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Urban sprawl and farming practices: Examining farm diversification and its intensity in Hyderabad's peri-urban areas

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Abstract

Background: Urban expansion exerts substantial pressures on peri-urban agriculture, including land reduction, resource competition, and environmental externalities, necessitating adaptive strategies such as farm diversification. Despite its role in enhancing resilience and sustainability, there is a paucity of research that simultaneously explores diversification, its intensity, and the drivers shaping these adaptations, particularly in urbanizing contexts. Methods: This study explores the dual decision making process of diversification – diversification choice and its intensity – among peri-urban farmers in Hyderabad, India. Drawing on survey data from 330 farm households collected through a multi-stage sampling method, the analysis employs the Double Hurdle Model (DHM) to capture the nuanced effects of farm characteristics, environmental factors, and risk perceptions, while accounting for potential variations in the direction and magnitude of these effects. Results: The results demonstrate that initial decisions to diversify are significantly influenced by socio-environmental factors, such as proximity to urban areas, sole reliance on agriculture for income, household size, and risk attitudes. Conversely, the intensity of diversification is largely determined by farm-specific resource conditions, such as soil fertility, alongside farmers' subjective assessments of production and market uncertainties. These findings suggest that while diversification choices are primarily shaped by external socio-economic drivers, the extent of diversification reflects a strategic response to resource limitations and perceived risks, underscoring the crucial role of risk management in shaping agricultural practices. Conclusion: Peri-urban farms in India are transitioning toward diversification, albeit at low intensity, particularly among small and semi-medium landholdings. Policy interventions should prioritize supporting diversified farming, ensuring risk-appropriate returns, and conserving resources to foster sustainable, resilient agricultural systems in peri-urban areas.

Keywords: urban sprawl, farm diversification, peri-urban agriculture, risk perception, resilience

Introduction

As cities expand at unprecedented rates, peri-urban agriculture – farming activities at the urban-rural interface – faces mounting pressures that reshape local agrifood systems (Marshall and Randhawa, 2017; de Bruin *et al*., 2021). Peri-urban farms operate within dynamic socio-economic and environmental conditions, influenced by urban expansion, market integration, and policy frameworks. While urban development offers opportunities such as improved infrastructure, access to urban markets, and the potential for reconnecting food production and consumption through integrated food networks (Rivaroli *et al*., 2017; Tedesco *et al*., 2017; Sroka and Żmija, 2021), it simultaneously imposes significant challenges, including land-use conflicts, increased resource competition, and pollution (Tsuchiya *et al*., 2015; Menakanit *et al*., 2022). Consequently, farmers in these transitional spaces must adopt adaptive strategies to remain viable, with farm diversification emerging as a key response to mitigate risks and enhance resilience and sustainability (Song *et al*., 2022).

Farm diversification refers to the strategic reallocation of farm resources beyond conventional crop and livestock production to increase income and stability (Meraner and Finger, 2019; Vecchio *et al*., 2020). However, diversification encompasses a spectrum of activities, requiring clear differentiation. Following Van Der Ploeg's framework, farm diversification can be categorized into deepening

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and broadening activities (Van der Ploeg and Roep, 2003). Deepening activities focus on enhancing agricultural productivity through improvements within the farming system. This includes transitioning from traditional to commercial crops, adopting organic farming practices, integrating agroforestry, and implementing advanced management techniques. In contrast, broadening activities expand beyond core agricultural production by incorporating non-agricultural on-farm ventures such as agritourism, farm-based educational services, and processing agricultural products into marketable goods. While such diversification strategies are well-established in developed economies, in developing countries like India, diversification remains at a nascent stage, primarily centered on on-farm agricultural improvements rather than commercialized non-agricultural enterprises.

In peri-urban India, diversification is often driven by both push and pull factors. Push factors, such as declining farm incomes, climate uncertainty, and shrinking landholdings, necessitate farmers to explore alternative livelihood strategies (Doernberg *et al*., 2016). Pull factors, including proximity to urban consumers, infrastructure access, and policy incentives, encourage farmers to diversify into high-value crops, contract farming, or direct-to-consumer models (Akimowicz *et al*., 2016; Noack and Larsen, 2019). Recent studies have also underscored the role of external structural determinants, such as social infrastructure and public transport accessibility, in shaping diversification decisions (Das, 2018).

Despite increasing academic interest in farm diversification, a significant research gap persists regarding the intensity of diversification – the extent to which farms engage in multiple diversification activities. While much of the literature explores the decision to diversify, the intensity dimension remains underexplored. The intensity of diversification is crucial as it affects resource allocation, income variability, and long-term farm sustainability. Factors such as risk perception, generational succession, land quality, and market access influence the degree to which farmers diversify (Bartolini *et al*., 2014; Aheibam *et al*., 2017). However, one of the most overlooked yet critical determinants is the risk profile of farmers, which is shaped by their experiences, perceptions, and responses to uncertainties in agricultural production and market conditions.

Farmers' risk perception significantly influences diversification decisions, shaping how they navigate trade-offs between stability and opportunity. While risk-averse farmers tend to pursue minimal diversification as a protective measure, risk-tolerant farmers are more inclined toward extensive diversification, engaging in high-value production or commercialized ventures despite market uncertainties (Nainggolan *et al*., 2023). Studies indicate that attitudes toward risk, prior exposure to economic or environmental shocks, and access to risk-mitigating mechanisms such as insurance and credit play a pivotal role in shaping diversification behavior (Meuwissen *et al*., 2001; Hardaker *et al*., 2015). Therefore, a comprehensive analysis of diversification must extend beyond economic and structural determinants to incorporate the behavioral dimensions of farmers' decision making.

Building on this context, the present study aims to analyze both the determinants and intensity of farm diversification in peri-urban areas, with a specific focus on the Hyderabad Metropolitan Region – one of India's fastest-growing urban agglomerations. A key contribution of this research is the incorporation of farmers' risk profiles, developed from their experiences and perceptions, into the broader discussion of farm diversification determinants. Unlike previous studies that primarily focus on physical and economic factors, this study integrates a behavioral dimension, offering a more comprehensive understanding of diversification choices. The methodological framework employs a count-based approach to measure diversification intensity, thereby capturing the multi-dimensional nature of diversification.

Ultimately, this study seeks to provide empirically grounded insights into the evolving nature of farm diversification in peri-urban India. By examining internal farm characteristics, external market conditions, and risk perceptions, this research aims to inform policies that support sustainable diversification strategies, enhance farmers' resilience, and strengthen rural-urban food systems. The study aligns with Sustainable Development Goal (SDG) 11, which advocates for inclusive, resilient, and sustainable urbanization.

The article is structured as follows: first, the methodology section outlines the data collection process, study area, and key variables. Next, the estimation results are presented and discussed, followed by a conclusion that highlights broader policy implications for sustainable peri-urban agriculture.

