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Factors Associated with Vegetable Diversification among Small-Scale and Minority Urban Gardeners in Maryland, USA

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ABSTRACT

Vegetable diversification within urban gardening systems can improve dietary diversity, provide economic opportunities through surplus sales, and enhance urban biodiversity conservation. Researchers have examined the impacts of diversification; however, understanding of the extent to which individual, household, and project support-related factors affect vegetable diversification among small-scale and minority urban gardeners is limited. The objective of this study was to assess the factors influencing vegetable diversification among small and minority urban gardeners participating in an urban gardening project in Maryland, USA. Using a cross-sectional study design, this study collected data from 74 urban gardeners belonging to Asian American immigrant communities across Baltimore City, Baltimore County, Howard County, and Montgomery County. The Ordinary Least Squares (OLS) regression technique was applied to assess the association between vegetable diversification and factors at individual, household, and project-support levels. The multivariate results revealed that only household-level factors, particularly the involvement of gardeners in community gardening ($\hat{\beta} = -6.09$, $p<0.01$) and family size ($\hat{\beta} = -0.86$, $p<0.05$), were significantly associated with reduced vegetable diversification. The study suggested that home gardening should be prioritized, and extension support services should be provided to households with larger family sizes in order to promote vegetable diversification through the urban gardening initiative. Future studies should incorporate broader socio-economic and environmental variables, including cultural preferences and market access, to provide a better understanding of the dynamic factors influencing vegetable diversification among small-scale and minority urban gardeners.

INTRODUCTION

Urban gardening refers to the growing, processing, and distributing of food and other products through intensive plant cultivation and animal husbandry in and around cities (Bailkey & Nasr, 1999). It is gaining significance as consumer demand for alternative foods, such as organic and locally produced food products, continues to rise in the U.S. (Zepeda & Leviten-Reid, 2004). This demand for local and fresh food will likely grow as the world's population is projected to reach 9.7 billion by 2050 (United Nations, 2022). In Maryland, urban gardening has emerged as a vital initiative to enhance food security and provide economic opportunities for small-scale ethnic minority populations (Gurung *et al.*, 2025).

Urban gardening contributes to food and nutritional security by ensuring the availability of fresh, healthy, and culturally relevant foods (Hodgson *et al.*, 2011). It can also supplement access to unaffordable foods and support cost savings on grocery bills (Algert *et al.*, 2016; Beavers *et al.*, 2020). Additionally, urban gardening can benefit the environment by increasing crops, livestock, and insect biodiversity, while also improving pollinator habitats that support fruit and vegetable production and preserve soil health (Clucas *et al.*, 2018).

Various studies have investigated the impact of crop diversification (Chavas & Di Falco, 2012); however, limited research exists on the factors that influence vegetable diversification and food security, particularly among small-scale and minority urban growers (Lovell, 2010; Zezza & Tasciotti, 2010). Furthermore, the socio-economic, institutional, and support-related factors have often been overlooked in urban agriculture research, despite their critical role in shaping gardening outcomes. Therefore, this study tested the hypothesis that vegetable diversification is significantly associated with individual-level, household-level, and urban gardening project-support related factors among small and minority farmers engaged in urban gardening. The objective of this study was to assess various factors associated with vegetable diversification among small-scale minority urban gardeners in Maryland.

LITERATURE REVIEW

The well-known saying, "don't put all your eggs in one basket," illustrates the motivations of farmers to diversify their urban lands in an unpredictable agricultural landscape (Lancaster & Torres, 2019). From a food security perspective, crop diversification can increase access to a variety of crops for farm households, significantly improving dietary diversity and nutritional outcomes, especially in communities with limited access to fresh produce (Alam *et al.*, 2023). From an economic standpoint, crop diversification can potentially offer multiple income streams to smallholder farmers,

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especially when gardeners can sell surplus produce in direct or niche markets (Karki & Bhandari, 2023). From an environmental stance, the diversification of urban farms improves nutrient recycling, soil fertility, organic matter content in soils, biological soil activity, and water holding capacity, thereby providing resilience to climatic variability (Altieri *et al.*, 2025; Lithourgidis *et al.*, 2011). From a cultural and social viewpoint, diversified urban gardens act as hubs for preserving ethnic foods, transferring agroecological knowledge, engaging communities, and building social capital (Taylor & Lovell, 2015; Vitiello & Wolf-Powers, 2014).

