported in Table 6 is 0.022, indicating that the exogenous variables included in the model (food access, area of residence, and number of households within a dwelling) explain a relatively small proportion of the variance in social protection participation. This modest explanatory power is not unexpected in social policy research, where program participation is typically shaped by a broad set of administrative, institutional, and eligibility-related factors that are not fully observable in household survey data. Accordingly, the low R^2 does not undermine the validity of the structural

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relationships identified in the model, but rather suggests that observed household characteristics capture only a limited dimension of the broader targeting and implementation mechanisms of social protection programs.

In addition, model fit is assessed using the Standardized Root Mean Square Residual (SRMR), which yields a value of 0.066. This is below the commonly accepted threshold of 0.08, indicating an acceptable level of fit between the observed and model-implied correlations.

Table 3 - Root value of AVE square between constructs

	Moderating Effect 1	**Food access**	**Number of household members**	**Social protection**	**Region of residence**
Moderating Effect 1	**1,000**				
Food access	–0,033	**0,806**			
Number of household members	–0,003	–0,005	**1,000**		
Social protection	0,001	0,081	0,033	**0,816**	
Region of residence	–0,008	–0,016	–0,012	0,118	**1,000**

Table 4 - The cross-loading value of each indicator

	Moderating Effect 1	**Food access**	**Number of household members**	**Social protection**	**Region of residence**
A11	–0,003	0,072	0,017	**0,802**	0,076
A12	0,010	0,062	0,030	**0,795**	0,090
A14	–0,003	0,065	0,031	**0,851**	0,118
A21	–0,016	**0,801**	–0,002	0,085	–0,006
A22	–0,035	**0,822**	–0,007	0,062	–0,004
A23	–0,034	**0,856**	–0,006	0,061	–0,019
A25	–0,024	**0,739**	0,000	0,038	–0,033
X11	–0,008	–0,016	–0,012	0,118	**1,000**
X21	–0,003	–0,005	**1,000**	0,033	–0,012
Food access * number of household members	**1,000**	–0,033	–0,003	0,001	–0,008

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Table 5 - Heterotrait-Monotrait Ratio (HTMT)

	Moderating Effect 1	Food access	Number of household members	Social protection	Region of residence
Moderating Effect 1					
Food access	0,037				
Number of household members	0,003	0,005			
Social protection	0,008	0,097	0,037		
Region of residence	0,008	0,021	0,012	0,134	

Table 6 - Variance of latent variable

	R Square	R Square Adjusted	SRMR
Social protection	0,022	0,022	0,066

Path correlation

The assessment of the structural model is based on the direction of the path coefficients and their statistical significance. A hypothesis is considered supported when the sign of the relationship is consistent with the proposed direction and the associated t-value exceeds the critical threshold ($t > 1.96$) with a p-value below 0.05.

As presented in Table 7, the results indicate that H1, H3, and H4 are statistically supported, while H2 is not supported. Food access, area of residence, and the number of household members are each positively associated with social protection participation. These findings suggest that households with better food access, those located in certain residential areas, and those with more household members are statistically more likely to be linked with social protection programs.

In contrast, the relationship hypothesized in H2 between food access and area of residence is not statistically supported. This implies that differences in food access between rural and urban areas are not sufficiently captured by the model. Nevertheless, the descriptive pattern observed in the data indicates that urban households may experience particular constraints in food access, which warrants further investigation using more detailed socio-economic and spatial variables.

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Table 7 - Correlation Between Variables

Hypothesis	Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/ STDEV|)	P Values
H1	Food access → social protection	0,083	0,083	0,006	12,812	0,000
H2	Food access → region of residence	**–0,016**	–0,016	0,006	2,639	0,009
H3	Region of residence → social protection	0,120	0,121	0,006	21,529	0,000
H4	Number of household members → social protection	0,035	0,035	0,006	5,723	0,000

Mediation analysis

The results presented in Table 7 indicate that the total association between food access and social protection participation is positive and statistically significant. After including the mediating variable (area of residence), the direct association between food access and social protection remains positive and significant. However, the indirect association through area of residence is negative and statistically significant. This pattern suggests that area of residence is statistically linked to the relationship between food access and social protection in a way that differs in direction from the direct association. In other words, the spatial context appears to be related to how food access corresponds with social protection participation. Nevertheless, because the indirect association operates in the opposite direction to that hypothesized, H5 is not supported. These findings should be interpreted as indicative of structural associations rather than causal mediation, given the cross-sectional design of the study.