Methods

STUDY AREA AND SAMPLING STRATEGY

This study was conducted in the peri-urban farms of Hyderabad, the capital city of Telangana, which is the fifth largest metropolis in India and one of Asia's fastest-growing cities. Despite comprising only 0.6% of Telangana's land area, Hyderabad accommodates over 20% of the state's population (GoT, 2022). In recent years, significant infrastructure projects, such as a new international airport, an eight-lane outer ring road spanning 162 km, and the establishment of a 1050-acre 'Fab City' for semiconductor manufacturing, have contributed to rapid urban and economic development, resulting in an annual population growth rate of approximately 8 percent.

The peri-urban zone of the Hyderabad Metropolitan Region is situated between the Greater Hyderabad Municipal Corporation (GHMC) and the Hyderabad Metropolitan Development Authority (HMDA). Covering an area of 7228 km^2, it encompasses 39 blocks/mandals, three municipalities, and 813 gram-panchayats. A significant proportion of families in these peri-urban areas depend on agriculture for their livelihoods, underscoring the economic importance of this region (Hussain and Hanisch, 2014).

The selection of the study area was informed by research conducted by the South Asia Consortium for Interdisciplinary Water Resource Studies (saciWATERs), which employed a comprehensive methodology combining field data and spatial analysis to map the peri-urban region accurately (Banerjee *et al*., 2014). This mapping incorporated socio-economic and psychological factors, including exposure to mass media and levels of social development, allowing for the classification of blocks/mandals based on their urban–rural characteristics. The resulting classification divided the peri-urban areas into three distinct zones: (1) Peri-urban to Urban (Urban_Peri-urban), (2) Peri-urban to Peri-urban (Peri-urban_Peri-urban), and (3) Rural to Peri-urban (Peri-urban_Rural), as illustrated in Fig. 1. Out of the 39 mandals, 22 were classified as 'Peri-urban_Rural,' 12 as 'Peri-urban_Peri-urban,' and the remainder as 'Urban_Peri-urban.' Given the focus on rural transformation due to urban sprawl, the study concentrated on the 'Peri-urban_Peri-urban' and 'Peri-urban_Rural' mandals.

To explore predominantly rural peri-urban areas, mandals were selected based on agricultural diversification, quantified via Simpson's Diversification Index (SDI), a well-established empirical measure ranging from 0 (no diversification) to 1 (highest diversification) (Joshi *et al*., 2003). The SDI was computed using secondary data from the Directorate of Economics and Statistics (DES, 2021) on the area under total food crops (food grains, fruits, and vegetables) and total non-food crops. A threshold of 0.5 was employed to classify diversification levels: mandals with an SDI above 0.5 were considered highly diversified, while those below this cut-off were classified as low diversification areas. Based on these classifications, four mandals each were chosen from the 'Peri-urban_Peri-urban' and 'Peri-urban_Rural' categories. Multistage random sampling was then used to select two villages per mandal, yielding a total of 400 surveyed households (25 per village). Of these, 330 were farm households and included in the study, while the remaining 70 were classified as non-farm

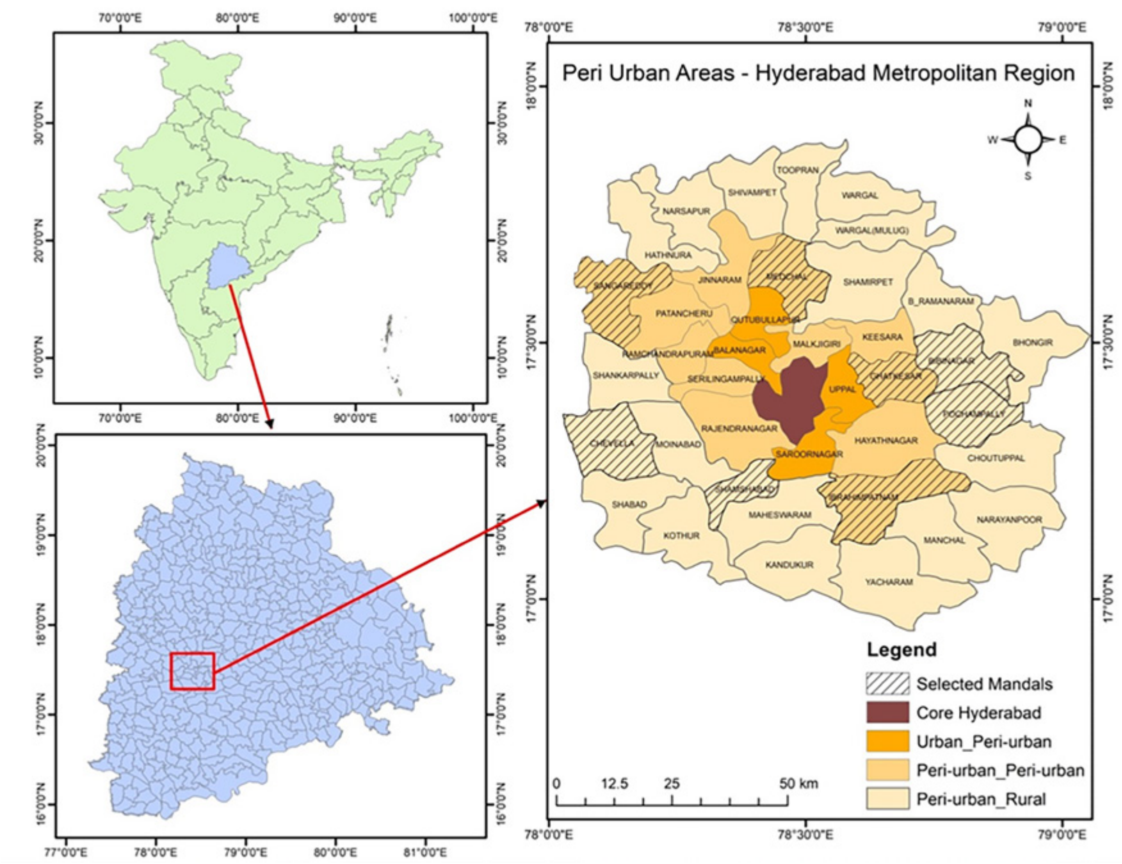

Fig. 1. Map showing peri-urban areas of Hyderabad Metropolitan Region.

households and excluded from the analysis, as the focus remained on diversification within agricultural activities.

DATA AND DATA COLLECTION

Data were collected from farm households via Computer Assisted Personal Interviewing (CAPI) with CSPro software from August to October 2021. A comprehensive literature review and a preliminary survey identified common diversification activities in peri-urban areas, which included the transition from traditional to commercial crops, mixed crop–livestock systems, direct marketing via on-farm sales, polyhouse cultivation, and rental activities. To refine the survey instrument, a pilot study was conducted to evaluate the effectiveness of the survey questions and to identify widely adopted diversification practices. This involved consultations with agricultural officers, extension officials, village heads and a few farmers to gather insights on diversification patterns and timelines, ensuring that the main questionnaire addressed relevant activities. The questionnaire used is provided as Online Supplementary Material S1.