Lancaster and Torres (2019) investigated key drivers affecting farm diversification among U.S. fruit and vegetable operations. The study reported that market access, especially local markets, was the primary factor that significantly increased crop diversification. Moreover, practices such as growing a combination of fruits and vegetables, adopting seasonal extension technologies, and using organic agricultural practices were also significantly associated with increased crop diversification among fruit and vegetable operators in the U.S. The study also reported that farming experience was significantly associated with increased diversification among medium and highly diversified farms. On the other hand, part-time farming and information from peers were found to significantly decrease crop diversification in the study context. However, Thomas *et al.* (2011) and Valliant *et al.* (2017) opposed that claim, reporting that farmer networks can potentially increase farm diversification.

The relationship between farm diversification and land size depicts instability in existing literature. A negative correlation between diversification and farm size was reported by Mishra and El-Osta (2002) in the U.S. On the contrary, the studies conducted by McNamara and Weiss (2005) and Pope and Prescott (1980) in Austria and the U.S., respectively, admitted that increased farmland positively affects crop diversification due to increased resource availability. Inconsistent with all the above findings, Lancaster and Torres (2019) reported no significant effect of increasing land size with crop diversification among U.S. fruit and vegetable operators.

Grebitus (2021) studied behavioral and socio-demographic factors affecting small-scale urban gardeners' choice to grow diverse agricultural produce in home and community gardening. The study found that knowledge about farming was positively associated with increased cultivation in both home and community gardening. Moreover, household size was positively linked to increased cultivation in home gardening, whereas gender, age, and income of the gardener were negatively associated with cultivation in community gardening.

A study conducted by Obisesan and Awolala (2021) reported that household size, crop income, farm size, total household income (on-farm and off-farm), and use of inorganic fertilizers significantly increased crop diversification, whereas age and sex of the household heads significantly decreased crop diversification. Likewise, a study conducted by Vekariya *et al.* (2022) reported that crop diversification was positively affected by family size, size of landholding, income of the family, and education level of the farmer, whereas distance from a farm to the market was found to be negatively associated with crop diversification.

Philpott *et al.* (2020) noted that the richness and composition of plant species in urban gardening are affected by the gender of the gardener, the region of national origin, the time spent gardening (hours per week), and the gardener's motivations for food or recreation. In the context of ethnic and migrant gardeners, the decision to diversify their urban gardens is largely influenced by cultural preferences and traditional agroecological knowledge. Additionally, uncertainties in environmental conditions and the performance of crop plants further motivate these gardeners to diversify their urban spaces (Taylor & Lovell, 2015).

Access to university Extension services, farmers' associations, and other institutional support networks can influence the diversification decisions of fruit and vegetable operators by providing access to technical information and business opportunities (Fitz-Koch *et al.*, 2018; Rodriguez *et al.*, 2009).

Conceptual Framework

Based on the theoretical explanations and empirical evidence from the literature, the following conceptual framework (Figure 1) was developed to guide this study. We argue that individual-, household-, and urban gardening project support-related factors influence gardeners' decisions for vegetable diversification.

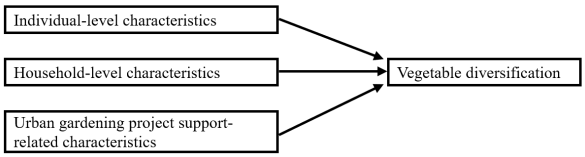

Figure 1: A conceptual framework to assess factors associated with vegetable diversification among urban gardeners in Maryland, USA.