H5: *The region of residence plays a positive and significant role in mediating the relationship between food access and social protection*

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Table 8 - Hypothesis testing on mediation

Total Effect (food access - social protection)		Direct Effect (food access - social protection)		Indirect Effect (food access - region of residence - social protection)	
Original Sample (O)	**P Values**	**Original Sample (O)**	**P Values**	**Original Sample (O)**	**P Values**
0,081	0,000	0,083	0,000	**–0,002**	0,007

Moderating analysis

The results presented in Table 8 show that the interaction term representing household size has a positive coefficient in the relationship between food access and social protection participation; however, this association is not statistically significant ($p > 0.05$). This indicates that variation in family size is not statistically associated with differences in the relationship between food access and social protection within the sample. Although the direction of the coefficient is positive, the lack of statistical significance means that H6 is not supported. These findings should be interpreted as evidence of a non-significant statistical interaction rather than proof that family size plays no role at all, particularly given the cross-sectional nature of the data and the possibility of unobserved socio-economic factors.

H6: *Household size plays a positive and significant role in moderating the relationship between food access and social protection*

Table 9 - Hypothesis testing on moderation

Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Food access * number of household members → social protection	0,005	0,006	0,007	0,740	**0,460**

4. Discussion

The results reveal notable spatial differences in the observed associations. Households in rural areas are statistically more likely to be linked with social protection participation, whereas food access constraints are more

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pronounced among urban households. These patterns are consistent with previous studies highlighting higher and emerging food insecurity risks in urban settings due to rapid urbanization, declining agricultural land, and environmental pressures (Opitz *et al.*, 2016; Piontak & Schulman, 2014; Ramsey *et al.*, 2012). From a food systems perspective, these dynamics reflect how spatial governance and distributional structures shape food access outcomes (Au-Yong-Oliveira *et al.*, 2025).

Food security is inherently multidimensional, encompassing availability, access, utilization, and stability (FAO, 2023). While this study focuses on food access due to data constraints, the utilization dimension remains critical, as dietary quality and nutritional diversity may differ significantly across spatial contexts (FAO, 2023; Jones *et al.*, 2013). Urban households, despite better market access, may exhibit higher consumption of processed and energy-dense foods, whereas rural households are more likely to rely on staple-based diets with limited diversity (Fanzo *et al.*, 2020; Popkin *et al.*, 2020; Sibhatu & Qaim, 2017). These differences underscore the importance of incorporating food utilization into broader food security assessments.

The stronger association between rural residence and social protection participation may reflect long-standing policy orientations that prioritize rural poverty (Midgley & Piachaud, 2013). Eligibility criteria often rely on observable indicators such as land ownership and agricultural livelihoods, which are more prevalent in rural settings, thereby improving targeting accuracy in these areas (Kidd & Pathways, 2017; World Bank Group, 2018). In contrast, urban poverty tends to be more heterogeneous and less visible, often characterized by informal employment and higher living costs, which are less effectively captured by conventional targeting mechanisms (Gentilini *et al.*, 2020).

Administrative and institutional constraints may further reinforce this disparity. Rural areas often benefit from community-based governance structures that facilitate beneficiary identification and program delivery, whereas urban areas face greater population mobility, density, and weaker social cohesion, complicating targeting processes (International Labour Organization, 2021; Sabates-Wheeler *et al.*, 2020). These factors contribute to a structural bias in social protection systems that may inadvertently favor rural households, even as urban food insecurity continues to rise (World Bank, 2020).

Household size is also positively associated with social protection participation, suggesting that larger households are more likely to be included in assistance programs. This finding aligns with evidence that larger households face higher dependency ratios, greater food expenditure burdens, and increased vulnerability to food insecurity (Nurdiani & Widjojoko, 2016;

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Sinaga *et al.*, 2013; Syamola & Nurwahyuni, 2019). This pattern may reflect the use of household size as an implicit proxy for vulnerability in targeting mechanisms, although the cross-sectional nature of the data prevents confirmation of whether this is an intentional design feature or an emergent outcome.

Environmental shocks, such as flooding, represent an additional dimension of vulnerability that may not be fully captured in static targeting systems. Existing evidence suggests that rigid eligibility criteria and outdated beneficiary databases can limit the responsiveness of social protection programs to shock-induced food insecurity (FAO, 2023; World Bank, 2020). Consequently, households experiencing temporary vulnerability may not be immediately reached by assistance programs. Strengthening adaptive and shock-responsive social protection systems – through flexible targeting, dynamic beneficiary updating, and integration with disaster risk management frameworks – could enhance program responsiveness in disaster-prone regions such as Central Java (Hallegatte & Rozenberg, 2017; Smith & Bowen, 2020).