Within the sample, 57% of the respondents engaged in diversified farming, whereas the remaining households were categorized as non-diversified. The intensity of diversification activities for each household was assessed on the basis of the range of activities selected, revealing a limited extent of diversification within the sample. Specifically, the intensity of diversification activities ranged from 1 to 4, with an average intensity of 1.4.

A comprehensive overview of the variables utilized in the study is given in Supplementary Material: Table S1. The environmental factors included the proximity of farmland to the city center and farmers' self-assessment of soil fertility. In addition to standard socio-economic variables, farm and farmer characteristics such as succession planning, Tropical Livestock Units, and the Crop Diversity Index (calculated via Simpson's Diversity Index) were also considered. The study incorporated a framework for assessing risk perceptions among farm households, encompassing market, institutional, production, and labor risks.

To ensure the accuracy and reliability of the results, cross-validation techniques, including variance inflation factors and Spearman correlation coefficients, were employed to assess the predictive model's performance (Supplementary Material: Table S2). Although a wide array of variables was initially considered, only those exhibiting low variance inflation factors (<5) were retained in the model. Furthermore, highly correlated variables were excluded to mitigate multicollinearity and enhance the robustness of the analysis.

A summary of the descriptive statistics for the two respondent groups – diversified and non-diversified – is presented in Table 1. The mean self-reported proximity score of farmland to the nearest city or town, as assessed by farmers on a scale from 1 (highly rural) to 10 (highly urban), was 5.71. Diversified households rated their proximity to the city center more favorably, with an average score of 6.14 compared with 5.31 for non-diversified households. This finding aligns with those of previous studies (Joshi *et al*., 2003; Zasada, 2011; Meraner *et al*., 2018). Additionally, the mean soil fertility score was significantly higher for diversified households. A greater proportion of diversified households relied solely on farming for income (67%), surpassing the overall sample mean of 62%. This suggests that increased income from agricultural activities is correlated with a greater likelihood of engaging in diverse farming practices (Ibrahim *et al*., 2010).

Demographically, the average age of respondents was 49.54 years, with heads of diversified households being approximately 2 years younger than those of non-diversified households. Most respondents had attained secondary-level education, with no

Table 1. Descriptive statistics of the variables.

Variable	Units	Full sample N=330		Non-diversified N=143		Diversified N=187		Mann–Whitney U test
		Mean	SD	Mean	SD	Mean	SD	
Environmental factors								
Proximity	Self-assessment (SA) by farmer on scale 1 to 10	5.78	1.52	5.31	1.56	6.14	1.38	0.0000***
Marginal		5.74	1.59	5.39	1.65	6.21	1.31	
Small		5.82	1.57	4.97	1.25	6.21	1.55	
Semi medium		5.76	1.2	5.57	1.51	5.79	1.17	
Medium		6.12	1.36	5.67	1.53	6.31	1.37	
Soil fertility	SA scale of 1 to 5	3.24	0.59	3.04	0.57	3.4	0.56	0.0000***
Farm and farmer characteristics								
Only farm income	Yes=1	0.62	0.49	0.55	0.5	0.67	0.47	0.0245**
Age	Years	49.54	9.09	50.3	8.28	48.98	9.65	0.1399
Education	Levels[a]	3.01	1.41	3.02	1.46	3.14	1.43	0.2721
Succession	Scale[b]	−0.59	1.01	−0.81	0.96	−0.42	1.03	0.0001***
HH size	Nos	3.89	1.28	3.69	1.14	4.04	1.36	0.0216**
Experience	Years	26.53	8.63	27.3	8.04	25.97	9.03	0.1041
GCA	Ha	1.37	1.14	1.01	0.84	1.64	1.26	0.0000***
Marginal		0.67	0.2	0.67	0.2	0.65	0.2	
Small		1.34	0.19	1.36	0.2	1.33	0.18	
Semi medium		2.48	0.5	2.46	0.65	2.6	0.48	
Medium	No. units	5.07	1.37	5.03	1.76	5.26	1.34	
TLU		1.3	2.59	0	0	2.29	3.1	0.0000***
Marginal		0.99	2.23	0	0	2.63	2.99	
Small		1.53	3.23	0	0	2.22	3.7	
Semi medium		1.64	2.33	0	0	1.91	2.41	
Medium		1.91	2.3	0	0	2.32	2.34	
CDI	Index	0.25	0.29	0.05	0.15	0.41	0.28	0.0000***
Marginal		0.11	0.22	0.03	0.12	0.24	0.28	
Small		0.34	0.28	0.13	0.2	0.44	0.26	
Semi medium		0.47	0.29	0	0	0.55	0.23	
Medium		0.5	0.29	0	0	0.6	0.19	
Non-farm income	In Rs.	85850	2E+05	94769	154833	79029	152477	0.0744*
High value crops	Yes=1	0.41	0.5	0.03	0.17	0.7	0.46	0.0000***
Frame of reference[c]								
PercMarRisk[c]		13.56	1.96	12.7	1.65	14.25	1.9	0.0000***
Marginal		13.76	2.06	13	1.63	15.02	2.08	
Small		14.07	1.83	12.2	1.38	14.92	1.29	
Semi medium		12.62	1.18	10.9	0.91	12.91	0.95	
Medium		11.53	1.41	10.3	0.58	11.79	1.41	
PercInstRisk[c]		11.59	4.18	11.2	4.25	11.88	4.11	0.0515*
Marginal		12.05	4.55	11.1	4.38	13.66	4.39	

Continued

Table 1. Continued.

Variable	Units	Full sample N=330		Non-diversified N=143		Diversified N=187		Mann–Whitney U test
		Mean	SD	Mean	SD	Mean	SD	
Small		11.67	3.03	11.3	3.83	11.82	2.6	
Semi medium		9.96	4.76	13.1	5.11	9.44	4.55	
Medium		11.47	3.57	10	1.73	11.79	3.83	
PercProdRisk[c]		13.9	2.09	12.9	1.48	14.65	2.19	0.0000***
Marginal		14.24	2.11	13	1.47	16.24	1.34	
Small		14.59	1.65	13.1	1.39	15.26	1.29	
Semi medium		12.28	1.67	11.6	0.93	12.38	1.74	
Medium		11.44	0.87	10.7	0.58	11.6	0.84	
PercLabRisk[c]		14.15	2.99	13.9	3.1	14.35	2.9	0.191
Marginal		14.12	3.15	13.8	3.1	14.71	3.14	
Small		14.18	2.87	13.8	2.91	14.37	2.85	
Semi medium		14.08	2.87	16.5	3.41	13.68	2.6	
Medium		14.65	2.71	14.1	3.02	14.76	2.75	
Risk attitude		6.08	1.04	5.26	0.65	6.7	0.83	0.0000***
Marginal		5.55	0.71	5.29	0.65	5.96	0.61	
Small		6.2	0.88	5.2	0.63	6.65	0.53	
Semi medium		7.03	0.99	4.75	0.46	7.4	0.34	
Medium		7.69	1	5.75	0.9	8.11	0.21	