MATERIALS AND METHODS

Data Collection

This study employed quantitative research design complemented by a literature review to assess factors associated with vegetable diversification among urban gardeners. Due to the short duration of the project and limited resources, this study employed a cross-sectional study design, as recommended by Wang and Cheng (2020) in situations with similar constraints. The study collected data from 74 participants engaged in the urban gardening project. The project participants were from ethnic minority immigrant communities, particularly Asian Americans residing in Baltimore City, Baltimore County, Howard County, and Montgomery County of Maryland. As limited information was available regarding

the exact population of Asian American immigrants in the study area, the probability sampling technique was not feasible for this study. Therefore, this study adopted a non-probability sampling technique, particularly the convenience sampling approach, for collecting responses from urban gardeners.

Data were collected using a questionnaire that consisted of both closed- and open-ended items. Closed-ended questions consisted of Likert-scale (5-point), dichotomous (mainly yes/no), and multiple-choice questions. The multiple-choice questions were designed to allow respondents to select one option or multiple options depending on the nature of the question. Wherever required, the multiple-choice questions were supplemented with open-ended options integrated as "other (please specify)" allowing participants to add responses not covered by the provided answer choices. Other open-ended questions, such as the number of family members, farming experience, and the total number of months growing vegetables, were also included in the questionnaire.

Measurement of Variables

The measurements of variables used to empirically assess different factors associated with vegetable diversification by applying the regression analysis are described below.

Dependent Variable

The survey collected the names of all vegetables grown by each farmer in a year. The vegetables were listed in a survey sheet, and respondents were asked if they grew a vegetable listed in the growing season of 2024. The responses were recorded as "Yes" (coded as 1) and "No" (coded as 0) for each vegetable. If a farmer reported additional vegetables, those vegetables were also included in the list. The total number of vegetables cultivated by each farmer in 2024 was counted. This number was considered as the measure of vegetable diversification, which was therefore used as a dependent variable in the regression analysis.

Independent Variables

To explain the variation in the dependent variable—vegetable diversification—the independent variables were grouped under three broad categories: (a) Individual-level variables, (b) Household-level variables, and (c) Urban gardening support-related variables.

a) Under the individual-level variables, respondents' gender, age group, education level, and farming experience were included. Respondents' gender was recorded as female (coded 1) and male (coded 0). Two age group categories (18–30 years and 30–45 years) were combined into a single category (18–45 years) to increase the sample size within the category and simplify analysis. The respondents were divided into three dichotomous age-group categories: 18-45 years, 46-64 years (reference category), and 65 years and above. Similarly, for the education level of respondents, those with less than high school, high school/GED, and some college degrees were grouped together, and the combined category was named "less than a university degree." The respondents with undergraduate and graduate degrees were grouped into a single category named "University degree." These two categories were then compared to the reference category, i.e., respondents with no formal education.

b) Household-level factors considered to explain diversification were respondents' engagement in different types of gardening, family size, children's participation in gardening, length of growing season, time spent on gardening, growing method, average annual household income, and garden plot size. The diversification of vegetables among respondents engaged in community gardening and those participating in both home and community gardening was compared with those engaged solely in home gardening. Time spent on gardening was measured as a dichotomy, "more than 6 hours per week" (coded 1) and "less than 6 hours per week" (coded 0). Those urban gardeners using chemical fertilizers and pesticides alongside organic techniques were grouped under the "integrated" method (coded 1), and those who did not use any chemical fertilizers and pesticides were grouped under the "indigenous" method (coded 0). The income level of respondents was regrouped as "more than $50,000 a year" (coded 1) and "less than $50,000 a year" (coded 0). Since respondents practiced gardening in limited private or community spaces, land area measurements were recorded in square footage.

c)The study also examined the association between urban gardening project-support-related variables and vegetable diversification. These variables were the number of inputs received by the gardening households and the usefulness of perceived project interventions. The urban gardeners received token support from the project, such as farmyard manure, compost bins, rainwater harvesting tanks, hardwood natural mulch, garden soil, garden tools, plant nutrients, fencing materials, and materials for raised beds. The total number of inputs received by each household was calculated by summing the various types of inputs received by them from the project in the growing season of 2024. The variable was then used as a continuous variable in the analysis. Similarly, the usefulness of project interventions as perceived by the project participants, originally measured on an ordinal scale ranging from 0 (strongly disagree) to 4 (strongly agree), was also horizontally summed to make a composite index and treated as a continuous variable in the analysis.