Finally, the mediation results suggest that spatial context plays a role in shaping the relationship between food access and social protection participation. However, given the cross-sectional nature of the data, causal mediation cannot be inferred. Overall, the observed mismatch between urban food vulnerability and social protection participation points to potential governance and targeting limitations that warrant further policy attention.

Although household size did not show a statistically significant moderating effect, socio-demographic characteristics remain important in understanding vulnerability. Previous studies consistently document associations between household size and food security conditions (Esturk & Oren, 2013; Muche *et al.*, 2014). Beyond economic factors, cultural and behavioral dimensions related to food acquisition and preparation also play a role in shaping food security outcomes (Alonso *et al.*, 2018).

From a policy perspective, the findings highlight the need to recalibrate social protection targeting frameworks to reflect better the evolving geography of food vulnerability, particularly in urban areas. Urban food insecurity is increasingly driven by structural economic constraints such as labor informality, income volatility, rising cost of living, and housing affordability pressures, which are often not adequately captured by conventional proxy indicators used in targeting systems (Gentilini *et al.*, 2020; World Bank, 2020). This suggests that reliance on traditional poverty markers may systematically underestimate urban vulnerability and contribute to exclusion errors. Strengthening targeting accuracy, therefore, requires the incorporation of more dynamic and urban-relevant indicators that

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reflect real-time economic precarity, alongside improvements in beneficiary data updating mechanisms (Kidd & Athias, 2020). These adjustments would enhance the responsiveness of social protection systems to shifting vulnerability patterns and improve their effectiveness in rapidly urbanizing contexts.

The findings highlight the importance of aligning food access vulnerability with social protection targeting, particularly in urban contexts. Strengthening beneficiary data systems, enhancing benefit adequacy, and improving monitoring and updating mechanisms are critical to reducing both exclusion and inclusion errors. In addition, food security strategies should not be limited to availability and access, but also incorporate food quality and dietary diversity dimensions. Broader agricultural policies that support diversified production systems (Ceballos *et al.*, 2020) and improved input accessibility (Salazar *et al.*, 2016) remain relevant for ensuring food supply stability. These considerations are consistent with integrated food systems approaches that link social protection, agricultural sustainability, and supply chain resilience (Au-Yong-Oliveira *et al.*, 2025).

This study has several limitations. First, the use of cross-sectional data limits the ability to draw causal inferences among variables. Second, reliance on secondary survey data may not fully capture dynamic household behavior or unobserved institutional factors influencing social protection targeting. Third, potential endogeneity may arise from the simultaneous relationship between food access and social protection participation. Future research could address these limitations by employing longitudinal data and more robust econometric strategies.

Despite these limitations, the study contributes to the literature by integrating food access, spatial heterogeneity, and social protection participation within a unified empirical framework. While previous studies often examine these dimensions separately, this research highlights their interdependent nature, particularly in developing country contexts. The findings suggest that policy interventions should move beyond uniform targeting approaches and incorporate spatial and socio-demographic heterogeneity to improve program effectiveness. In particular, urban food vulnerability warrants greater policy attention, given the emerging mismatch between food access constraints and social protection coverage.

Overall, the findings should not be interpreted solely as household-level relationships, but also as reflections of broader governance structures that shape how vulnerability is defined, measured, and addressed within social protection systems.

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Conclusion

This study examines the statistical relationships between food access, area of residence, household size, and social protection participation. The results show that food access and household size are positively associated with social protection participation, while area of residence is also significantly associated within the structural model. These findings indicate that observable household and spatial characteristics are related to patterns of social protection participation, although they explain only a small portion of the overall variation.

The analysis further highlights spatial differences in food access conditions. Food access constraints appear more pronounced among urban households, whereas rural households are statistically more likely to be linked with social protection participation. The mediation results suggest that area of residence is statistically connected to how food access relates to social protection participation, but this should be interpreted as a structural association rather than causal mediation due to the cross-sectional design. Household size, while positively associated with participation, does not significantly alter the relationship between food access and social protection.

From a policy perspective, these findings underline the importance of improving the alignment between food access vulnerability and social protection targeting, particularly in urban areas where food insecurity risks may be less visible. Strengthening beneficiary data systems, improving monitoring, and ensuring that assistance supports food quality and dietary diversity are important considerations. However, given the limited explanatory power of the model and the cross-sectional nature of the data, these implications should be viewed as indicative, and further research using more comprehensive and longitudinal data is needed.

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Declaration of Generative AI Use

During the preparation of this article, the author(s) used ChatGPT to After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author only on reasonable request.

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