[a]Levels of education: 1 – No school, 2 – Primary, 3 – Secondary 4 – Technical, 5 – Intermediate, 6 – Graduation, 7 – Post grad, 8 – Adult literacy only, 9 – Religious only, 10 – Others.
[b]Succession: 1 = succession is sure, 0.5 = quite sure, 0 = not planned in the next 15 years, −0.5 = quite unsure, −1 = unsure, −2 if farm exit is planned.
[c]Frame of reference: perceived market risk, perceived institutional risk, perceived production risk, and perceived labour risk.
*, **, and *** denote statistical significance at the 10, 5, and 1% levels, respectively.

significant differences in education levels between the two groups. Both groups had an average of about 26 years of farming experience. However, noticeable differences were observed in succession planning and family size; diversified households tended to have larger families, potentially providing additional on-farm labor that facilitates engagement in diverse agricultural activities (Mishra *et al*., 2004; Meraner *et al*., 2015).

With respect to specific farming parameters, diversified households operated on an average gross crop area of nearly 2 ha, exceeding the total average of 1.37 ha reported by Calle *et al*. (2022). These findings support those of Makate *et al*. (2016), who reported a positive relationship between land size and on-farm diversification. Additionally, while Tropical Livestock Units and the Crop Diversity Index met expectations, it was notable that marginal households engaged in more intensive livestock rearing than those in other land categories did. Conversely, as land size increased, crop diversity also expanded. On average, specialized farming households have greater non-farm income, reflecting the need for multiple income sources to meet growing family needs (Salvioni *et al*., 2020). This trend is consistent with that of Joshi *et al*. (2003), who noted that urbanization significantly impacts the shift toward high-value crops (HVCs), such as fruits and vegetables, with diversified households showing a mean HVC score of 0.70 compared with their non-diversified counterparts.

In terms of risk perceptions, labor risk was identified as the most severe risk among the four risk categories by households in the study area. However, there was no significant difference in average labor risk scores between the two groups. In contrast, the mean scores for market and production risks varied significantly, with diversified households perceiving these risks as more severe than their non-diversified counterparts. Notably, ratings for both market and production risks decreased with increasing land size. Overall, the sample respondents exhibited a favorable outlook toward risk (mean score of 6.06), with diversified households demonstrating a greater propensity for risk-taking (6.70) than non-diversified households (5.26). This is consistent with findings by Calle *et al*. (2022), who indicated that farmers, particularly those on small to medium scales, tend to diversify their activities in response to opportunities, influenced by their willingness to assume risks.

CONCEPTUAL FRAMEWORK AND EMPIRICAL STRATEGY

The conceptual framework for this study is adapted from Meraner *et al*. (2018), which is an extension of the traditional expected utility framework of economic decision making to include intrinsic perceptions, attitude and value settings. A farmer's decision making process is shaped not only by personal characteristics but also by the decision making environment constructed from their lived experiences and perceptions. Thus, the framework includes personal and farm characteristics, alongside a comprehensive frame of reference that encompasses risk perception and risk attitudes, which distinguishes between diversified and non-diversified farmers.

Figure 2 illustrates this framework, highlighting the differences between diversified and non-diversified farmers based on their inherent characteristics and perceived realities.

These components collectively shape farmers' decision making behavior regarding diversification. Once a farmer opts to diversify their operations, the intensity of that diversification becomes a critical focus, influenced by the same factors of farm and farmer characteristics (P), risk perceptions and attitudes (E/P), and environmental conditions (S).

Empirical strategy

The analytical framework of this study addresses two key stages in the decision making process regarding farm diversification, considering possible differences in the direction of the estimated effects. The first stage involves the farmer's decision to diversify their farmland, whereas the second stage assesses the extent of diversification undertaken. Common econometric models for limited dependent variables, such as the Tobit and Heckman models, are often used in such contexts. However, these models carry inherent assumptions that can constrain their applicability. Therefore, this study employs the Double Hurdle Model, a more flexible generalization of the Tobit model developed by Cragg (1971), to analyze the factors influencing both the decision to diversify and the degree of diversification.

The double-hurdle model assumes that farmers encounter two sequential decision "hurdles": the initial choice to diversify (participation) and the subsequent choice regarding the extent of diversification (intensity). This separation allows for a nuanced analysis, recognizing that the factors influencing a farmer's decision to diversify may differ from those affecting the degree of diversification. The first hurdle, which addresses the binary participation decision, is estimated using a probit regression. For the second hurdle, a truncated normal regression captures the intensity of diversification, as it is relevant only for farms that have chosen to diversify.

In the model, the diversification decision (y^*) is conceptualized as an outcome of a utility-maximization problem on the basis of various household characteristics, including farm, farmer, and environmental factors (X_i for i^{th} farm household). The dataset comprises observations from 330 farm households, with the probability of a farm being diversified defined by:

$$y_i^* = \alpha X_i + \varepsilon_i \cdots \forall i = 1, \ldots N \qquad (1)$$

where $y_i = 1$ ($y_i^*>0$, Diversified farm)

$y_i = 0$ (Otherwise, Non-diversified farm)

α = Estimated coefficients

X_i = Observed characteristics

ε_i = Error term

For the first hurdle, a probit model assesses the factors that influence a farm household's decision to diversify. For the second hurdle, which considers the extent of diversification, we use a truncated count model to capture the number of diversification activities adopted by each household, ranging from 1 to K. This truncated approach is appropriate because diversification intensity can be measured only for farms that have diversified (Ground and Koch, 2008). Thus, the utility function (u_i^*) of the i^{th} farm household, considering household characteristics (Z_i), is represented as:

$$u_{i,j}^* = \beta_j Z_i + u_{i,j\ldots} \forall i = 1, \ldots N; \; j = 1, \ldots K \qquad (2)$$

where $u_{i,j} = u_{i,j}^*$, if $u_{i,j}^* > 0$ and $y_i = 1$

$u_{i,j} = 0$; otherwise,

β_j = Estimated coefficients

$u_{i,j}$ = Error term

The model estimates both stages (Eqns 1 and 2) using the double-hurdle approach, which offers a comprehensive and robust understanding of the factors influencing farm diversification decisions and intensity. All the empirical analyses were conducted using STATA (version 14).

Results

This section presents the results from the double-hurdle analysis, identifying the primary factors influencing both the decision to diversify farm activities and the intensity of diversification. The results are discussed in two parts: (1) the decision to engage in diversification activities and (2) the intensity of diversification for households that have diversified. Table 2 provides a detailed summary of the double-hurdle model estimation results, with variables such as proximity to urban areas, farm income dependence, risk attitudes, perceived market risk, and land category emerging as significant factors.