Data Analysis

An urban gardening household was the unit of analysis. The survey considered a household as an urban gardening household if at least one member (not necessarily the household head) was engaged in growing any vegetable in the backyard garden, community space, or both locations. The collected data were entered into the Statistical Package for Social Sciences (SPSS) and MS-Excel software. The data were analyzed using Microsoft

Excel and SPSS (version 21). A descriptive statistical analysis was conducted to examine general distributions, variations, and trends of the interest variables, and multivariate regression analyses were employed to assess various factors associated with vegetable diversification.

As the dependent variable, i.e., number of vegetables grown, was a continuous variable (a count measure of vegetable diversification), the Ordinary Least Squares (OLS) regression technique was used to explain the variance of this variable by the independent variables of interest. According to Wooldridge (2016), the general OLS regression equation can be written as:

$$\hat{Y} = \widehat{\beta_0} + \widehat{\beta_1}X_1 + \ldots + \widehat{\beta_k}X_k \quad \ldots.(1)$$

Where,

$\hat{Y}$ = Estimated value of the dependent variable y

$\widehat{\beta_0}$ = estimate of the intercept

$\widehat{\beta_1}, \ldots, \widehat{\beta_k}$ = estimates of the parameter associated with independent variables ($X_1, \ldots, X_k$)

$X_1, \ldots, X_k$ = k independent variables used in the regression

The Intercept ($\widehat{\beta_0}$) is the predicted value when $X_1, \ldots, X_k = 0$. The estimate $\widehat{\beta_1}$ is interpreted as the predicted change in Y given the change in X_1, holding all other factors constant. The same interpretation was followed for all other coefficient estimates.

Before conducting the analysis, collinearity among variables was assessed using the Pearson correlation coefficient and the Variance Inflation Factor (VIF) to minimize the risk of multicollinearity in the model. The Pearson correlation coefficient indicated that none of the independent variables were highly correlated with the dependent variable. The VIF values ranged from 1.359 to 3.287, confirming no collinearity between the chosen variables since a VIF of less than 10.0 is acceptable (Hair *et al.*, 2019). The overall significance of the model was assessed by analyzing F-statistics, and the adjusted R2 value was used to estimate the goodness of the fit of the regression model.

RESULTS AND DISCUSSION

Descriptive Results

The descriptive findings of the variables used in the empirical model are presented in Table 1. On average, each urban gardening household cultivated about 15 different vegetable crops during the 2024 growing season, with the number of vegetables grown ranging from a minimum of 4 to a maximum of 31.

Among the individual-level factors, the survey found that a higher proportion of females (67.6%) participated in gardening as compared to males (32.4%). Over half (56.8%) of them belonged to the 46-64 years age group, about one-third (31.0%) were from the 18-45 age group, and the remaining 12.2% were 65 years and above. Nearly half of the respondents (44.6%) reported having no formal education, while 21.6% had less than a university degree, and 33.8% had received a university-level education. The urban gardeners had diverse farming experiences ranging from 1 year to 60 years, with a mean farming experience of 26.5 years.

The descriptive results of the household-level characteristics showed that the home gardeners constituted 59.5% of the survey participants. The remaining individuals either engaged in community gardening (24.3%) or participated in both home and community gardening (16.2%). The surveyed households, on average, had 5 members in a family, with family size ranging from 2 to 12 members per household. Slightly more than 35% of the participants also reported that their children participated in gardening. The growing season for vegetables spanned seven months, from April through November each year. Nearly half (47.3%) of the participants dedicated more than 6 hours per week to gardening, while the rest (52.7%) spent less than 6 hours per week. Likewise, 47.3% of them followed integrated farming, and the remaining (52.7%) followed the indigenous method of cultivating vegetables. Among all, 46.0% of the respondents reported an annual household income of less than $50,000, while the rest (54.0%) reported an average annual household income of $50,000 or more.