DECISION TO DIVERSIFY

The proximity of farmland to urban centers emerges as a significant factor influencing a household's decision to diversify. Households situated closer to urban areas benefit from improved access to markets, infrastructure, and consumer demand, motivating them to expand

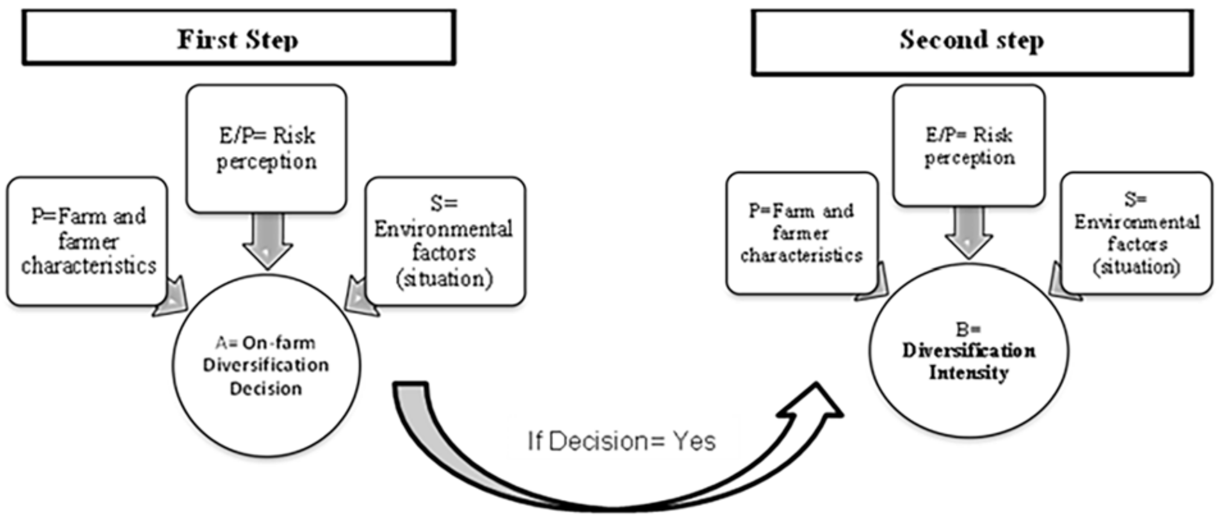

Fig. 2. Conceptual framework of the study. P = farm and farmer characteristics; E/P = risk perception and attitude of the farmer; S = environmental factors (situation).

Table 2. Estimation results of the double hurdle model.

Variables	Coefficient	Std. Err.	z	P>z
Intensity				
1. PercMarkRisk	−0.06	0.02	−2.37	0.018**
2. PercProdRisk	−0.04	0.02	−2.05	0.040**
3. Soil fertility	0.18	0.08	2.28	0.023**
Selection model				
1. Proximity	0.47	0.09	5.04	0.000***
2. Only Farm Income	0.00	0.00	3.17	0.002***
3. Risk Attitude	1.03	0.16	6.26	0.000***
4. PercMarkRisk	0.62	0.08	7.33	0.000***
5. HH_Members	0.29	0.11	2.65	0.008***
6. Land category				
Medium	0.58	0.69	0.85	0.397
Semi medium	1.38	0.54	2.55	0.011**
Small	0.54	0.29	1.84	0.066*
7. Education	0.03	0.08	0.28	0.777
Log likelihood= −234.899				

"*", "**", and "***" represent statistical significance of factors at 10, 5, and 1% levels, respectively.

agricultural activities to meet the needs of nearby urban populations. This finding aligns with previous research, which emphasized the role of urbanization in creating economic opportunities for rural farming households (Rehima *et al*., 2013; Aheibam *et al*., 2017; Pölling and Mergenthaler, 2017; Yoshida *et al*., 2019).

Households that rely solely on agriculture as their main source of income are more likely to diversify. The dependence on farming as a primary livelihood source may make these households more inclined to adopt diverse activities to stabilize income and reduce vulnerability. Similarly, studies by Almås (2004) and Gecho (2017) report that farm-dependent households pursue diversification to achieve greater income security. This pattern is often motivated by a lack of alternative income opportunities, highlighting the role of diversification as a vital income-stabilizing mechanism for farming households with limited off-farm income options.

Risk attitudes significantly influence the diversification decision, with risk-tolerant households being more likely to diversify their activities. This positive association suggests that risk-tolerant farmers perceive diversification as a proactive means to maximize returns while managing potential losses. This finding corroborates previous work indicating that risk-loving households are more inclined to adopt diversification as part of a progressive farming approach (Ullah and Shivakoti, 2014; van Winsen *et al*., 2016; Asrat and Simane, 2018). In contrast, studies by Hellerstein *et al*. (2013) and Meraner and Finger (2019) have shown that risk-averse farmers prioritize stability over diversification, favoring on-farm risk management strategies. This difference may reflect contextual variations in farmers' risk perceptions or resource limitations.

Perceived market risk also significantly impacts the decision to diversify. Households with high market risk perceptions are more likely to diversify, viewing it as a strategy to mitigate income volatility in uncertain market conditions. This finding supports the results of Assefa *et al*. (2017) and van Winsen *et al*. (2016), who documented that market risk perception can drive households toward diversification as a coping mechanism. However, our results contrast with those of Meraner *et al*. (2018), who reported that households with high market risk often shift resources away from farming. This discrepancy may be due to regional differences in market stability or the availability of off-farm opportunities.

Larger household size is positively associated with diversification, possibly due to the availability of family labor, which enables households to diversify into labor-intensive farming practices. This relationship is consistent with findings from Aribi and Sghaier (2021), Dembele *et al*. (2018), Anuja *et al*. (2020), and Bansal *et al*. (2020), who observed that household labor availability facilitates the adoption of diverse agricultural activities. Land category also influences diversification decisions, with larger landholdings showing a higher likelihood of diversification. Households with greater land resources are better positioned to engage in diversified agricultural practices (Sichoongwe *et al*., 2014; Rehan *et al*., 2017). Larger farms require full-time attention by their owners, who, in turn, have no time to dedicate to additional off-farm activities and prefer to implement on-farm diversification (Grilli *et al*., 2024). Conversely, Kankwamba *et al*. (2012) and Rahman (2010) suggest that smaller farms may also pursue diversification due to specific household constraints, highlighting that land size is only one of several factors shaping diversification strategies.

Discussion

DIVERSIFICATION INTENSITY

The intensity of diversification, reflecting the number of agricultural activities undertaken by households that diversify, is influenced by various factors, including perceived market and production risks and soil fertility. Perceived market risk has a negative association with diversification intensity, suggesting that households with higher market risk perceptions tend to limit the scope of their diversification activities. This finding challenges the expectation that market risk perception leads to extensive diversification as a protective measure, suggesting instead that households with limited resources may opt to focus on fewer, more manageable activities under uncertain market conditions. This observation is supported by studies on smallholders who face resource constraints that limit their ability to fully commercialize farming activities, compelling them to adopt only a few income-generating crops or livestock types (Eakin *et al*., 2014; Pingali *et al*., 2019).

Similarly, perceived production risks, such as variability in weather and access to irrigation, are inversely related to diversification intensity. Households that view production risks as high may be reluctant to diversify extensively, fearing potential losses. Studies by Kaur *et al*. (2021) and Tacconi *et al*. (2022) provide evidence that production risk can deter investment in on-farm diversification, as farmers may avoid expanding their agricultural portfolio in the face of unpredictable environmental challenges. This risk-averse behavior emphasizes the cautious approach that some households adopt in response to perceived production risks, opting to minimize potential exposure to loss by limiting diversification.

Soil fertility plays a positive role in enhancing diversification intensity, as fertile soils allow households to cultivate a wider range of crops, promoting a greater number of agricultural activities. This finding aligns with studies by Pfeifer *et al*. (2009) and Lange *et al*. (2013), who reported that higher soil fertility facilitates diversified cropping systems. Conversely, farms with poor soil fertility may rely on fewer income sources or pursue off-farm income-generating activities to compensate for lower productivity. This dynamic highlights the influence of natural resource endowments, such as soil quality, on the intensity of diversification strategies adopted by farm households.

CONCLUSION

Farm diversification has emerged as a pivotal strategy for enhancing income stability and promoting sustainable livelihoods among peri-urban farmers in India, particularly as they navigate the challenges posed by climate change and fluctuating global markets. This study illustrates that while factors such as proximity to urban centers, risk attitudes, market risk perceptions, and land size significantly influence the decision to diversify, the overall level of diversification intensity remains low. This indicates that many peri-urban farmers in India are still in an early, transitional phase and have yet to fully capitalize on the potential of diversified, high-value farming practices.

The findings reveal partial alignment with Van der Ploeg's framework of farm diversification, particularly in the domains of deepening and broadening, and remain constrained by structural and behavioral factors. While deepening occurs through shifts toward commercial crops and enhanced farm management practices, its intensity is limited by risk perceptions and resource constraints, particularly soil fertility. Broadening, which involves expanding into non-agricultural activities, remains underdeveloped despite proximity to urban centers. While urbanization theoretically facilitates market access, the study indicates that market volatility, weak institutional support, and infrastructure deficits limit engagement in non-agricultural enterprises such as agritourism or value-added processing. Unlike the structured diversification seen in developed contexts, peri-urban diversification in India is fragmented and risk-sensitive, necessitating targeted interventions such as risk management programs, improved infrastructure, and institutional support to enhance its viability and sustainability.

The inverse relationship between perceived production and market risk and diversification intensity points to a cautious approach among households facing uncertainty. This nuanced insight into the behavioral and economic factors at play emphasizes the importance of risk perception and resource availability in shaping peri-urban farming practices. While farmers may be inclined toward diversification as a risk-averse strategy, their actual ability to intensify diversification depends on resource quality and subjective risk assessment. The current trend of low-intensity diversification, particularly among small and semi-medium-sized landholders, points to both an opportunity and a limitation in agricultural transformation in peri-urban India, where diversification can be a promising pathway to sustainable farming but requires adequate targeted interventions, including risk management programs, financial support mechanisms, and improved access to agricultural extension services.

Enhancing infrastructure – such as market connectivity, storage facilities, and irrigation systems – will be essential to facilitating effective diversification. Strengthening cooperative institutions can empower smallholders by improving collective bargaining power and market access. Additionally, promoting public food procurement opportunities and local food policies can create stable demand for diversified farm products, encouraging broader participation in high-value agricultural activities. Interventions that support soil fertility, such as subsidies for organic fertilizers, are crucial for regions with low soil quality to enable more robust diversification.

The positive influence of urban proximity on diversification calls for urban planning policies that protect peri-urban farmland from encroachment, safeguarding agricultural opportunities for rural households and supporting urban food security. Recognizing the advantages that medium landowners have in adopting high-value crops, targeted policies should address the constraints faced by smallholders as well as medium farmers, enabling demand-driven diversification even in high-risk contexts.

Furthermore, promoting precision farming and other innovative practices can increase productivity, create new entrepreneurial opportunities, and enhance rural–urban linkages, offering a pathway to higher incomes and resilience for diversified farm households.

The limitations of the study should be acknowledged, especially the cross-sectional design, which limits the ability to infer causal relationships. Future research with longitudinal data would provide a more comprehensive view of how diversification evolves over time in response to changing economic and environmental conditions. Integrating objective risk indicators, such as weather variability indices and market price volatility, would provide deeper insights into how different risk dimensions shape diversification strategies. Further investigation into the barriers preventing farmers with high-risk perceptions from intensifying diversification could yield valuable policy recommendations.

Finally, given the intense competition for land in peri-urban areas, policies must prioritize the preservation of these agricultural landscapes to sustain local food production and protect environmental services. Integrating cooperatives, community-based models, and public–private partnerships into policy frameworks can help smallholders improve market access and bargaining power. With strategic support and ongoing research, farm diversification can become a robust pathway to sustainable and resilient livelihoods in peri-urban farming communities in India.

CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

ETHICS STATEMENT

Following the standard ethical procedures for undertaking research on human subjects, written consent from the Deputy Commissioners or Sarpanch of Gram panchayat of the selected locations was taken prior to the data collection. Moreover, informed written consent was taken from each respondent.

AUTHOR CONTRIBUTIONS

JT: Conceptualization, methodology, data collection, formal analysis, writing-original draft. NS: Conceptualization, writing-review and editing, supervision VK: Conceptualization, writing-review and editing JP: formal analysis, writing-review and editing

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DATA AVAILABILITY

The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

CONSENT FOR PUBLICATION

All authors have consented to this submission.

SUPPLEMENTARY MATERIAL

The supplementary material is available in the online version of this article.

References

Aheibam, M., Singh, R., Sheikh, F., Singh, N., Singh, R. and Singh, A. (2017) Identifying the determinants and extent of crop diversification at household level: An evidence from Ukhrul district, Manipur. *Economic Affairs* 62, 89. DOI: 10.5958/0976-4666.2017.00031.6.

Akimowicz, M., Cummings, H. and Landman, K. (2016) Green lights in the greenbelt? A qualitative analysis of farm investment decision-making in peri-urban southern Ontario. *Land Use Policy* 55, 24–36. DOI: 10.1016/j.landusepol.2016.03.024.

Almås, R. (2004) From state-driven modernization to green liberalism 1920–2000. *Norwegian Agricultural History* 12(1), 296–357.

Anuja, A.R., Kumar, A., Saroj, S. and Singh, K.N. (2020) The impact of crop diversification towards high-value crops on economic welfare of agricultural households in eastern India. *Current Science* 118(10), 1575–1582. https://www.jstor.org/stable/27138784.