Among the different inputs and support services provided to motivate and engage urban gardeners, respondents reported receiving an average of about four inputs, with the number of inputs received per household ranging from 0 to 10. The overall usefulness of project interventions, which was measured as an index, had a mean score of 12.9 (SD = 5.4).

Table 1: Descriptive results of the variables used to examine factors associated with vegetable diversification among urban gardeners, based on a 2025 field survey in Maryland, USA (n=74).

Variables	Mean (SD)/%
A. Dependent variable	
Number of vegetables grown	14.6 (6.4)
B. Independent variables	
i. Individual-level	
Female	67.6%
Age-groups	
18-45 years	31.0%
46-64 years	56.8%
65 years and above	12.2%
Education levels	
Less than a university degree	21.6%
University degree	33.8%
No formal education	44.6%
Farming experience	26.5 (18.2)
ii. Household-level	
Community gardener	24.3%
Both home and community gardener	16.2%
Home gardener	59.5%
Family size (Number of household members)	4.9 (2.0)

Children's participation in gardening	35.1%
Length of growing season (months)	7.0 (1.3)
Time spent gardening (per week)	
More than 6 hours	47.3%
Less than 6 hours	52.7%
Growing method	
Integrated	47.3%
Indigenous	52.7%
Average annual household income	
$50,000 and more	54.0%
Less than $50,000	46.0%
Land size (in square feet)	751.5 (1015.4)
iii. Urban gardening support-related	
Number of inputs received	3.5 (1.8)
Usefulness of project intervention (Indexed)	12.9 (5.4)

1 acre = 43,560 square feet; 1 hectare = 2.471 acres

Factors Associated with Vegetable Diversification

The association between the individual-level factors and vegetable diversification is presented in Model 1 of Table 2. Empirical evidence showed that education and farming experiences were the factors that were significantly associated with vegetable diversification among urban gardeners, net of other individual-level factors. For example, urban gardeners with a university degree tend to grow four fewer vegetables ($\hat{\beta}$ = -4.00, $p<0.05$) than those without formal education. In the full model, i.e., Model 4, having a university degree negatively influenced vegetable diversification ($\hat{\beta}$= -3.36; $p>0.05$); however, its significance weakened compared to Model 1. This suggests that some of the relationship between education and vegetable diversification may be mediated or confounded by household characteristics or access to urban gardening resources. For instance, higher education may be associated with better income and better access to vegetables from grocery stores, which in turn may decrease participation in gardening and hence diversification. Meraner *et al.* (2018) also reported a negative relationship between education and farm diversification, arguing that the opportunity costs associated with on-farm diversification are higher for educated farmers, who may therefore look for off-farm income opportunities.

Farming experiences of respondents tend to contribute positively to vegetable diversification in Model 1. With each additional year of farming experience, the number of vegetables grown increased by 0.12 ($p<0.05$), net of other factors. This relationship showed that farmers with 10 years of farming experience tend to grow about one (10*0.12 = 1.2) additional vegetable in their garden. The positive and significant relationship between farming experience and vegetable diversification suggests the importance of ethnic knowledge about gardening practices accumulated over time. However, in Model 4, total farming experience remained positively associated with vegetable diversification ($\hat{\beta}$ = 0.08; $p>0.05$), although it was no longer statistically significant, potentially due to confounding or mediation effects of controlling household-level and support-related factors in the model. The study conducted by Taylor and Lovell (2015) revealed that ethnic and migrant gardeners used their cultural practices and agroecological knowledge to grow different kinds of crops and contributed to enhanced crop biodiversity in their urban home gardens.

The estimation of the relationship between household-level factors and vegetable diversification is presented in Model 2 (Table 2). Among the household-level characteristics, the coefficient of community gardening was -7.52 ($p<0.001$), which indicated that farmers engaged in community gardening grew approximately 8 fewer vegetables compared to those who cultivated vegetables in their home garden. Interestingly, engagement in community gardening was still associated with a decrease in the number of crops grown with a slightly weaker statistical significance ($\hat{\beta}$= -6.09, $p<0.01$) in Model 4 as compared to Model 2. This suggests that home gardening could potentially offer greater flexibility, space, or security needed to diversify the urban gardening space. Although community gardens can offer shared space in urban areas, they may limit individual control over land use, leading to less diversification. Existing literatures argue that home gardeners grow a wide range of traditional crops by exchanging those species and varieties through social networks, including culturally preferred and experimental varieties, due to having full control over their garden design, crop choices, and management (Aguilar-Støen *et al.*, 2009; Galluzzi *et al.*, 2010). Moreover, a study conducted by Drake and Lawson (2015) highlighted that space constraints, unavailability of funding, communal rules, lack of collaboration with other institutions, and cross-cultural conflicts in community gardening can limit the types and quantities of crops grown

The study results also indicated that increased time commitment to gardening was associated with a significant increase in vegetable diversification in Model 2. Empirically, gardeners who dedicated more than six hours per week to gardening tend to cultivate approximately 3 more vegetables ($p<0.05$) than those who spent less than six hours per week on gardening. This finding was in the expected direction because, as gardeners invest more time in gardening, they could potentially manage a wider variety of vegetables, provide proper care for plants, and keep the land mostly occupied with vegetables, ultimately leading to greater diversification. This finding was consistent with Lancaster and Torres (2019), who reported that part-time farmers were less likely to diversify their farms due to time constraints. However, when individual-level and urban gardening support-related variables were controlled in Model 4, the magnitude and direction of the coefficient for spending more than 6 hours per week weakened and became insignificant ($\hat{\beta}$= 2.35; $p>0.05$), suggesting that individual-level variables and institutional support-related

variables may partially explain the relationship.

Surprisingly, family size ($\hat{\beta}$= -0.86, p<0.05) appeared to be negatively associated with vegetable diversification in Model 4, indicating that for each additional family member, gardeners grew about one fewer vegetable. This counterintuitive result suggests that larger households might face resource competition or prioritization of off-farm activities to meet the household's economic needs. In contrast to this finding, Thomas *et al.* (2025) found that a larger household size potentially provides more family labor, and diversification is increased because of their engagement in labor-intensive farming practices.

The association between urban gardening project support-related variables and vegetable diversification is presented in Model 3 (Table 2). The negative and statistically significant association between receiving more physical inputs and vegetable diversification in Model 3 ($\hat{\beta}$= -0.81, p<0.05), though not statistically significant in Model 4 ($\hat{\beta}$ = -0.16, p>0.05), contrasted with theoretical expectations. One possible explanation is that the type or quantity of inputs provided by the project may not have been adequately aligned with the needs required for diversifying vegetable production. Instead of enabling farmers to grow a broader variety of crops, the inputs may have supported only a limited range of vegetable types or basic garden establishment. A study conducted by Taylor and Lovell (2015) found that home gardeners relied mostly on external inputs such as seeds and fertilizers, which constrained some gardeners from diversifying their crops due to a lack of access, availability, and affordability of such inputs. The study also pointed out the need for material (input) support to help gardeners fully realize the production potential of their gardens.

The perceived usefulness of project interventions was positively and significantly associated with vegetable diversification ($\hat{\beta}$= 0.55, p<0.001) in Model 3. However, it was not significant in Model 4 ($\hat{\beta}$= 0.27, p>0.05), where variables related to individual and household level characteristics were controlled. The study conducted by Blair *et al.* (1991) to evaluate the dietary, social, and economic values of the Philadelphia urban gardening project found that those city residents participating in the urban gardening project cultivated a diverse range of vegetables, leading to improved dietary diversity and food security.