Aribi, F. and Sghaier, M. (2021) Livelihood vulnerability assessment to climate change and variability: The case of farm households in south-east Tunisia. *Environment, Development and Sustainability* 23, 12631–12658. DOI: 10.1007/s10668-020-01172-4.

Asrat, P. and Simane, B. (2018) Farmers' perception of climate change and adaptation strategies in the Dabus watershed, north-west Ethiopia. *Ecological Processes* 7(1), 7. DOI: 10.1186/s13717-018-0118-8.

Assefa, T.T., Meuwissen, M.P.M. and Oude Lansink, A.G.J.M. (2017) Price risk perceptions and management strategies in selected European food supply chains: An exploratory approach. *NJAS – Wageningen Journal of Life Sciences* 80(1), 15–26. DOI: 10.1016/j.njas.2016.11.002.

Banerjee, P., Mallik, C. and Babu, N. (2014) Measuring and mapping transitory spaces in India: A case study of Hyderabad city. *Vision* 18(4), 277–287. DOI: 10.1177/0972262914553260.

Bansal, H., Sharma, S., Kumar, R. and Singh, A. (2020) The factors influencing and various technological and socioeconomic constraints for crop diversification in Haryana. *Economic Affairs* 65(3), 409–413. DOI: 10.46852/0424-2513.3.2020.13.

Bartolini, F., Andreoli, M. and Brunori, G. (2014) Explaining determinants of the on-farm diversification: Empirical evidence from Tuscany region. *Bio-based and Applied Economics* 3(2), 137–157. Doi: 10.13128/BAE-12994.

Calle, M., Watson, A., Lai, J. and Porter, W.A. (2022) Opportunity alertness, risk-taking, and diversification by small- and medium-sized farmers. *Journal of Developmental Entrepreneurship* 27(2), 2250015. DOI: 10.1142/S1084946722500157.

Cragg, J.G. (1971) Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica* 39(5), 829–844.

Das, V.K. (2018) Looking beyond the Farm and Household: Determinants of on-Farm Diversification in India. Indira Gandhi Institute of Development Research, Mumbai, India; (No. 2018-023).

de Bruin, S., Dengerink, J. and van Vliet, J. (2021) Urbanization as driver of food system transformation and opportunities for rural livelihoods. *Food Security* 13(4), 781–798. DOI: 10.1007/s12571-021-01182-8.

Dembele, B., Bett, H.K., Kariuki, I.M., Bars, M. Le and Ouko, K.O. (2018) Factors Influencing Crop Diversification Strategies among Smallholder Farmers in Cotton Production Zone in Mali. Available at: http://41.89.96.81:8080/xmlui/handle/123456789/2675 (accessed 5 September 2024).

Directorate of Economics and Statistics (DES) (2021) Agricultural Statistics at a Glance, Telangana, 2021. Government of Telangana, Hyderabad, India.

Doernberg, A., Zasada, I., Bruszewska, K., Skoczowski, B. and Piorr, A. (2016) Potentials and limitations of regional organic food supply: A qualitative analysis of two food chain types in the Berlin metropolitan region. *Sustainability* 8(11), 1125. DOI: 10.3390/su8111125.

Eakin, H., Perales, H., Appendini, K. and Sweeney, S. (2014) Selling maize in Mexico: The persistence of peasant farming in an era of global markets. *Development and Change* 45(1), 133–155. DOI: 10.1111/dech.12074.

Gecho, Y. (2017) Rural farm households' income diversification: The case of Wolaita zone, southern Ethiopia. *Social Science* 6(2), 45–56. DOI: 10.11648/j.ss.20170602.12.

Government of Telangana (GoT) (2022) Telangana Socio Economic Outlook 2022. Hyderabad: Planning Department. Available at: https://ecostat.telangana.gov.in/PDF/PUBLICATIONS/Socio_Economic_2022.pdf (accessed 8 April 2024).

Grilli, G., Pagliacci, F. and Gatto, P. (2024) Determinants of agricultural diversification: What really matters? A review. *Journal of Rural Studies* 110, 103365.

Ground, M. and Koch, S.F. (2008) Hurdle models of alcohol and tobacco expenditure in south African households. *South African Journal of Economics* 76(1), 132–143. DOI: 10.1111/j.1813-6982.2008.00156.x.

Hardaker, J.B., Lien, G., Huirne, R.B.M. and Anderson, J.R. (2015) *Coping with Risk in Agriculture*. 3rd edn. CABI Publishing, Wallingford, UK. DOI: 10.1079/9780851998312.0000.

Hellerstein, D., Higgins, N. and Horowitz, J. (2013) The predictive power of risk preference measures for farming decisions. *European Review of Agricultural Economics* 40(5), 807–833. DOI: 10.1093/erae/jbs043.

Hussain, Z. and Hanisch, M. (2014) Dynamics of peri-urban agricultural development and farmers' adaptive behaviour in the emerging megacity of Hyderabad, India. *Journal of Environmental Planning and Management* 57(4), 495–515. DOI: 10.1080/09640568.2012.751018.

Ibrahim, H., Rahman, S.A., Envulus, E.E. and Oyewole, S.O. (2010) Income and crop diversification among farming households in a rural area of North Central Nigeria. *Agro-Science* 8(2). DOI: 10.4314/as.v8i2.51102.

Joshi, P., Gulati, A., Birthal, P. and Tewari, L. (2003) Agriculture diversification in South Asia: Patterns, determinants, and policy implications. *Economic and Political Weekly*, 39. DOI: 10.2307/4415148.

Kankwamba, H., Mapila, M. and Pauw, K. (2012) *Determinants and Spatiotemporal Dimensions of Crop Diversification in Malawi*. Project Report Produced under a Co-Financed Research Agreement between Irish Aid, USAID, and IFPRI.

Kaur, J., Prusty, A.K., Ravisankar, N., Panwar, A.S., Shamim, M. *et al.* (2021) Farm typology for planning targeted farming systems interventions for smallholders in Indo-Gangetic Plains of India. *Scientific Reports* 11(1), 20978. DOI: 10.1038/s41598-021-00372-w.

Lange, A., Piorr, A., Siebert, R. and Zasada, I. (2013) Spatial differentiation of farm diversification: How rural attractiveness and vicinity to cities determine farm households' response to the CAP. *Land Use Policy* 31, 136–144. DOI: 10.1016/j.landusepol.2012.02.010.

Makate, C., Wang, R., Makate, M. and Mango, N. (2016) Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. *Springerplus* 5, 1–18. DOI: 10.1186/s40064-016-2802-4.

Marshall, F. and Randhawa, P. (2017) India's Peri-urban frontier: Rural–urban transformations and food security. In: *The Institute of Development Studies and Partner Organisations*. Available at: https://www.iied.org/10794iied.

Menakanit, A., Davivongs, V., Naka, P. and Pichakum, N. (2022) Bangkok's urban sprawl: Land fragmentation and changes of peri-urban vegetable production areas in Thawi Watthana District. *Journal of Urban and Regional Analysis* 14(1), 59–78. DOI: 10.37043/JURA.2022.14.1.4.

Meraner, M. and Finger, R. (2019) Risk perceptions, preferences and management strategies: Evidence from a case study using German livestock farmers. *Journal of Risk Research* 22(1), 110–135. DOI: 10.1080/13669877.2017.1351476.

Meraner, M., Heijman, W., Kuhlman, T. and Finger, R. (2015) Determinants of farm diversification in the Netherlands. *Land Use Policy* 42, 767–780. DOI: 10.1016/j.landusepol.2014.10.013.

Meraner, M., Pölling, B. and Finger, R. (2018) Diversification in peri-urban agriculture: A case study in the Ruhr metropolitan region. *Journal of Land Use Science* 13(3), 284–300. DOI: 10.1080/1747423X.2018.1529830.

Meuwissen, M.P.M., Hardaker, J.B., Huirne, R.B.M. and Dijkhuizen, A.A. (2001) Sharing risks in agriculture; principles and empirical results. *NJAS: Wageningen Journal of Life Sciences* 49(4), 343–356.

Mishra, A.K., El-Osta, H.S. and Sandretto, C.L. (2004) Factors affecting farm Enterprise diversification. *Agricultural Finance Review* 64(2), 151–166. DOI: 10.1108/00214660480001160.

Nainggolan, D., Moeis, F.R. and Termansen, M. (2023) Does risk preference influence farm-level adaptation strategies? Survey evidence from Denmark. *Mitigation and Adaptation Strategies for Global Change* 28(7), 40.

Noack, F. and Larsen, A. (2019) The contrasting effects of farm size on farm incomes and food production. *Environmental Research Letters* 14(8), 084024. DOI: 10.1088/1748-9326/ab2dbf/meta.

Pfeifer, C., Jongeneel, R.A., Sonneveld, M.P. and Stoorvogel, J.J. (2009) Landscape properties as drivers for farm diversification: A Dutch case study. *Land Use Policy* 26(4), 1106–1115. DOI: 10.1016/j.landusepol.2009.01.007.

Pingali, P., Aiyar, A., Abraham, M. and Rahman, A. (2019) Enabling smallholder prosperity through commercialization and diversification. In: *Transforming Food Systems for a Rising India. Palgrave Studies in Agricultural Economics and Food Policy*. Palgrave Macmillan, Cham. DOI: 10.1007/978-3-030-14409-8_7.

Pölling, B. and Mergenthaler, M. (2017) The location matters: Determinants for 'deepening' and 'broadening' diversification strategies in Ruhr metropolis' urban farming. *Sustainability* 9(7). DOI: 10.3390/su9071168.

Rahman, S. (2010) Determinants of crop choices by Bangladeshi farmers: A bivariate probit analysis. In: *Agricultural Economics: New Research*, pp. 189–203.

Rehan, S.F., Sumelius, J. and Bäckman, S. (2017) Determinants of on-farm diversification in Bangladesh. *International Journal of Agricultural Resources, Governance and Ecology* 13(3), 294. DOI: 10.1504/IJARGE.2017.087001.

Rehima, M., Belay, K., Dawit, A. and Rashid, S. (2013) Factors affecting farmers' crops diversification: Evidence from SNNPR, Ethiopia. *International Journal of Agricultural Science* 3(6), 558–565.

Rivaroli, S., Ghelfi, R., Bertazzoli, A. and Piorr, A. (2017) Diversification pathways and farming systems: Insights from the Emilia-Romagna region, Italy. *Outlook on Agriculture* 46(4), 239–247. DOI: 10.1177/0030727017741701.

Salvioni, C., Henke, R. and Vanni, F. (2020) The impact of non-agricultural diversification on financial performance: Evidence from family farms in Italy. *Sustainability* 12(2), 486. DOI: 10.3390/su12020486.

Sichoongwe, K., Mapemba, L., Ng'ong'ola, D. and Tembo, G. (2014) The determinants and extent of crop diversification among smallholder farmers: A case study of Southern Province, Zambia. *International Food Policy Research Institute* 5.

Song, B., Robinson, G.M. and Bardsley, D.K. (2022) Multifunctionality and path dependence: Farmer decision-making in the Peri-urban fringe. *Journal of Rural Studies* 96, 64–77. DOI: 10.1016/j.jrurstud.2022.10.012.

Sroka, W. and Żmija, D. (2021) Farming systems changes in the urban shadow: A mixed approach based on statistical analysis and expert surveys. *Agriculture*, 11. DOI: 10.3390/agriculture11050455.

Tacconi, F., Waha, K., Ojeda, J.J. and Leith, P. (2022) Drivers and constraints of on-farm diversity: A review. *Agronomy for Sustainable Development* 42(1), 2. DOI: 10.1007/s13593-021-00736-6.

Tedesco, C., Petit, C., Billen, G., Garnier, J. and Personne, E. (2017) Potential for recoupling production and consumption in Peri-urban territories: The case study of the Saclay plateau near Paris, France. *Food Policy* 69, 35–45. DOI: 10.1016/j.foodpol.2017.03.006.

Tsuchiya, K., Hara, Y. and Thaitakoo, D. (2015) Linking food and land systems for sustainable peri-urban agriculture in Bangkok metropolitan region. *Landscape and Urban Planning* 143, 192–204. DOI: 10.1016/j.landurbplan.2015.07.008.

Ullah, R. and Shivakoti, G.P. (2014) Adoption of on-farm and off-farm diversification to manage agricultural risks: Are these decisions correlated? *Outlook on Agriculture* 43(4), 265–271. DOI: 10.5367/oa.2014.0188.

Van der Ploeg, J.D. and Roep, D. (2003) Multifunctionality and rural development: The actual situation in Europe. *Multifunctional Agriculture: A New Paradigm for European Agriculture and Rural Development* 3, 37–54.

Van Winsen, F., De Mey, Y., Lauwers, L., Van Passel, S., Vancauteren, M. and Wauters, E. (2016) Determinants of risk behaviour: Effects of perceived risks and risk attitude on farmer's adoption of risk management strategies. *Journal of Risk Research* 19(1), 56–78. DOI: 10.1080/13669877.2014.940597.

Vecchio, Y., Adinolfi, F., Albani, C., Bartoli, L. and De Rosa, M. (2020) Boosting sustainable innovation in densely populated areas: A milieux innovateurs approach. *Sustainability* 12(21). DOI: 10.3390/su12219131.

Yoshida, S., Yagi, H., Kiminami, A. and Garrod, G. (2019) Farm diversification and sustainability of multifunctional peri-urban agriculture: Entrepreneurial attributes of advanced diversification in Japan. *Sustainability* 11(10). DOI: 10.3390/su11102887.

Zasada, I. (2011) Multifunctional peri-urban agriculture – A review of societal demands and the provision of goods and services by farming. *Land Use Policy* 28(4), 639–648. DOI: 10.1016/j.landusepol.2011.01.008.