Table 2: Ordinary Least Squares (OLS) regression results for factors associated with vegetable diversification among urban gardeners, based on a 2025 field survey conducted in Maryland, USA. (n=74)

Independent variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
	Coefficient (Std. error)	**Coefficient (Std. error)**	**Coefficient (Std. error)**	**Coefficient (Std. error)**
Individual-level variables				
Female (Reference = Male)	0.57 (1.48)	-	-	-1.39 (1.43)
Age-groups (Reference = 45-64 years)				
18-45 years (1=yes)	0.15 (1.87)	-	-	2.43 (1.84)
65 years and above (1=yes)	-2.24 (2.36)	-	-	-1.70 (2.37)
Education levels (Reference = No formal education)				
Less than a university degree (1=yes)	2.40 (2.14)	-	-	0.88 (2.01)
University degree (1=yes)	-4.00 (1.81)*	-	-	-3.36 (2.21)
Farming experience	0.12 (0.05)*	-	-	0.08 (0.05)
Household-level variables				
Community gardener (Reference = Home gardener)	-	-7.52 (1.76)***	-	-6.09 (2.09)**
Both home and community gardener (Reference = Home gardener)	-	-0.32 (1.84)	-	-0.94 (1.95)
Family size	-	-0.49 (0.35)	-	-0.86 (0.37)*
Children's participation in gardening (1=yes)	-	1.21 (1.35)		1.15 (1.48)
Length of growing season (months)	-	0.51 (0.49)	-	0.56 (0.53)
Time spent gardening (per week) (Reference = <6 hours)				
More than 6 hours (1=yes)	-	3.26 (1.43)*	-	2.35 (1.44)
Growing method (Reference = Indigenous)				
Integrated	-	-0.82 (1.33)	-	-2.80 (1.40)
Average household income (yearly) (Reference = <$50,000)				
$50,000 and more	-	0.01 (1.43)	-	1.74 (1.55)

Land size (square feet)		0.01 (0.01)		0.01 (0.01)
Urban gardening project support-related variables				
Number of inputs received	-	-	-0.81 (0.37)*	-0.16 (0.45)
Usefulness of project interventions (Indexed)	-	-	0.55 (0.13)***	0.27 (0.14)
Intercept	12.29 (2.37)***	13.37 (3.80)***	10.43 (2.01)***	11.33 (4.81)*
F-statistics	4.32***	4.87***	10.59***	3.88***
Regression degrees of freedom	6	9	2	17
Adjusted R-square (%)	21.40	32.30	20.80	40.10

****p<0.001, **p<0.01, *p<0.05*

CONCLUSIONS

The conceptual framework theoretically expected that vegetable diversification choices among smallholder minority gardeners would be affected by the individual, household, and project support-related factors. The study findings reveal that individual-level factors (e.g., education and farming experience), household-level factors (e.g., community gardening and time spent on gardening), and project-related factors (e.g., number of physical inputs received and perceived usefulness of project interventions) all significantly influenced vegetable diversification in the preliminary models (Models 1–3). However, in the full model (Model 4), where all variables were jointly considered, only household-level factors, particularly engagement in community gardening and family size, significantly hindered vegetable diversification. The results suggest that promoting vegetable diversification through urban gardening requires prioritizing home gardening and providing tailored support services to larger households in order to encourage greater participation among smallholder minority gardeners.

This study has several limitations. First, the findings of this study can only be generalized to the population from which the sample was drawn or to populations with similar characteristics, as the use of a convenience sampling technique may limit the external validity of the results (Andrade, 2021). Second, the samples were mostly homogeneous, potentially leading to biased conclusions if applied to a heterogeneous group. Third, the study's cross-sectional design also restricts its ability to establish causality between the explanatory variables and the observed outcomes. Fourth, this study did not record some potentially influential variables, such as soil quality, weather patterns, availability of local markets, and respondents' cultural preferences. Thus, the conclusion drawn in this paper should be considered carefully. Future research should consider these limitations and conduct longitudinal studies in a diverse population to derive more conclusive evidence.

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